

**An investigation of the perceived impact of ICT
on the self-directed professional development of
Zimbabwean A-level science and mathematics
teachers**

**Thesis presented in fulfilment for the requirements of
the PhD Programme**

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September, 2005

Abstract

The aim of this research was *to investigate the perceived impact of ICT on Zimbabwean A-level science and mathematics teachers' self-directed professional development.*

The study was based on a questionnaire survey of 254 teachers throughout the country. Supplementary data came from 54 interviews. Some observations of teachers using ICT in teacher-centres, e-mail correspondence, and field reports also contributed to the database of the study. An analysis framework was developed through the use of grounded theory on the interview transcripts. The framework yielded 9 themes relating to the teachers' use of ICT for their professional development. These were: (1) perceived professional identity; (2) career development; (3) Managing the ICT environment; (4) theoretical and content knowledge; (5) practical knowledge and skills; (6) adaptation; (7) professional networking and; (8-9) perceived benefits to teachers and students.

Chaos (complexity) theory was used to identify the major attractors (goals) for teachers' self-directed professional development using ICT. Two attractors were identified. These were personal professional development and classroom practice. However, an over-riding factor common to both attractors was identified as self-efficacy. The study identified the over-arching driver for self-directed professional development as the teacher's need to improve their self-efficacy. A two dimensional model of self-directed professional development was suggested. The systemic element of the model focused on the self-correcting impact of ICT use on professional development, whilst the personal element focused on self-efficacy as the central *stratum* for self-directed professional development.

The study concluded by acknowledging the potent role that ICT is playing in the self-directed continuing professional development of teachers in Zimbabwe, and recommended, among other things, the inclusion of A-level teachers in the development of localised online materials resources for their subjects. This will help to enhance relevance of the materials to the Zimbabwean context. This dissertation contains 96865 words.

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Acknowledgements

The guide said to the explorer, my journey ends here, yours begins. From now on, you do not follow my footsteps in the sand – you have to make your own for others to follow....
(Marx et. al., 1991 p1)

In Zimbabwe we have a saying: “*Nzombe huru yakabva mukurerwa*” (literally: An adult bull is the result of careful breeding). There are some people who have played a pivotal role in making this journey not only possible for me, but successful as well.

I extend my gratitude to the administration of the University of Zimbabwe, especially professor L. Nyagura, whose kind words of encouragement during my field-work in 2003/2004, gave me inspiration. I am also grateful to the Dean of Education, Dr. C. Dyanda who assisted me to negotiate for access into the schools. My thanks also go to my colleagues in the Department of Science and Mathematics Education, namely Dr. D. J. K. Mtetwa and Ms. R. Ngara, who provided moral and logistical support during the field-work phase of the project.

Several officers in the Ministry of Education, Sport and Culture in Harare and in the Regions played a crucial role in facilitating my access to the teachers’ resource centres. I am therefore indebted to Dr. S. M. Mahere, Mr. Chinamasa and their colleagues for granting me access letters and for providing me with information concerning nationwide statistics on A-level schools and their enrolment. Education officers; Mr. Mushonga in Masvingo, Mr. W. Moyo in Bulawayo, and Mr. Chisindi in Mashonaland East, among others, played a pivotal role in ensuring that my questionnaires reached the teachers and were returned to me, for that I am grateful. My gratitude also goes to the A-level science, mathematics and geography teachers throughout the country, who allowed me into their milieu and enabled me to get first hand experience of their struggle for professional liberation. I am cognisant of the fact that the research

was carried out during a very difficult and trying period for the teaching profession, and yet they managed to make time, from their busy schedules, to assist me. Without their determination and courage in the face of difficulties, I would not have been able to carry on with the study.

I am also keenly aware that the production of this thesis was not easy. During the period when I was developing and writing my research, there were times when I was ready to give up, times when I felt as much on the verge of “researcher burnout” as the teachers’ I was describing. I am very grateful to my colleagues and fellow Ph.D and M.Phil students in Department of Educational Studies, University of York, who provided useful advice and a sympathetic ear when I needed to discuss my problems with someone. In particular, I want to thank Lilian Sheu, Qaimah Ismael and Marco Delgado.

Researcher *breeding* would not have been possible without the consistent input of the members of my TAG and the ERG. Other members of staff who played a significant role in my “*breeding*” include Professor Vulliamy, Professor Andrews, Dr. Kyriacou, Dr. McGuinn, Dr. Avramidis and my supervisors, Dr. Campbell and Mr. Lubben. I must therefore express my gratitude to these guides who, like the guides in the caption at the top of this page (cf. Marx *et al.*, 1991), have led me through the chaotic system we call educational research.

Finally, at the very core of my life as a researcher, I was anchored by those dearest to me – the people who sacrificed all to ensure my success – my wife, Ngonidzashe and sons, Tendaishe and Vimbainashe; and my dear friend and colleague, Dr. Martie Sanders. Thank you for believing in me and for encouraging me even when things appeared most difficult. Thank you also for opting to go without, in order to support my field-work and above all, thank you for being there when I needed you most.

List of Abbreviations

AEI	Australian Education Index
AIEMS	Action to improve English Mathematics and Science
BEI	British Education Index
BERA	British Educational Research Association
BSPZ	Better Schools Programme in Zimbabwe
BUSE	Bindura University of Science Education
CDU	Curriculum Development Unit
CSO	Central Statistics Office
DETYA	Department of Education, Training and Youth Affairs
EFA	Education for all
ICT	Information communication technology
ICDL	International computer driver's licence
ISP	Internet Services Provider
NUST	National University for Science and Technology
PCK	Pedagogical Content Knowledge
PGCE	Post-graduate Certificate in Education
PG DipScEd	Post-graduate Diploma in Science Education
SEITT	Science Education In-service Teacher Training Programme
SOCQ	Stages of Concern Questionnaire
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Educational Fund
WORLD	World Links for Development
UZ	University of Zimbabwe
ZIMSEC	Zimbabwe Schools Examinations Council

Chapter 1: Background to the study

Educational reforms require that teachers learn new roles and ways of teaching that translate into a long time developmental process requiring teachers to focus on changing their own practice. The demands posed by daily teaching and other aspects of the dynamic school curriculum continue to absorb a bulk of teachers energy, thoughts and attention. (McDiarmid et. al., 2002 p 410)

1.0 Introduction

The observation above summarises the state of education reforms the world over. New reforms in education are constantly being introduced in a bid to improve the quality of delivery. At the centre of all these reforms, teachers are the key players. However, in the developing world, teachers are expected to do so much with so little. In many cases, they are not adequately prepared for the reforms which are imposed upon them. In some cases, they have little institutional support. My own experience as a teacher in Zimbabwe, and as one who later on worked with science and mathematics teachers across the whole country, highlighted the enormous professional pressure that Zimbabwean teachers have to operate under. The teachers showed remarkable resilience in their daily struggle to make meaning of their existence as professionals. They continue to adapt to the changes mirrored in society, such as the introduction of information, communication technology (ICT) in commerce, industry and business.

I was fascinated by this resilience and adaptability especially with respect to ICT and chose to try and understand at greater depth what impact ICT was having on the teachers' professional development, considering that the teachers were under no obligation to use ICT for their professional development and received negligible institutional support for these activities. This study was born

out of a need to develop a supportive and sustainable structure which would facilitate self-directed professional development initiatives by teachers.

1.1 The context of science and mathematics education in Zimbabwe

1.1.1 Country profile

Figure 1.1 shows Zimbabwe's geographical location in Southern Africa.



Figure 1.1 Map of Zimbabwe (HTS Maps, 1998)

With a population of 12.8 million (UNICEF, 2003), Zimbabwe covers almost 391,000 square kilometres of high plateau country. Most of the population live in the rural areas although Harare, the capital city is estimated to be home to almost 2 million people (CSO, 2000). The main ethnic groups are the Shona

(74%) and Ndebele (19%), with the rest of the population being of Asian, European and other ethnic minorities. The United Nations Development Programme (UNDP) estimates that the average life expectancy has dropped to 33 years as a result of the current HIV / AIDS crisis which has ravaged sub-Saharan Africa (UNDP, 2003).

Zimbabwe is a developing country in the low income group, with a low human development index in 2001 of 0.496 (UNDP, 2003). The human development index measures a country's development in terms of social, political and economic development benchmarks agreed upon by the United Nations. The index ranges from 0.3 for the least developed country, to 0.99 for the most developed country. Zimbabwe is currently ranked number 145 out of the 175 United Nations member states currently participating in the United Nations Development Programme.

Zimbabwe has a high adult literacy rate of 90.0% (EFA, 2005). The country has three official languages, i.e. English, Shona and Ndebele. Until recently, primary education was universal and subsidised.

1.1.2 Pathways to A-level teaching in Zimbabwe

At Independence in 1980, the new Government expanded the education system by increasing enrolment and investing in the education sector. The general education index increased from 0.46 in 1980 to 0.79 in 2001 (UNDP, 2003). The increase was caused by the rising enrolment at both primary and secondary levels (UNESCO, 2004). However, the increase in pupil enrolment was not mirrored by a similar increase in the training of teachers and over the years teachers have been presented with challenges to their professional practice, associated with large classes and diminishing resources (Chivore, 1986). The greatest pressure has been felt by A-level science and mathematics

teachers, who need specialised equipment, resources and training. The country's single university in the 1980s could not cope with the demand.

To meet some of these challenges, more teachers' colleges and universities have been commissioned, and curricula and programmes at the existing institutions had to be modified to cater for the increased demand.

By 2001 Zimbabwe had seven state and four private universities. Most of these are involved in initial teacher training. In addition, the government has entered into partnership with friendly countries, to help train science and mathematics teachers to teach up to A-level. This has increased the number of routes that prospective science and mathematics teachers could take to acquire their qualifications. The table below show some of the Teacher qualifications held by Zimbabwean A-level Science and Mathematics teachers.

Training Institution	Subject Theory	Length of Programme		Qualification
		Professional Theory	Teaching Practice	
University of Zimbabwe	24 months	2 hrs per week	nil	B. Ed
University of Zimbabwe	36 months	nil	nil	BSc
University of Zimbabwe	nil	6 months	3 months	Post-GradCE
University of Zimbabwe	3 months	3 months (concurrent)	18 months	PGDipScEd
National University of Science and Technology	36 months	Information not available	Information not available	BSc.
Bindura University of Science education	48 months	24 months (concurrent)	12 months	B.Sc.Ed
Cuba Programme	Total time = 60 months	Information not available	Information not available	Licentiate

Table 1.1 Qualification routes for science / mathematics teachers

The University of Zimbabwe (UZ) as the country's oldest institution, has initiated several programmes to increase both the quantity and quality of A-level science / mathematics teachers in Zimbabwe. The programmes highlighted in table 1.1 bear testimony to these initiatives. The traditional route (*Bachelor of Science (BSc) + Post graduate certificate in education (PGCE)*) offers the University's own initial teacher training programme. The *Bachelor of Education*

(B.Ed) programme is aimed at upgrading college-trained teachers and hence the focus on subject content. The *Post-Graduate Diploma in Science Education* (PG DipScEd) programme is a recent initiative aimed at producing resource teachers who can act as mentor teachers in their regions. The emphasis of the programme is on professional knowledge and practice.

The Bindura University for Science Education (BUSE) provides Bachelor of Science Education (B.Sc.Ed.) qualifications. BUSE was the first university dedicated to science education. The National University of Science and Technology (NUST) was conceived as a university with strong industry and technology links and therefore focuses more on subject content theory. Its graduates have to enrol with the University of Zimbabwe (UZ) for the PGCE programme in order to operate as qualified graduate teachers.

In other universities both within the country and without, the foci differ depending on the orientation of the university.

Unfortunately, as can be deduced from the above argument, the diversity of training routes also presents challenges to further professional development as, although they all cover training in the essential strands of teacher education, i.e. subject content, professional foundations and teaching practice, the training institutions have no standardised curriculum (Maringe, 2005).

Zimbabwe has been divided into 10 educational regions to facilitate administration of the country's rapidly expanding educational system. However, for administrative reasons, two regions (Matebeland North and Bulawayo) remain fused together because the former region has poor infrastructure, thus effectively, nine educational regions are operational, (see page 67). In 2001 Zimbabwe had 172 high schools which offered A-level subjects in Biology, Chemistry, Geography, Mathematics and Physics (Ministry of Education, 2001)

If one assumes that each of these schools employs at least one teacher per A-level mathematics / science subject, then these subjects are taught by at least 860 teachers who have received their initial qualification through the routes identified in table 1.1.

This means that in 2001 science and mathematics A-level subjects in schools were taught by teachers from a mixture of backgrounds having a range of competencies and skills in their specialist subjects and pedagogy. Depending on where they obtained their teaching qualifications, these teachers also have very different views about the epistemology of teaching, professionalism and what it means to be a teacher (Maringe, 2005).

1.1.3 Challenges facing A-level science / mathematics teachers in Zimbabwe

The establishment of the Zimbabwe Schools Examinations Council (ZIMSEC) in 1994 and the localisation of O-level examinations in 1998 (reported in Machinga, 2000) was inevitably accompanied by a shift in perspective and emphasis on the O-level curricula, as new syllabi were introduced. Localisation of O-level examinations resulted in a gap in pupil knowledge between what they learned in O-level and teacher expectations at the start of the lower sixth form (i.e. the first year of A-level). This meant that lower sixth teachers could no longer make assumptions about pupil prior knowledge when introducing topics and this was viewed as a drop in the quality of educational provision at O-level (Engels and Ncube, 1995). Thus A-level teachers had to cover the pre-requisites as well as the unwieldy, content-rich A-level syllabus within the 18 month provision for A-level. Teachers were faced with the onerous task of finding ways to assist increasingly less able students to cope with the demands of A-level work.

Due to the country's "developing nation" status, the expansion in education could not be matched with a proportional expansion in resources and personnel. Therefore teachers found themselves teaching large classes of ill-prepared students with fewer textbook and equipment resources (Engels, 1994). In the high density suburbs of Harare and Bulawayo, typical A-level classes can have up to 32 students per class.

Another big problem for teachers of all science and mathematics subjects has been the introduction of new topics such as Remote-sensing, Biotechnology and Astronomy. The problem is that some teachers have not covered these same topics during their training and feel out of their depth when they have to teach them (McKenney, 2001).

Some other problems linked to the lack of resources for teaching including a lack of institutional support for teachers' professional development (Mushayikwa *et al.*, 1999) and to the introduction of the performance appraisal system which has tended to heighten anxiety among teachers.

All these problems have combined together to cause stress and frustration to teachers as they are still expected to produce good passes at the end of A-level and in some cases this means that they have to use their own resources to ensure that their students do well.

1.1.4 The use of ICT in professional development activities in Zimbabwe

In its Science and Technology Policy Document, the Government of Zimbabwe has stressed the central role played by the Information Communication Technology (ICT) industry in spearheading the economic development of the country (SLO, 2002). Indeed, the United Nations (UNDP,

2003) links information access to socio-economic development in its human development goals and states:

Access to information enables empowerment and speeds up community development through increases in productivity, creativity and locally sprung innovative solutions to problems. (UNDP, 2003 p 144)

Several researchers, for example Nonaka and Takeuchi (1995), Perraton and Creed (2000) and Cawthera (2001), have also linked unequal economic development with access to technology. The division between those with access and those without has been termed the “digital divide” and Perraton and Creed (2000) argued:

..The digital divide compounds existing inequalities between people within and between countries: the disparities of access are not random, but correlate strongly with income, education, ethnic origin, location and gender...(p. 4)

Beardon (1994) also recognised that the unequal distribution of information processing capability between and within societies creates unequal distribution of power. Hodson (1992) contends that acquiring ICT skills is especially important for science teachers because the computer is increasingly becoming an important tool for scientific research. Scientists use computers as modelling tools, as well as for theory building.

The education system, as a primary agent for change, has to lead in the fight for information access through ICT and thus prepare future citizens for a better life (Cawthera, 2001). The problem therefore lies in determining the exact relationship between ICT and educational practice. However, as Herdman (1996) observed:

A majority of teachers report feeling inadequately trained to use computer based technology. Although many teachers see the value of learning about computers, some are not aware of the resources this technology can offer them as professionals in carrying out many aspects of their jobs (Herdman,1996 p. 2.)

While the situation may have improved in the US (which was the target of the report), in Zimbabwe Herdman's statement is likely to remain largely true for most teachers.

Among sub-Saharan countries, Zimbabwe is considered as having a relatively sophisticated telecommunications system (Jensen, 2003). It also has lower dial up Internet access costs compared to most other countries in sub-Saharan Africa (see figure 1.2 below).

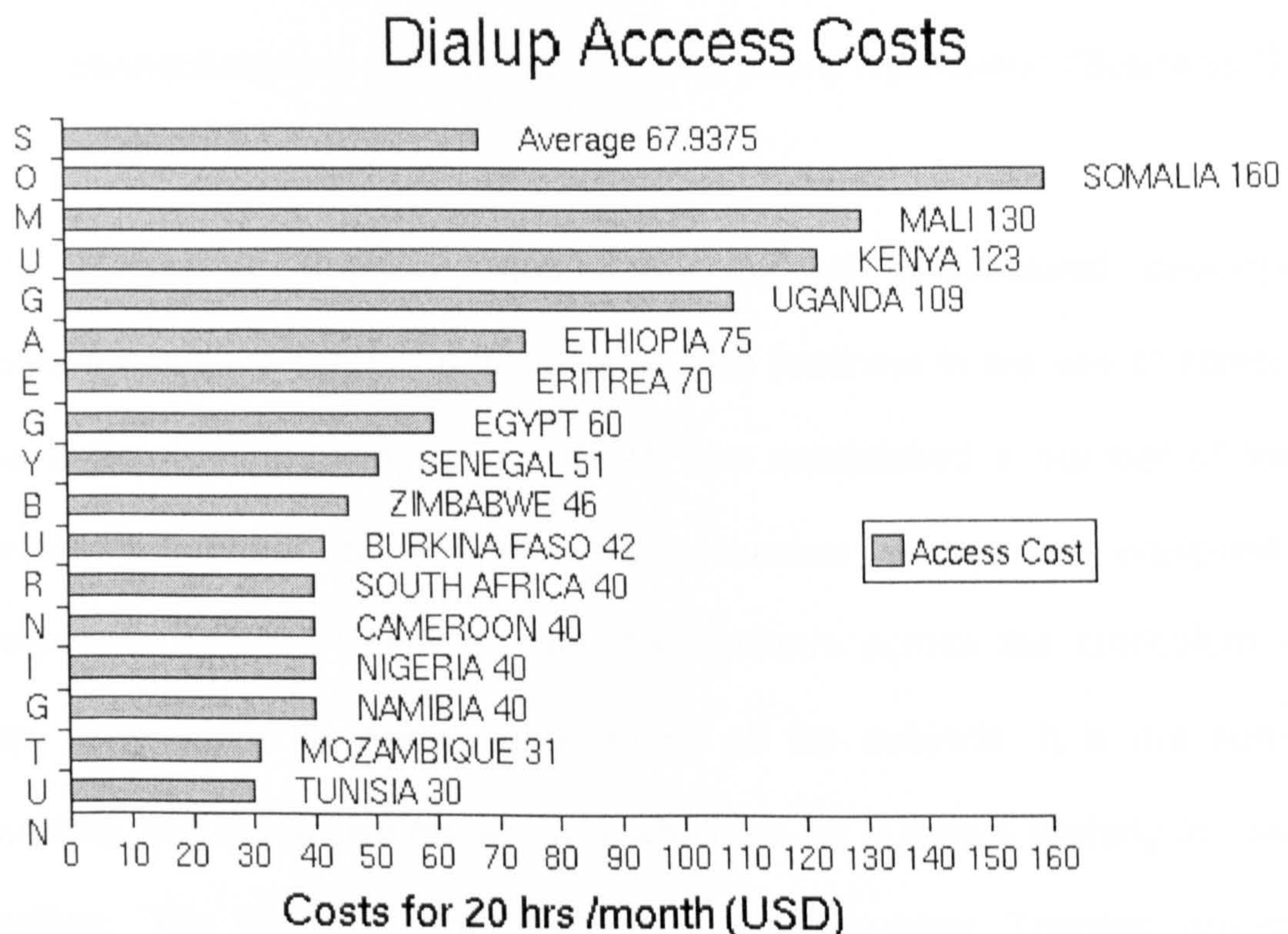


Figure 1.2 Dial-up Internet access costs for Africa (adapted from Jensen, 2003)

With an access density of 1 computer to every 50 people, Zimbabwe is rated as having the 3rd highest Internet access after South Africa and Egypt (UNDP, 2003).

Internet access is also linked to the density of fixed telecommunications networks in a country, as these networks are responsible for providing the Internet services through services such as dial-up and broadband. The Business-guide page on the *New Zimbabwe* website lists typical access problems faced by individuals in Africa as a result of a low tele-density as including:

- a) the cost of Internet connection is usually too high
- b) the Internet connection speeds are very slow, hampered by phone line inadequacies both in number and quality; and
- c) shortage of skilled technology manpower so that the few working connections are over-subscribed and poorly maintained (Business Guide, 2005)

In Zimbabwe, however, two donor funded professional development programmes have taken the initiative to train teachers in the use of computers. The Better Schools Programme (BSP) has established a number of teacher centres throughout the country. These teacher centres are equipped with computers. The BSP centres cater for teachers across the curriculum range from kindergarten to A-level and across all the subjects. It is not surprising therefore that these centres are overwhelmed by teachers wishing to use their facilities. The Science Education In-service Teacher Training programme (SEITT) was run by the University of Zimbabwe. It had 10 resource centres dedicated to the teaching of A-level science and mathematics. Each centre was equipped with some computers and printers. As is the case with the BSP centres, there were more teachers who wanted to use these facilities than could

be supported by the supplied equipment. Both these programmes were funded by the Netherlands government and the funding period ended in 2002.

1.2 Researcher's Background

Having worked as a teacher, and also having worked with teachers on a nation wide scale, I was interested to find out how teachers were coping. In the absence of formal intervention mechanisms for professional development, how do teachers engage and direct their development? What strategies do they use to promote their growth in the profession? What part can information communication technology play in the professional development of science and mathematics teachers?

I was aware that there could have been several avenues for self-directed professional development that teachers could follow, but one avenue in particular lent itself more easily to investigation. As one who had worked to promote the use of computers and information technology among A-level teachers, I was naturally interested in following this lead. In this case information technology is taken in its narrow sense, to mean the use of networked computers to access the Internet or use e-mail or the local area network. Radio communications, cell phone text messaging and other aspects of information communication technology are not part of the study.

1.3 Aim of this research

The diversity of training programmes for A-level science and mathematics teachers as described in section 1.1. implies that these teachers will have very different professional development needs. Zimbabwe being a poor country, has hitherto relied on donor agencies to provide support for teacher professional development. However, support from donors is usually fragmented and

temporary and thus might not be effective (Mushaikwa, 1999). Schools certainly will not afford the expenses involved since they are operating on shoe-string budgets. If teachers need to develop themselves, they have to invest in their own professional development. It is hoped that this research has illuminated the current professional development practices of A-level science and mathematics teachers, especially where they used ICT as their vehicle for professional development. The researcher also hopes that the study paves the way for the development of a model of self-directed professional development and thus added to our understanding of this phenomenon. Such a generic model would be useful in helping education planners and teachers on designing sustainable professional development programmes.

1.4 Layout of this research report

This chapter has described the context of this research and has shown that its inception was motivated by a need to understand how teachers were coping with challenges to their professional development arising from lack of resources, personnel and institutional support. ICT was chosen as a possible vehicle for such a professional development process and the study seeks to find out what impact ICT has had on the professional development of these teachers. Chapter 2 provides the theoretical framework of the study, dealing with the issues of impact, professional development and change processes. Chapter 2 will also set out the research problem, and the research questions in the light of the context just discussed and the literature reviewed. The methodology chapter (3) discusses the design strategy of the study, the instruments used, data collection and its organisation. Chapters 4 through 7 will discuss the data according to the research questions. Chapter 8 will provide the concluding remarks to the study.

Chapter 2: Literature Review

2.0 Introduction

This literature review will explore the rationale behind various continuing professional development strategies in practice. It will examine the impact these strategies have had for practicing teachers. The researcher regards professional development as a process which is dynamic and constantly renewing, as opposed to a linear development.

Section 2.1 provides the theoretical background to the professional development process. Section 2.2 suggests reasons why professional development is viewed as a dynamic process and tries to link the professional development inputs to their outputs, and thus suggests criteria for measuring impact. Some models of professional development are also considered several aspects of the professional development process. Section 2.3 discusses the usefulness of such models in terms of inputs, implementation and output processes. Section 2.4 focuses on the extent to which information communication technology (ICT) has been used as a vehicle for teacher professional development and what impact, if any, ICT has had on self-initiated professional development of science and mathematics teachers. The chapter concludes by summarising issues arising from the literature, to be addressed by this study. Due to the nature of the design of the study (discussed in more detail in chapter 3) it was envisaged that more literature would be reviewed simultaneously with the discussions on the findings (chapters 4-8) to shed light on the interpretations suggested in these chapters.

For the purposes of this study, *impact* is taken to mean the long term effects which manifest themselves in change of teacher behaviour with respect to their

personal and professional conduct. Impact will be discussed more fully in section 2.2.2.

2.1 Theoretical framework

2.1.1 Professional development and change strategies

Vonk defines teacher professional development as:

...the result of a learning process which is directed at acquiring a coherent whole of the practical and theoretical knowledge insights, attitudes and repertoire a teacher needs for everyday practising of the profession. (Vonk, 1991 p.64)

This definition is concomitant with the one posed by Bertani and Tafael (1992) who see professional development as the acquisition of knowledge, experience and skills, and the development of personal qualities for the execution of professional and academic duties that enable the individual member to effectively contribute to the institution and community. The authors recognised three important aspects of professional development: experience, knowledge and skills. They also recognised the need for the professional teacher to be emotionally involved in their profession by developing certain attitudes or as Bertani and Tafael called them, "*personal qualities*".

While Vonk's definition is generalised, Tafael and Bertani are more specific and identify the goals of professional development to be effective service to the institution and community. Thus, according to Tafael and Bertani, there is a symbiotic interaction between the needs of the institution and the professional development needs of the teacher. In other words, professional development is a directed process, i.e. it is goal-oriented. The current study helped to further clarify this relationship (see fig 5.8; page 230).

Butler (1992) on the other hand, sees teacher professional development as a complex interaction between teacher knowledge and the teaching context.

Butler sees teacher knowledge as consisting of four domains i.e. public (theoretical) knowledge, professional (practical) knowledge, personal knowledge (experience, values, attitudes, beliefs) and world view (derived from culture, and tradition). Freire (1970) and Valli, (1997) argue that these knowledge sets interact with the teacher's personal and social contexts. The interactions are defined by a process of action and reflection cycle which ultimately results in professional growth (Dewey, 1933).

All these views of professional development seem to agree on the premise that professional development is multi-faceted and consists of growth and the adjustment of different facets of teacher knowledge to their context. Teachers bring their beliefs, experiences and knowledge about teaching to the learning process and refine these into a coherent and integrated knowledge system (Schon, 1983). This knowledge system is then applied to the teachers' professional practice. Thus teacher professional development is concerned with teachers as learners.

What teachers learn or decide to learn is shaped by what they bring to the professional development process – their concerns as professionals and individuals and the perceived needs of their profession. Thomas (1992), Hargreaves (1994) and Ball (1996) note that modern day professionals work in a climate of rapid change. They need to be flexible in accessing, updating and applying new knowledge to the changing circumstances. Thus creation and assimilation of knowledge becomes imperative and for many organisations, the ability to embed new knowledge is the greatest organisational resource and a necessary part of any career.

Roffe (2000) lends support to this argument by comparing the education system to an industrial concern. Roffe suggests that the accelerating pace of

market and technological change, and the growth of information affect industrial firms and education systems in the same manner. He comes to the conclusion that they both require individuals who are able to take initiative and responsibility for developing activities appropriate to new circumstances. To do this, both industrialists and educators have to keep abreast of developments at the front line, in their field of work. In a society with constantly changing values and needs, professional development is a continuous activity. Professional development aims to keep the professional in touch with unfolding events and developments in their field, so that they keep in pace with the changing demands on their skills, knowledge and professional outlook.

Lange and Burroughs-Lange (1994) view teacher professional development as taking place on two levels: at the pedagogical level, teachers are interested in subject content mastery; at the reflection level, teachers focus on moving from current teaching practice to learning new practical skills and gaining professional knowledge. Professional development is often accompanied by a shift in focus from one plane to the other. Richardson (1990) argues that the shift in focus is often accompanied by changes in teacher belief systems, attitudes and perceptions. For example the shift in focus from content to skills acquisition enables teachers to deal more effectively with changes in their context and results in adaptive practitioners. Marx *et al.* (1998) argue that in any organisation, emphasis should be placed on developing adaptive learners *"...who have skills to attain competence and information when need arises."* (Marx *et al.*, 1998 p.35) Such professionals are well armed to adapt to the constantly changing environment – a situation that is highly desirable for any organisation or industry.

De Feiter *et al.* (1995) believe that the process of continuing professional development is the outcome of a complex interaction between the individual and the various environments in which the individual participates. This means that continuing professional development process is private and personal. Butler (1992) and Jay and Johnson (2002) also argue that continuing professional development has to do with changing personal values, personal attitudes, personal skills and worldviews to accommodate the challenges that emerge from the individual's environment.

The literature provides two major reasons why teachers choose to engage in professional development:

a) A search for additional resources: Teachers realise that richness of thought is made possible by greater diversity and number of resources. The greater their exposure to resources and to alternative pedagogical approaches, the more rewarding they find their work. They consciously seek to construct multi-dimensional models of their professional practice (Thomas, 1992; Smith and Coldron, 1999). The search for variety is a search for enrichment and does not imply that teachers are deficient in any way, but that as adult learners, they have an intrinsic desire to grow within their profession (Schon, 1987; Ball, 1996).

b) Self improvement: Reflective practices and research expose the teacher to a wider universe of resources. Elbaz (1983) suggests that reflection on own practice enables teachers to identify opportunities for learning. Teachers, particularly if they engage in reflective practice, decide on what they want to improve upon, and voluntarily seek ways to pursue their interests. Thus reflective practice may lead to self-directed professional development for teachers. Clark and Peterson (1986) emphasise the crucial role played by thought and reflection in professional development of individual teachers. This

view is also supported by Palinscar and Brown (1986) and Bodner (1986) who argue that teachers have some control over the processes of knowledge acquisition that they use through the reflection on what they know, understand and can do. In the process, Handal and Lauvas (1987) argue, they construct a practical theory of learning which is dynamic and integrated. This theory of learning includes knowledge, experience, and values which are relevant to teaching at any time.

The first reason (gaining access to additional resources) for engaging in professional development given above contributes towards an increase in teacher competence with their subject matter, professional and pedagogical knowledge skills. The second reason (self improvement) focuses on the self-critical and growth oriented aspects of teacher's professional life. A good amalgamation of the two motives would result in individuals who possess an integrated system of content, pedagogy and professional knowledge which gives rise to a new form of knowledge which Shulman (1986) calls *pedagogical content knowledge* (PCK). A discussion of the impact of a professional development strategy on teachers' development should therefore take these underlying reasons into account. In both cases the individual is motivated to participate as a response to an intrinsic challenge, which the individual interprets as a need.

2.1.2 Areas of Professional Development

Two areas of professional development can be highlighted from the preceding discussion. The first area has to do with the teachers' practice in the classroom, and focuses on the pedagogical content knowledge of the teachers, whilst the second area focuses on the issues that teachers raise as being of concern to them. These issues are identified as the concerns that teachers

bring to the professional development process. These two areas of professional development are discussed in more detail below because they were used to provide insights in the development of the data collection instruments used in this research.

2.1.2.1 Pedagogical content knowledge

Shulman (1987) has argued that teachers develop a specific type of knowledge that they use to define effective classroom practice. Shulman defines pedagogical content knowledge (PCK) as:

... that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding...
(Shulman, 1987 p. 8)

This original definition of PCK was further developed by Bullough (2001) who felt that PCK identifies a unique body of knowledge for teaching. For Bullough, PCK was more than just the blending of content and pedagogy to aid adaptation issues, but also took cognisance of the teaching context. Brophy and Good (1986) had determined that students' academic learning is influenced by, among other things, the behaviour of the teacher in monitoring performance and providing feedback, and that these depend on the specific context within which the teaching occurs.

Brophy and Good's most important finding was that teachers' classroom organisation and management has an impact on student performance. Knowledge of classroom management and organisation would constitute what Gess-Newsome (1999) calls *contextual knowledge about the teacher's subject*. Thus contextual knowledge would complement subject content knowledge and teaching skills knowledge that teachers would need to effectively execute their

duties. Further clarifications of Shulman's PCK theory were advanced by Cochran *et al.* who write:

Science teachers differ from scientists not necessarily in the quality or quantity of subject matter knowledge – but in how the knowledge is organised and used. Experienced science teachers' knowledge is structured from a teaching perspective and is used to help students understand, A scientist's knowledge is structured from a research perspective and is used to construct new knowledge. (Cochran *et al.*, 1993 p. 5)

This special type of structured knowledge which is suitable for teaching purposes is what they see as PCK. This knowledge enables teachers to modify, adapt and innovate new teaching strategies to enable students to benefit most from their learning experiences.

Shulman (1986) argues that previous initial teacher education programmes have focused on content knowledge of the teacher. However more recent studies (Ball and McDiarmid, 1990) indicate that the focus has now shifted to pedagogy, sometimes at the expense of content. Studies carried out by Hewson and Hewson (1988) and Cochran *et al.* (1993) indicate that professional preparation of teachers becomes disjointed when pedagogy is separated from subject matter – hence the need for PCK as a separate body of knowledge.

It follows that changed classroom behaviour only results from changed PCK, not from independent changes occurring in subject content knowledge, pedagogical knowledge or contextual knowledge. Thus one desirable impact of continuing professional development will be a change in the teacher's pedagogical content knowledge.

A change in teachers' pedagogical content knowledge can be achieved in one of two ways; firstly, the three areas of teacher knowledge (pedagogical, subject matter and context) may be developed separately and then integrated during the teaching process (Van Driel *et al.*, 2001). The integration process

takes place during the active preparation of teaching materials. For the integration to be successful, teachers need to have adequate skills for action and reflection as these skills will aid in the selection of appropriate learning experiences and knowledge bases. However, Cochran *et al.* (1993) note that it has been difficult for researchers to come up with a suitable model to describe the actual process of implementing PCK in this mode. An added problem has been the difficulty in drawing a relationship between two key elements of PCK: knowledge of subject matter and understanding of specific learning difficulties and conceptions. This point was also highlighted by Carlsen (1999) and Magnusson *et al.* (1999).

b) The second method requires full transformation of the knowledge bases (pedagogy, subject matter and context) prior to the development of the materials for teaching (Van Driel *et al.*, 2001) so that the materials are integrated before being used in the classroom. This alternative would be more demanding for teachers and is best achieved by selecting already existing PCK exemplar materials which teachers can use as a basis for further development (Mason, 1999; Morine-Dershimer and Kent, 1999). This method was used in Zimbabwe for the SEITT materials writing programme. The use of exemplars allows the teacher to move from uncertainty to a more comfortable position in a process akin to the Joyce and Showers model of enabling teachers to gain confidence in innovation (Joyce and Showers, 1988).

Basing his arguments on previous research, Kinach (2002) has summarised the levels of understanding that teachers go through during the course of their professional development. These are presented in the table below:

Level of Understanding	Descriptives	Researcher
Instrumental understanding	Concept level understanding	Schwab (1978)
Relational Understanding	Problem solving	Perkins and Simmons (1988)
	Epistemic level	Wiske (1998)
	Inquiry level	Kinach, (2002)

Table 2.1: Kinach's levels of understanding (adapted from Kinach, 2002)

Kinach concluded that context makes critical thinking and judgements possible. However context can only be applied if the teacher is operating in a natural environment and is challenged and has to respond to that unique environment. Kinach (2002) also argues that the use of exemplars alone will not stimulate teachers to respond to unique environments and therefore transformation used in this manner might lead to instrumental understanding of teaching rather than deriving relationships. Thus teachers will simply use exemplar materials without critical engagement and reflection. Such a process will not lead to adaptation.

Both approaches described above are biased towards PCK relationship with subject matter and do not address the other two knowledge areas. In fact, Van Driel *et al.* (2001) argues that the key to identifying the knowledge base of teaching (PCK) lies in the intersection of content and pedagogy – i.e. the capacity to transform the content of subject matter knowledge into pedagogically responsive patterns of behaviour. However Cochran *et al.* (1993) believe that professional knowledge and contextual knowledge (i.e. teachers' personal knowledge, and social knowledge) should be given more attention. Argyris and Schon (1974), Scholz (1995), and Peterson and Treagust (1995) emphasize that teachers' beliefs also play a decisive role in ensuring that change in teacher behaviour is sustainable.

Morine-Dersheimer and Kent (1999) further argue that by ignoring contextual matters, earlier researchers rendered PCK unreliable as a knowledge base system because practicing teachers' decisions and actions are greatly influenced by their context-specific pedagogical knowledge. Kennedy (1991) suggests that as part of contextual knowledge, experience plays an important role... "*..Learners impose meaning on learning situations on the basis of their prior knowledge,*" (Kennedy, 1991 p.2). Feiman-Nemser and Remillard (1995) expand this view to include teachers as learners. They contend that how teachers were taught as students, how they viewed knowledge, and how they envisioned their role as learners play a powerful role in shaping their professional beliefs and teaching.

Wills (1998) emphasises the need for professional development programmes to respond to different levels of interest, skills and knowledge amongst staff and the need to realise how these needs change as staff move through different levels of need and ability. These arguments also seem to indicate that a model for continuing professional development would need to address the personal context of teachers.

The concept of PCK seems to ignore the psychomotor and affective domains in Bloom's taxonomy (as outlined by Krathwohl, 1964) by ignoring the important role that feelings, values and beliefs play in motivating teachers to become effective. Gess-Newsome (1999) however, argues that the PCK model is primarily a knowledge / cognitive model and should not be taken as an end-all in teacher education programmes. Nevertheless, Hord *et al.* (1987) indicate that development in other areas is also required as a pre-requisite for teacher professional growth. It is difficult to use the PCK model to identify teacher needs, though in theory it is possible. This is because PCK has been developed chiefly

as a model to assist the training of pre-service teachers (Shulman, 1986; Gess-Newsome, 1999; van Driel *et al.*, 2001) although some attempts have been made to use it in continuing professional development programmes (Kinach, 2002).

2.1.2.2 Teacher concerns

Another area of professional development that researchers have identified as being important for teachers is the area of teacher concerns. Several researchers, among them, Loucks-Horsley *et al.* (1996) and Monk (1999), have identified different models to describe teacher concerns. Monk, (1999) describes the Phases of Concern Model which categorises teacher needs as follows:

- (i) Concerns for security: – where teachers identify themselves as subject specialists. Teachers who operate at this level are interested in improving their subject content mastery so that they can gain confidence to explore new ways of presenting their work. The concern here is with teachers' understanding of the content.
- (ii) Concerns for methodology: – where the teacher is the classroom practitioner. Teachers who operate at this level are interested in improving their classroom management. Better methodological approaches are associated with better student discipline and better student engagement. The concern is with classroom management and task organisation, as well as student learning outcomes.
- (iii) Concern for aims: – Where teachers are professionals and reflect on whether they are meeting the goals of the curriculum and the expectations of the society. Teachers who are operating at this level of

concern tended to look holistically on the curriculum and thus decided on the best skills and approaches required in order for students to meet the goals of the curriculum.

These concerns are directed at the three anchors of pedagogical content knowledge – which are subject content knowledge, pedagogical knowledge and contextual knowledge. Marx *et al.* (1998) feel that professional development takes place in a context and therefore necessarily involves collaboration with colleagues. In other words, the professional can only develop meaningfully, when in interaction with others. This is because professional knowledge and competence are distributed far wider than any individual teacher's professional or social network and therefore access, through one's peers, to widely distributed knowledge is essential.

Bell and Gilbert (1994) go one step further and advocate that professional growth should improve the performance of the individual teacher as a professional, as well as a member of a professional group of teachers. Hargreaves and Dawe (1990) summarised these view points by proposing that one focus of professional development should be on building individual expertise, and the other focus should be on community / group expertise.

A growing body of evidence points to the fact that formalised and impersonal professional development initiatives are not sustainable (Russell and Bradley, 1997; Roffe, 2000). Instead Smith and Coldron (1999), and Bowskill *et al.* (2000) contend that the key to professional development is engagement in a continuing process of adjusting professional identity. Professional identity is taken to include the sum total of factors of growth within the profession, challenges and expectations, needs and concerns.

Professional engagement does not have to consist of face-to-face interaction with another professional's ideas and views: e-mail and Internet based activities can be equally effective for teachers' professional development.

As mentioned earlier, many in-service and staff development programmes in the past were mostly concerned with subject content upgrading. However, Dienne (1987) showed that assisting teachers to understand the nature of their work rather than just the content, was also an important function of staff development. Dienne's findings were corroborated by Bax (1995) who discussed the principles of *content negotiability* and *transferability* in professional development. Content negotiability is a departure from traditional continuing professional development practice in that the staff developer determines the form of professional development, but the teacher decides on content to focus on. In other words, the staff developer shows the way how, and the teacher decides what and how far. The principle of transferability places emphasis on the acquisition of transferable skills. Transferable skills refer to those basic skills that enable teachers to acquire knowledge and information on their own – skills such as those required for action research and reflective practice. The argument is that teachers, as adults, should be able to act as resource persons for each other. The task of the staff developer is essentially that of facilitator (Alexander, 1999).

2.2 The professional development process

Clark and Peterson (1986) and Bailey and Palsha (1992) assert that professional development has been used mainly as an agent of change in teaching and curriculum development. External interventions (in-service education) have been used to stimulate and mandate change. This is done in the belief that investing in skills training and other professional development

strategies will result in quality change in classroom practice. Zeegers (1994) indicates that indeed teachers claim most formal professional development programmes have used quality change in classroom practice as indicators of desirable outcomes of the programmes. Thus continuing professional development is seen as a change process by both the teachers and the staff developers.

However Corrigan *et al.* (1986) convincingly argued that initial teacher education programmes which are followed by episodic in-service training designed to implement policy initiatives were found to be largely ineffective and insufficient to sustain the life long professional development of most teachers. They thus argued for a more sustained continuing professional development strategy. Butler argues strongly for professional development programmes that include aspects of reflection which act as *"a forum for decision making that results in considered action in the teaching context (or professional practice)... it acts as a forum for interaction between elements that lead to understanding and growth"* (Butler, 1992 p.223).

Butler further argues that teachers benefit most from processes that build upon and value existing understanding and knowledge. This can be achieved by assisting teachers to take responsibility for their own self development through action and reflection processes. Teachers who engage in self-directed professional development can be said to be meeting these criteria for sustained professional development. Research is therefore needed to illuminate the stimulus of such processes among these teachers. Richardson (1990) supports this view by suggesting the need for research directed at identifying teachers' beliefs and mental processes as a key to understanding how teachers progress

from novice teachers to expert masters. By focusing on teachers' perceptions, this current study aimed at illuminating these processes.

2.2.1 Inputs, Implementation and Outputs

Figure 2.1 summarises the process of continuing professional development. This process is characterized by four stages, i.e. inputs, strategies, outputs and impact.

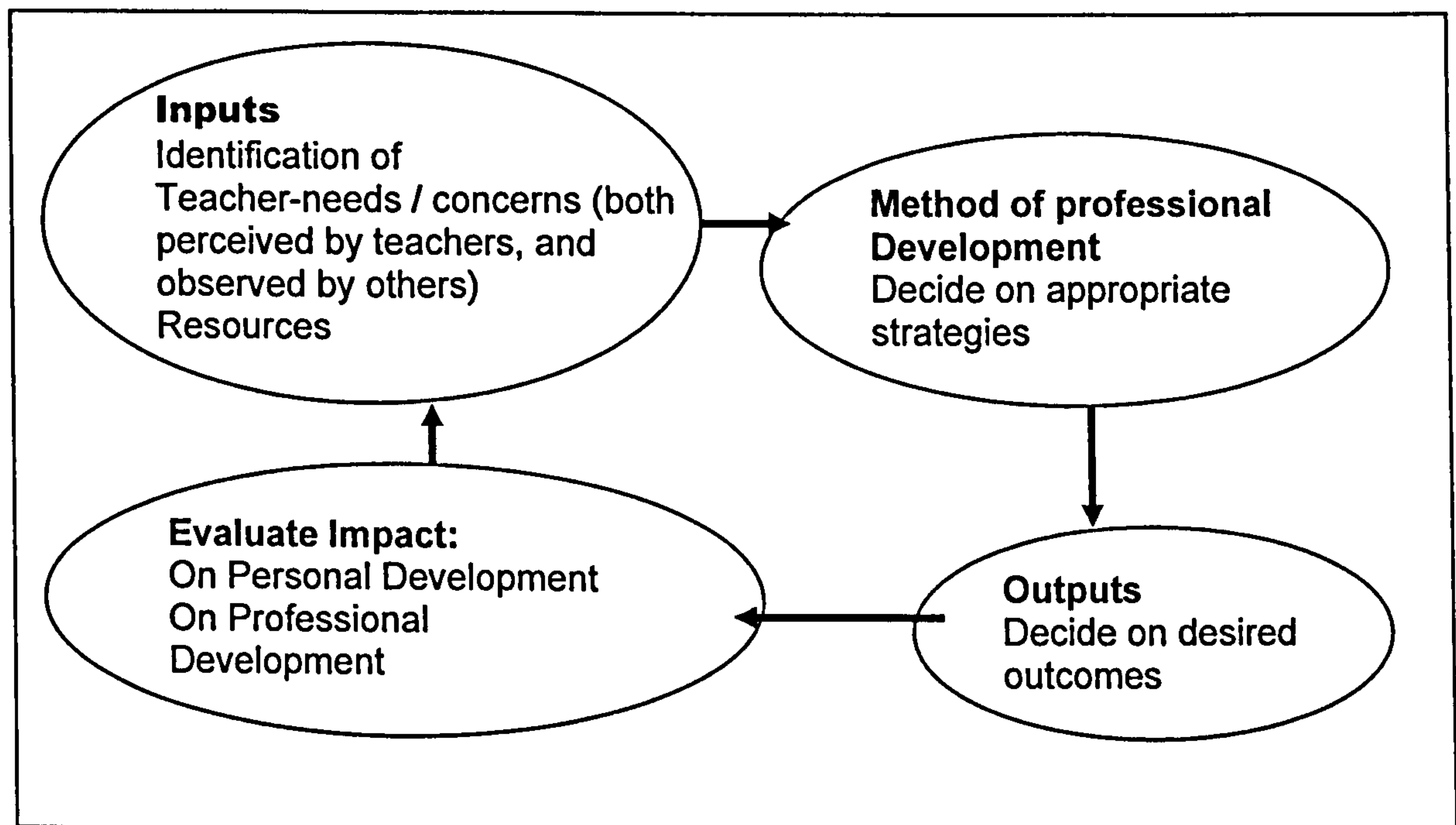


Figure 2.1: The professional development process

Teacher participants and staff developers bring to the professional development process their concerns, experiences and resources. These are made to interact through the use of professional development strategies such as workshops, or peer coaching. The interactions result in some positive (or negative) outcomes such as enhanced understanding of a particular teaching procedure or the acquisition of a new teaching skill. Acquisition of a skill in itself is no guarantee that the skill will be used in the classroom. Its use will depend on other contextual factors such as an enabling environment. In the same vein, non-use of a skill does not necessarily mean that the skill is lost, it may be

manifested in other spheres of teacher knowledge while the teacher is awaiting an opportune moment (such as availability of materials) to enable its use. Thus Impact should not be limited only to classroom behaviour, but also to an assessment of other areas of teacher behaviour utilizing personal knowledge growth and social knowledge development.

Teachers' concerns are highly personal and provide motivational influences on the participants thus helping them to go through the professional development process (Horsley and Loucks-Horsley, 1998). Hall *et al.* describe concerns as "*composite representations of feelings, preoccupations, thought and consideration given to particular tasks.*" (Hall *et al.*, 1986 p5)

The extent to which teachers are concerned about their practice, or want to see change in their practice, will determine how useful the outcome of the change process will be for them. Positive outcomes do not necessarily result in the desired impact. Some outcomes are measured against the objectives of the continuing professional development intervention and are in part, determined by the strategies used by the change agents. Chambers (2001) sees change as a measure of how far the desired outcomes have become part of the teacher's repertoire or integrated into the practice of the teacher. For example, in section 6.1.2.6 (page 274) teachers discussed how they used the idea of engaging children in active learning tasks using the "Prediction, Observation, Explanation" (POE) model. Using appropriate strategies, teachers may indeed master the skills required to implement this model. However, the local context in the school and the teaching environment may well require them to forgo any thoughts of implementing the model in the classroom. Though the professional development programme may be judged to be a success, it might thus have little impact on classroom practice.

2.2.2 Measuring Impact

Kinder *et al.* define impact as “*actual adaptation of practice or content at classroom level*” (Kinder *et al.*, 1991 p49). The definition can be broadened to include adaptation of practice at professional level as well.

Impact studies have been carried out in professional development, by Reeves *et al.* (2001) and Chambers (2001). The studies concluded that impact on practice was influenced by two main factors: the practitioners’ perception of their school context, and how the practitioners visualised / perceived the important issues in their practice. Perception of school context could inhibit or facilitate teachers’ implementation of skills learned during professional development activities. For example, Johnston (2000) found that some trained Resource Teachers in Zimbabwe used transmission methods of teaching despite the fact that they had undergone a two-year postgraduate course which emphasized the use of active learning strategies in teaching, and despite the fact that as Resource Teachers they were running workshops for their peers to promote active learning strategies. When asked to explain why their training had not seemed to have an impact on their teaching, the Resource Teachers cited pressures arising from the expectations of their students, and the school curriculum which was examination driven – thus underlining the importance of context on the impact of professional development.

Teachers’ perceptions of issues important to their practice, influence their selection and prioritization of professional development activities. Doyle and Ponder (1978) also visualised this aspect of *impact* as having components of validity and practicality. By *validity* the authors referred to methods of ascertaining that the system studied actually achieved its aims. For example, one way of determining the impact of ICT on teachers’ professional

development would be to ascertain whether the teachers actually and consistently used ICT in ways that were relevant to their professional development. It would also be important to determine how widespread this use of ICT was across the teacher population studied. The problem with the notion of validity however, is the fact that it is difficult to determine a measure of consistency in the use of ICT for example. For example, in trying to determine to what extent ICT is used by teachers, one would have to also define some arbitrary measures of consistency.

By *practicality*, Doyle and Ponder referred to the usability of the outcomes of the teachers' ICT activities to their professional development, when compared with, for instance, practical constraints they had to overcome to access the ICT. Usability can also be linked to how the activities fit in with the teachers' perceptions of their needs, ambitions, attitudes and beliefs i.e. how the use of ICT contributes to the teachers achieving their personal goals. Practicality, thus defined, involves three sub-concepts:

- a) Instrumentality – the usefulness of ICT (in this case) to provide the teachers with exemplars of the intended resources or activities such as lesson plans, worksheets or guidelines which can be tried out in a real situation. This would provide teachers with the confidence to accept and use the resource materials or ideas. This seeks teachers' impressions on the usefulness of the ICT materials that they obtained *vis a vis* their targets.
- b) Value congruence – providing a fit between the values held by teachers about their practice and the values transmitted through the use of the ICT packages. Value congruence is also affected by the teachers' perceptions of the credibility of the resources' origin. Thus if materials are perceived to present erroneous content, or seem to originate from dubious sources, teachers

are most likely to reject their use. In this study, the researcher also sought to understand how teachers aligned their use of ICT to their values and beliefs about their profession.

c) Cost-benefit analysis – teachers also make mental comparisons between investment and perceived benefits. Figure 2.2 below shows a typical implementation curve subjected to cost-benefit analysis.

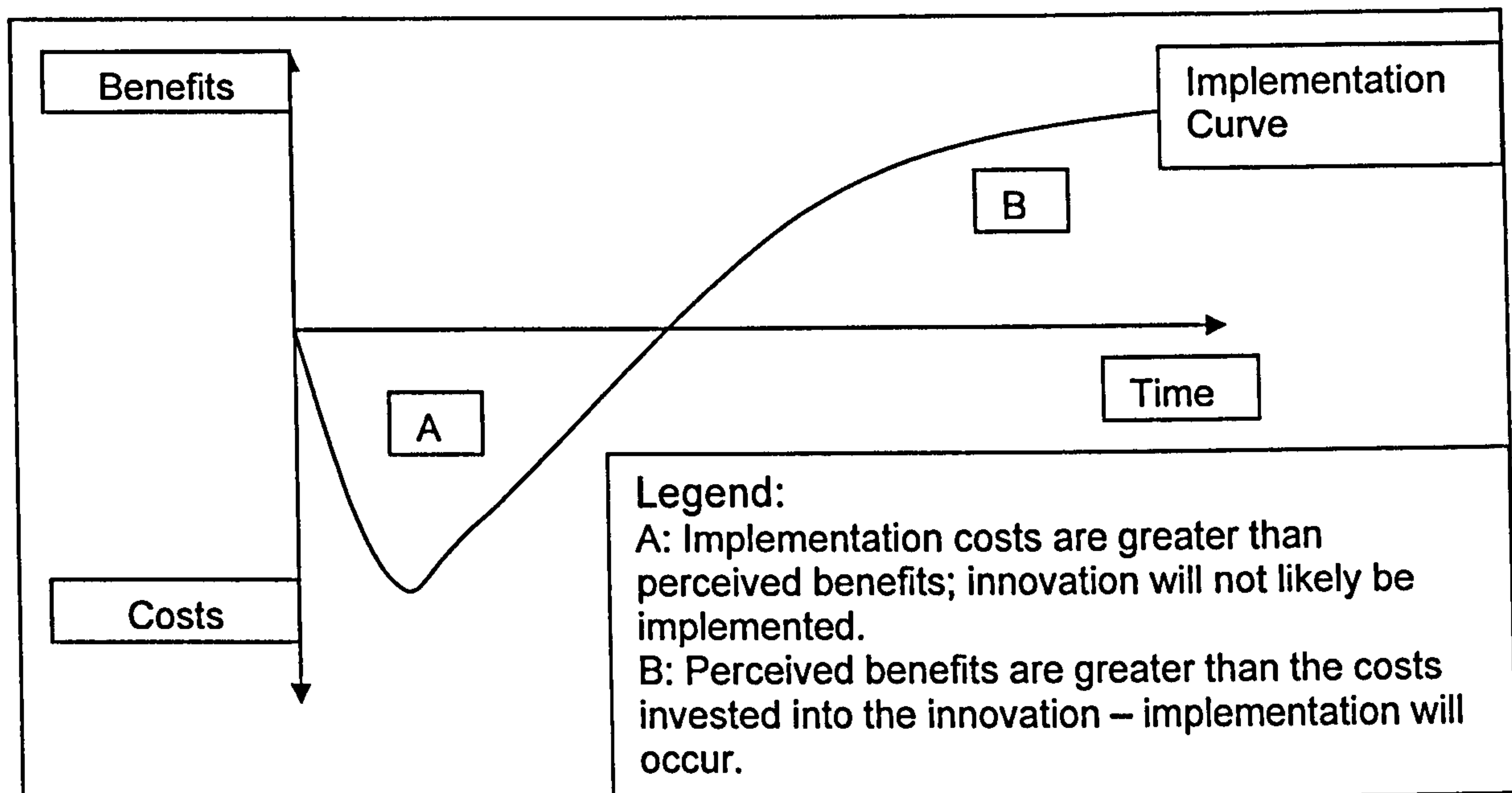


Figure 2.2 Implementation curve showing the cost-benefit analysis (adapted from De Feiter *et al.* 1999)

The curve is measured over time because teachers understand and accept that the benefits of an innovation take time to become apparent. However, the time taken in region A is an indication of the viability of the intended innovation. More investment is put in the activity, than the benefits accrued. Activities that have high input costs but yielding low benefits are not likely to be implemented. In terms of self-directed professional development, teacher satisfaction with the outcomes of the process would be an indicator of cost-benefit analysis. Doyle and Ponder (1978) argue that teachers make these comparisons on the basis of financial expenditure, effort, time, satisfaction, learning outcomes, and peer recognition. In the ideal case, teachers want low investment yielding high

results, i.e. shorter time in “A” and longer time in “B”. This research had to establish what investments teachers were prepared to put into the use of ICT for professional development and what benefits they derived from these activities. What did the teachers think about these benefits – were they worth the investment?

2.2.3. Importance of Context

The context of the teacher cannot be ignored in continuing professional development, for as Morine-Dershimer and Kent (1999) note, teachers’ actions are determined by physical resources and classroom resources as well as by the teacher’s circumstances. Lambert and Clark (1990) and Prawat (1991) also argue that ways in which teachers acquire and use knowledge are contextual, interactive and speculative. Well meaning initiatives may fail to be implemented because they are found to be incompatible with the teacher’s context. Hence Monk (1999) advocates for locally authored, teacher driven professional development initiatives where teachers act as equal partners and assist each other as colleagues. Similarly, Ball (1989) argues that reflective analysis by teachers, of their professional development contexts and own practices, can provide a robust understanding of innovations. Professional development is more likely to succeed if it operates in a social context. Hargreaves and Dawe (1990) summarized the advantages of a social context as including:

- a) Opportunity for teachers to gain access to new information through interaction with others;
- b) Clarification of ideas through self expression;
- c) Examination of different ways of carrying out reflective practice;
- d) Providing support for teachers working with new innovation;

- e) Willingness to experiment with new ways for which they may not be very skilled, by imitation and collaboration;
- f) Conviction and courage to take risks in implementing innovations.

Whilst, the use of formal professional development strategies could result in teachers finding more effective ways of identifying and dealing with issues in their professional lives, Guskey (1989) and Reeves *et al.* (2001) found short programmes to be less effective in bringing about long term perceptual change in teachers' practice. Since perceptions reflect teachers' concerns and needs, and they bring them along to any professional development activity, these concerns and needs can be regarded as teacher inputs. On the other hand, framing important issues about teachers' own practice requires that the teachers make sense of their practice by extending and expanding the meaning of what it is to be a teacher. This sense-making therefore becomes the targeted outcome of some professional development programmes (Shulman, 1987; Bell and Gilbert, 1994; Weick, 1995). Chambers (2001) highlights the importance of appropriate strategies in bringing out desired outcomes and long term impact on practice.

2.3 The Use of Models in Professional Development

2.3.1 Introduction

Most evaluations of continuing professional development strategies limit their focus to strategies used for promoting formal interventions. Evaluators in some cases use these planned and formal continuing professional development programmes to design models to assist in the evaluation of the continuing professional development process. For the purposes of this review, a *model* was taken to mean a theoretical construct that assists in the organization of knowledge about a specific aspect of professional development (cf. Bell and

Gilbert, 1996). For example, an *input model* was used to refer to how professional development inputs were organised with a view to aiding understanding about how these inputs affected the professional development process.

The literature search has not yielded any models that have been specifically developed to illuminate deeper understanding of how self-directed professional development processes might take place. A keyword search for the various terms used in professional development was carried out using the three major literature databases (ERIC; BEI and AEI) with a view to understand how these terms have evolved in the research literature. ERIC records go as far back as 1966 but contain records which were originally published in the 1930s. While British Education Index (BEI) and Australian Education Index (AEI) records go back as far as 1975, but they also contain records of literature published as early as the late 1940s. Table 2.2 shows the various records on professional development which are kept with the three databases.

Database	No of Records	Earliest Publication
Australian Education Index		
Action Research	1551	1978
Professional Development	5233	1948
Continuing professional development	131	1985
Self-directed professional development	7	1992
British Education Index		
Action Research	691	1973
Professional Development	1296	1976
Continuing professional development	127	1987
Self-directed professional development	2	2000
ERIC		
Action Research	3890	1938
Professional Development	18995	1966
Continuing professional development	408	1966
Self-directed professional development	14	1979

Table 2.2: Major database records on professional development

Although the term *self-directed professional development* has existed for some time, research in this phenomenon is still in its infancy. Even considering for example, that alternative terms are used by researchers (such as self-driven or professional growth), the point is that there are still very few research publications on these topics. The sparsity of research publications on self-directed professional development extends to the use of models for this phenomenon.

There are however, some models that are regarded as generic and which are said to work equally well in any professional development situations. Five of these models are discussed below. These have been selected because:

- i) They are the most commonly used models in southern Africa, thus their relevance to the southern African context has already been tested. (cf. SEITT, 1996; Engels, 1996; Monk, 1999; Mushayikwa *et al.*, 1999; AIEMS, 1996).
- ii) They lend themselves more easily to analysis because they are more widely used in different professional development contexts;
- iii) They can be readily applied to self-directed teacher professional development.

The models have been grouped into three groups: *input models*, *process models* and *output models*. In this review, *input models* are taken to describe those strategies that focus on teachers' needs or perceptions of needs, concerns and resources that are used in the intervention. These needs are usually manifested in the aims of the continuing professional development programme and also in the project documents i.e. if the intervention is a planned programme. *Process models* will be taken to refer to the implementation strategies actually used. The strategies are usually outlined in

the programme document or the structure of the programme. The term *output models* is here taken to refer to the strategies used to evaluate intervention outcomes. Output models are usually linked to inputs in behavioural terms, so that the input statements are expressed in the form of “*wish*” lists. The outcomes then measured the extent to which the “*wish*” has been realized.

The models selected are: Teacher Career Stages (Steffy, 1987); Concerns Based Adoption Model (Loucks-Horsley *et al.*, 1998); Professional Development Model (Joyce and Showers, 1988); Typology of Inset Outcomes (Harland and Kinder, 1997) and Teacher Development Model (Bell and Gilbert, 1996).

2.3.2 Input Models

The input models selected are the stage models for Teacher Career Stages (TCS models), (Steffy, 1987; Vonk, 1991) and the Concerns Based Adoption Model (CBAM), (Horsley and Loucks-Horsley, 1998)

2.3.2.1 Teacher Career Stages

The TCS models for career and professional development are many and varied. However, they all arise from the realization that professionals pass through definite stages in their careers and each stage is associated with specific needs and concerns. The models are mainly of two types, i.e. *chronological-experiential* models (e.g. Vonk, 1991) which look at the maturity of teachers or professionals as they gain experience through years of service, and the *motivational* models (Steffy, 1987) which look at teachers’ affective states as powerful incentives to professional development. Because this study explored teachers’ reasons for engaging in professional development, motivational models were chosen for further analysis.

Several researchers in the late eighties e.g. DeMoulin and Guyton (1988) and Steffy (1989) argued that professionals go through specific stages in their career development. They cited several stages of career from the entry point, right up to retirement. For example, Steffy claims that her career stages of professional development are readily observable and individuals at various stages will respond differently to professional development initiatives, because each career stage has specific professional development needs associated with it. The transition from one stage to another is largely influenced by contextual and professional demands upon the teachers. For example, enthusiasm in beginning teachers can be nurtured by the environment (school and classroom ethos, professional development activities, peer support) to produce expert masters.

De Feiter *et al.* (1995) report a similar model (Vonk's Model) for teacher professional development. However, this model looks at the historical progression of teachers from the point of entry to retirement. The two models are similar in structure, but differ in the motivational aspects for teachers' behaviour at the various career stages. Vonk puts implicit faith in teachers as professionals. Vonk recognises experience as a large contributor to expertise. In contrast, Steffy recognises that some teachers enter the profession as a stop-gap measure, and that many more are disillusioned by teaching and "want out". Steffy therefore argues that experience on its own is unlikely to produce teachers who want to grow within the profession, but may actually produce tired teachers who are simply looking forward to retire.

Table 2.3 below summarises Steffy's model of Teacher Career Stages. According to Steffy, lack of support can magnify the initial trepidation in

beginning teachers to the point where they lose confidence and slide into initial withdrawal.

Stage	Description	Characteristics
1	Beginning / Entry Level	Enthusiasm, Trepidation Excitement
2	Expert Master	Exhuding confidence Subject / discipline mastery Peak period for innovations and creativity
3	Initial Withdrawal	Loss of confidence, Discouragement Loss of steam
4.	Renewal Stage	New vigour, New vitality, New hope Cautious
5	Deep Withdrawal	Disillusionment, Disorientation Apathy / dejection, Lack of interest
6	Exit	Dismissal, Retirement, Retrenchment, Resignation

Table 2.3: Steffy's Model of Teacher Career Stages (Steffy, *et al.*, 2000)

If the situation is not arrested in time, the teachers might slide deeper into deep withdrawal and start actively looking for a way out of the system. However, if an effective intervention is employed at the initial withdrawal stage, confidence may be restored and the teacher becomes a renewed professional, with new hopes and vigour.

Steffy (1989) also claims that a change in the curriculum demands, e.g. in examination requirements, can result in expert masters losing confidence and sliding into initial withdrawal. This may be the case where the change results in demands for a major adaptation of teaching for which the teacher has not been adequately prepared.

Steffy's model seems to focus on reasons for teachers to participate in continuing professional development, and also on possible outcomes of such continuing professional development on the teachers' professional satisfaction.

An outsider can determine the career stage of continuing professional

development clients reasonably well using this model – so the model could be useful to planned and formal continuing professional development initiatives.

Research findings seem to support Steffy's model. In fact, Monk (1999) notes that teachers bring differing biographies to the classroom, and therefore have different in-service needs. Crossley and Guthrie (1987), suggest that teachers resistance to new innovations is not due to overall conservatism or irrational resistance to change but because the innovations create a dichotomy between their classroom practice and general expectations from stakeholders, such as the examination system, parents and students. The teachers rationally weighed the expected advantages of implementing the various alternatives. In professional development terms, they carry out a cost-benefit analysis (De Feiter *et al.*, 1995) and if the cost weighs much more than the perceived benefits, they will not support the implementation of the innovations.

Steffy's model has been applied extensively in Zimbabwe by the Science Education In-service Teacher Training (SEITT) programme to identify potential "Resource Teachers" who would work as mentor teachers and facilitators in the regional resource centres (SEITT, 1996; Ndeya-Ndereya and Mushayikwa, 2000). On-line professional development can also be linked to Steffy's model. This means that impact of ICT on professional development can be analysed using the model. Table 2.4 revisits the Steffy's model, highlighting, ICT-based continuing professional development interventions that have been reported by researchers at each stage.

As can be seen in table 2.4, research indicates that ICT as an intervention strategy, has been used to address most of the concerns raised by the TCS models.

Stage	Teacher Concerns	Suggested Interventions	ICT contribution Reported by
Entry / Beginning Teacher	<ul style="list-style-type: none"> • Content knowledge mastery • Curriculum depth coverage • Methodology 	Workshops Content upgrading Courses / Virtual University Guidance Mentoring / Coaching	Thompson, 1997 Wild, 1999 Preston, 2001
Expert Master	<ul style="list-style-type: none"> • New innovations • Expanding repertoire of skills • Trying new ideas 	Materials development Action Research Individual independent study Networking	Russell <i>et al.</i> , 2000 Rowntree, 1997 Marx, 1998 Hammond, 1998 Van der Wal and van der Linder, 1991
Initial Withdrawal	<ul style="list-style-type: none"> • Motivation • Confidence 	Peer mentoring Online community of learning / INSET Virtual University Networking	Preston, 2001 Ribbins and Burrige, 1994 Hammond, 1998 Laurillard, 1993
Renewal	<ul style="list-style-type: none"> • confidence • Increase in pedagogy skills • Deepen subject mastery 	Mentoring Networking Workshopping Peer Coaching Conferencing	Preston, 1999 Tambo, 1999 Hammond, 1998
Deep withdrawal	<ul style="list-style-type: none"> • Apathy • Negative attitudes 	Accreditation Motivation Open Learning New empowerment	Twining, 2002 Thompson, 1997
Exit	-----	-----	-----

Table 2.4: ICT and Steffy's Career Stages model

Although Steffy's model of career development stages offers a useful tool for analysing teacher professional development, the tool is a bit unwieldy because at any one moment teachers can exhibit one or more characteristics for the different stages. For example, a physics teacher may exhibit expert master characteristics (exhuding confidence and mastery of subject content), and yet at the same time be dissatisfied with teaching, its conditions of service and general well being (withdrawal).

2.3.2.2 Concerns Based Adoption Model

Another model which deals with teachers concerns as inputs into the professional development process, is the Concerns Based Adoption Model

(CBAM) developed in 1978 by Hall and Loucks (1978). This model combines Fuller's Stages of Concern model (Fuller, 1969) with another model called "*Levels of Use*", which describes how a new innovation is integrated into the existing repertoire of the teacher, and applied to the teaching task. The third component of CBAM is the innovation component, which identifies change components using what are called "practice profiles".

Fuller's Stages of Concern model has seven hierarchical concerns which range from *awareness* (stage 0) which describes an individual who is just coming into contact with an innovation, but not having a specific interest in its educational or professional value - to *refocusing* (stage 6), where the individual realizes the maximum benefits to be gained by the innovation. The *stages of concern* components of CBAM are summarized in table 2.5 below.

Stage	Characteristic	Description	Category
6	Refocusing	Impact is shown in terms of the implementation with students, value congruence and extensions of the original idea / innovations to create better models	IMPACT on Practice
5	Collaboration		
4	Consequence		
3	Management	Some concerns expressed include time spent on preparation, implementation etc., skills to be learned, and materials resources available	Task
2	Personal	The individual seeks to find out how the innovation will affect their teaching and general execution of duties	Self
1	Informational	The person seeks additional information about the innovation.	
0	Awareness	The person is not aware of the innovation, or is aware, but not interested in initiating change	Awareness

Table 2.5: Concerns Component of CBAM (adapted from Bailey and Palsha, 1992)

CBAM describes these stages in terms of impact on practice and contracts the seven stages of concern into four major categories for analysis. CBAM

categories range from *awareness* – which corresponds with Fuller’s first stage – to *impact on practice*, - which combines Fuller’s stages 4 to 6.

The second component of CBAM describes how the innovation / change is undertaken. It describes behavioural changes that are expected to take place as the teacher embraces innovation in teaching or professional practice. This component is aptly named “*the levels of use*” and is useful in distinguishing between users and non users of innovation. Table 2.6 provides a summary of the structure of the levels of use component.

Level	Characteristics	Behaviour	Category
VI	Renewal	Seeks more alternatives to the established use of the innovation	USER
V	Integration	Deliberately seeks others ideas and opinions on the innovation use	
IVB	Refinement	The teacher now assesses the effectiveness of the innovation (impact) and makes additional changes to make it more effective.	
IVA	Routine	A pattern of use has been established, and the teacher is comfortable. Fewer changes are being made.	
III	Mechanical	The implementation of the innovation is poorly organized. The teacher makes numerous changes to better organize themselves	
II	Preparation	The teacher prepares to use the innovation	NON USER
I	Orientation	The teacher seeks more information about the innovation	
0	Non use	The teacher takes no action with regard to the programme / innovation	

Table 2.6: Levels of Use of CBAM (adapted from Horsley and Loucks-Horsley, 1998 p.17)

The levels of use, map onto seven behavioural modes, from non-use to renewal. These seven levels correspond to the seven stages of concern

described above. For example, Level 0 (none use) corresponds with the stage 0 described above: i.e. the teacher maybe aware of the innovation, but has not yet started using it. Similarly, level VI (Renewal) corresponds with stage 6 (Refocusing) where the teacher experiences rejuvenation as a result of engagement with the innovation. The seven levels are further compacted into two major categories for describing *users* and *non-users*. Thus teachers operating at levels 0 to II are regarded as non users. Levels III to VI describe the degrees to which the innovation is put to use.

The third component of CBAM, i.e. *Innovation components*, provides tools for staff developers to manage professional development programmes. Loucks-Horsley *et al.* (1998) describe what they termed a *practice profile*, which divides the behaviour under scrutiny into three categories: *Ideal* - what is aspired towards; *acceptable* - behaviour that can be passed off as a fair representation of the change aspired towards and *unacceptable behaviour* – that signifies that the innovation is having no impact on professional practice – this could be exemplified by the maintenance of the status quo.

Loucks-Horsley and Stiegelbauer (1991) contend that their research into CBAM demonstrates that educational change is a process rather than a one-off event. CBAM enables researchers to keep track of the change process within any professional development initiative. In addition, since CBAM deals with teacher changes that are taking place at the individual level, it reinforces the idea that professional development change is highly personal and developmental and underlines the need for incremental support. CBAM as a model can be used to evaluate impact of professional development on a teacher's PCK, as it focuses on teachers' personal concerns, level of use and innovation profiles.

The two models discussed above (Steffy's Career Stage Model and CBAM) are concerned with teachers' concerns. The former identifies the likely source of the concerns and argues that if one is planning an intervention programme, one has to align it to the possible source of concerns, for the intervention programme to have a chance of succeeding. Another important observation is the tacit assumption that professional development is continuous but, as in Steffy's case, is moderated by the teacher's career stage. In contrast, CBAM looks at the concerns that are inherent throughout the process of the intervention. It provides a tool for determining the impact these concerns might have on the successful adoption and integration of the innovation for use by the practitioner.

2.3.3 Process Models

One model that is used extensively in southern Africa, to implement professional development programmes is the Professional Development Model (Joyce and Showers, 1988). The Professional Development Model uses procedural levels of professional development. These are presented in table 2.7:

Category	Description
Presentation Of Theory	New knowledge and skills are imparted in a presentation or exposition
Demonstration	The application of the new knowledge and skills is then demonstrated for all participants by the facilitators
Practice in a reduced setting	The participants are allowed to work in small groups and practice the skills or applications of the new knowledge.
Peer Coaching	The groups are able to critique each other and offer assistance collaboratively in a collegial manner
Actual Practice	Participants then implement the innovations in their own classrooms.

Figure 2.7: Professional Development Model (adapted from Joyce and Showers, 1988)

The SEITT Systemic Model in Zimbabwe is an amalgam of the Professional Development Model and the Cascade Model (see Mushayikwa *et al.*, 1999). Research has shown that the Professional Development Model is very effective when used to design an intervention strategy for planned professional development (Bradshaw, 1997). In the United States, the model was used to demonstrate the importance of incremental professional development (NASSP, 1995). NASSP was able to show that the level of impact increased with the increase in the number of categories that were applied in the staff development programme. The model is particularly effective where manipulative skills and higher order operations are acquired (Mushayikwa *et al.*, 1999).

The Professional Development Model has not been tested for self-directed professional development, and indeed some of its categories would appear to be difficult to implement especially in an ICT-based, self-directed professional development process. For example, the key categories of Demonstration and Peer Coaching require hands on / face to face instruction.

However, Preston's study (Preston, 2001), shows that the Joyce and Showers model can also be applied to ICT classrooms. In addition, the research of Kyriakidou (1999) and Reiner (1995) showed that demonstrations and peer coaching, respectively, can be achieved through online conferencing. Kyriakidou *et al.* (1999) also demonstrated that all the other categories of the Joyce and Showers model can similarly be realized through the use of open learning, conferencing, and discussion groups.

Nevertheless, it is important to note that Kyriakidou's project was managed through the Open University, and Preston's interventions were supported by the Mirandanet project. Both these organizations would have the resources to sustain online professional development activities. Self-directed ICT-based

professional development on the other hand has to rely on the limited resources of the teacher, a diminished networking capacity – since the teacher is acting as an individual – and no forum for online demonstrations. It is highly unlikely that individual teachers in Zimbabwe would use the approach outlined in the Professional Development Model for their own self-directed professional development.

2.3.4 Output Models

Two models will be discussed in this section. The two models offer alternative ways of looking at impact, and as they are generic they can be applied to the evaluation of ICT-mediated professional development strategies. The two models are; the Harland and Kinder model: *Typology of Educational Outcomes* and Bell and Gilbert's *Teacher Development Model*.

2.3.4.1 The Typology of INSET Outcomes

Kinder *et al.* (1991) have developed a model for evaluating the impact of INSET on classroom practice. They called their model, "A Typology of INSET outcomes". This model was specifically formulated for INSET programmes. However, the model is significant in that it tries to address issues of impact on classroom practice. The model can be summarized as in Figure 2.3.

The outcomes are arranged in a hierarchical order with impact being the apex of outcomes. The third order outcomes relate to teachers being aware of the innovation. The teacher has been exposed to the information but there is no engagement as yet. Second order outcomes refer to a minimal uncritical engagement. In this case, the teacher shows some interest and stirring of emotions pertaining to the innovation, there may also be interest to find out whether the innovation is supported by the school.

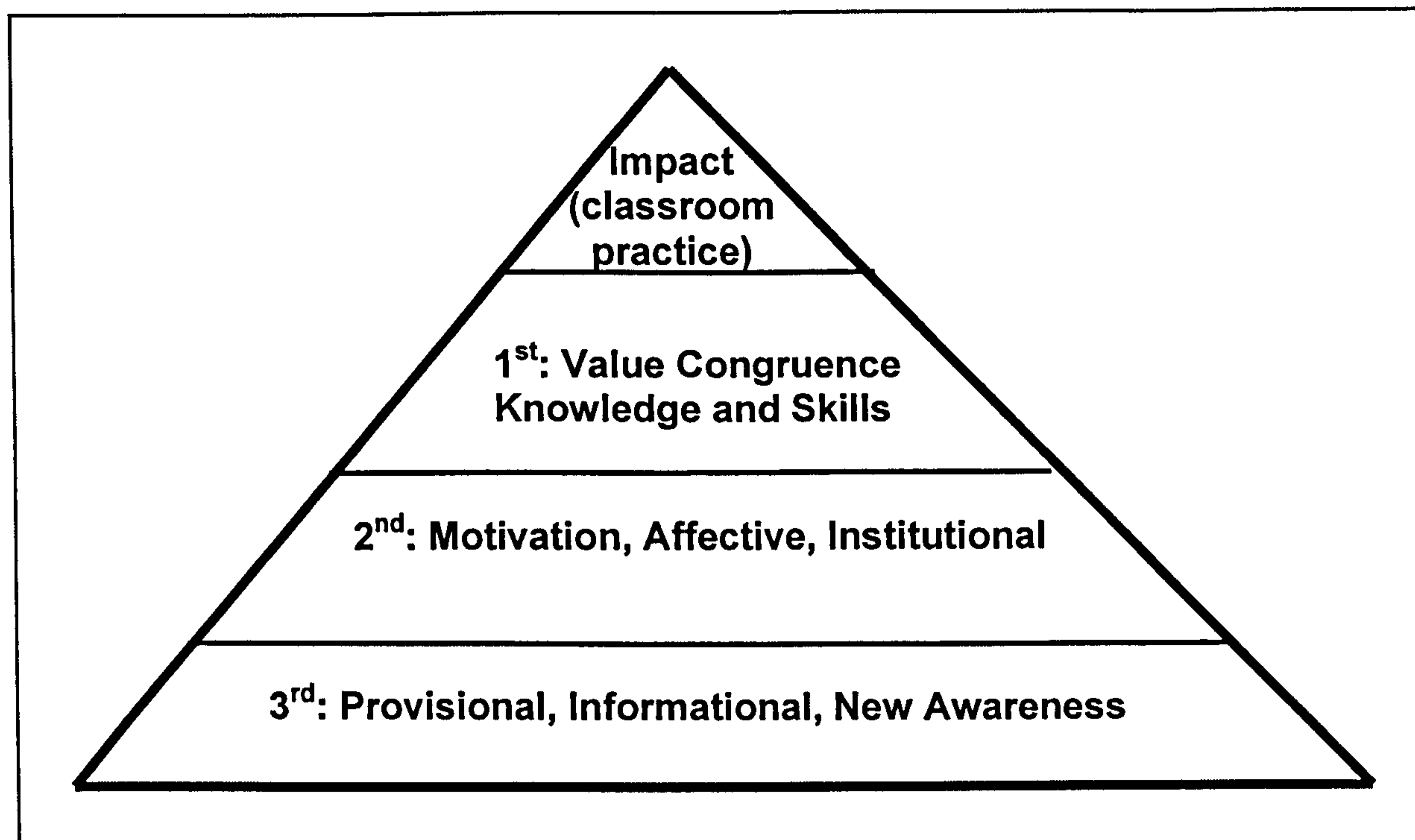


Figure 2.3: Typology of Educational Outcomes (Kinder *et al.*, 1991)

First order outcomes arise from the teacher's critical engagement with the innovation. Wilson and Berne (1999) believe that before any innovation can be implemented the teacher makes decisions on whether the innovation is in agreement with already existing values and goals, and whether the innovation will provide additional desirable knowledge and skills that satisfy felt concerns. When teachers are satisfied with this engagement, they will begin implementing the innovation in their practice. Thus the innovation will be seen to have an impact on their practice. The typology model combines elements of Doyle and Ponder's *Practicality Ethic* (see section 2.2.2) and the Concerns Based Adoption Model (see table 2.5).

The strength of this model lies in the fact that it spells out the expected outcomes hierarchically. One could argue that in so far as these outcomes can be related to initial concerns and needs, they result in impact on practice, once they are realized. Thus the model can be used to predict outcomes of innovations used in the classroom.

2.3.4.2 The Teacher Development Model

The second *outputs model* is the Bell and Gilbert Teacher Development Model. The model is anchored by a firm belief that professional development of teachers takes place in three different strands or dimensions, i.e. Social Development, Professional Development and Personal Development. Bell and Gilbert (1996) summarise the model as shown in table 2.8 below:

Social Development	Professional Development	Personal Development
Seeing isolation as problematic	Trying out new activities	Accepting an aspect of my work as problematic
Valuing Collaborative ways of working and reflecting on own practice	Development of ideas for classroom practice, and classroom practice.	Dealing with restraints
Initiating Collaborative ways of working	Initiating other Development activities	Feeling empowered

Table 2.8 Teacher Development model (from Bell and Gilbert, 1996)

The model touches on various aspects of impact on practice and does not ignore the personal development dimensions as well as the context. The Social Development strand characterizes the development of teachers as they realize that they are isolated, maybe because of geographical distance or communication problems, and actively resolve to end their isolation. They achieve de-isolation through seeking collaboration with peers. Gradually they begin to value collaboration as a way of working, initiating and promoting collaborative practice. Likewise, the other two strands begin at a level where teachers are dissatisfied with aspects of their professional or personal development and they take the responsibility to work through the various stages until they are empowered to initiate innovation as a matter of course – not as a response to a need.

Ribbins and Burrige (1994) argue that teacher professional development is at its peak when teachers are able to confidently face challenges and actively seek to improve their practice through action, reflection and collaboration.

Various aspects of the Teacher Development Model can be readily applied to teachers in a developing country like Zimbabwe. From personal experience, the researcher has identified with several stages in the model during his own process of professional development. It should be possible to use survey methods to identify the general levels of impact that professional development programmes such as SEITT may have on teachers who participate. The model would also be useful in analyzing the impact that self-directed continuing professional development processes may have on teacher development.

2.4 ICT as a professional development strategy

Teachers want to develop themselves to become even better teachers and they are challenged to renew and acquire new skills and capability. Zuboff (1988) argues that learning through the Internet and other ICT related activities is on the increase as teachers take responsibility for their professional development as free agent learners. This study is focused on these free agent learners, what motivates them to use ICT and how they make use of ICT?

There is some evidence that ICT has been used as an intervention strategy (Preston, 2000; Blease and Cohen, 1990;). The main issues highlighted from research, arising from these interventions can be summarised as: access to information; benefits to the profession and benefits to the teacher. These areas are discussed in detail below:

2.4.1 Access to information

ICT provides teachers with access to information that would otherwise be impossible to find, or too expensive to get by other means. For example, in Zimbabwe, the change from traditional practical examinations to *investigations* brought a lot of panic for teachers, because for some, the information was received only a few months before the examinations, and the teachers themselves had no idea what was involved in investigations. The frustration resulting from such problems can cause even expert teachers to slide into withdrawal and stagnation. Had teachers had ICT access in the form of e-mail or the Internet, the diffusion of the information would have been much faster and could have resulted in better prepared teachers. Bowskill *et al.* (2000) believe that vulnerable groups such as rural teachers have no recourse to other kinds of networking available to their urban colleagues and thus are left professionally isolated. In such instances, membership of online communities can be a solution. Cawthera, (2001) asserts that financial constraints notwithstanding, the networked computer could become the deprived school's most prized asset for professional development. However, in Zimbabwe, the situation of deprivation is compounded by the fact that deprived schools are most likely unable to afford even the electricity needed to power the computer facilities, or the communication facilities which make ICT usage feasible.

In addition, most ICT programmes that have been introduced in developing countries (and also in some developed countries) have focused on benefits to students, and not teachers. Lynch and Corry (1998) lamented that the neglect of teachers meant more and more teachers are expected to develop themselves in the use of technology, yet with little or no training or support. In Zimbabwe, most high schools are purchasing computers. Science teachers are expected to know how to operate these computers even though they have not

used them before. They are expected to take the lead in using ICT for both staff development and for teaching ICT skills to students.

Elsewhere Hardy (1998) observes that most in-service and pre-service courses provide minimal skills acquisition in ICT and educational technology. Researchers such as Crock and Andrews (1997), Collis (1998), Wills (1998) and Dearnley and Gatecliff (1999), have recommended that staff development at school level and also within the education system should use online resources and should cater for different levels of need.

Research on the value of ICT to the education community has yielded mixed findings. Maddux (1993) and Perraton and Creed (2000), claim that there is no automatic educational value in mere exposure to computers. Rather, the way in which they are used is critical. They recommend that computer literacy skills should be acquired by teachers in order to allow better data manipulation, information recovery, research and communication. Dearnley and Gatecliff (1999) and Coughlin and Lemke (1999) advocate that pedagogy should precede technology; Dearnley and Gatecliff write:

The range of professional development needs for online resources goes beyond technical skills to include pedagogical and managerial skills.. (Dearnley and Gatecliff, 1999 p.64)

Coughlin and Lemke expand on this observation by commenting:

The key to success isn't in the computers... it is liberated educators, whose understanding and creative use of technology can help them to achieve undreamed of levels of excellence for themselves and for their students (Coughlin and Lemke, 1999 p.2)

Moseley and Higgins (1999) also reiterate that even among educators, computer usage is encouraged for different, sometimes contradictory reasons. Some believe computers should only help teachers do their job, without greatly

changing their pedagogical practice. Others, for example Heppell (1993) – one of the architects of the United Kingdom's National Grid for Learning – feel that the use of computers will ultimately re-define our concept of teaching and learning by effecting a paradigm shift towards resource management and more independent learning by pupils. Squires and McDougall (1994), on the other hand feel that current practice in ICT use has been inappropriate because of over dependence on software packages that are developed by non specialists in the field of pedagogy. They argue that while computer simulations for example, are quite popular, lack of attention to pedagogy aspects by the software developers makes simulations in-effective as teaching tools.

Even in those studies that focused on the impact of ICT on students learning, research has produced mixed results. Andrews, and others, carried out systematic reviews of literature pertaining to the impact of ICT on literacy learning. They scoured through more than 2300 studies and reports (Andrews, 2004) focusing on five aspects of literacy education. One group in Andrews' team, Torgerson and Zhu, revealed that there seemed to be no significant impact of ICT on literacy learning (Torgerson and Zhu, 2004). Concerning moving image literacy, another group in Andrews' team lamented the fact that teachers were not adequately prepared for the technologies and they recommended inclusion of appropriate training during initial teacher training (Burn and Leach, 2004).

All these studies highlight the current confusion pervading issues surrounding the use of ICT in education. Above all, they also emphasize the need for ICT development to be matched with teacher professional development so that teachers can fully utilize its benefits.

2.4.2 Benefits of ICT to Professional Development

Many researchers testify to the beneficial effects of various aspects of ICT usage in teacher professional development. Preston (2001) carried out a study on what teachers perceive they can learn from ICT use. Her sample involved small groups of teachers who were subscribers to the "Mirandanet project". She sent them questionnaire attachments by e-mail.

These were returned using the same method. Preston found that the participant teachers treasured most, the online discussion activities which are part of the Mirandanet intervention. The teachers also felt that continued use of Internet and e-mail, sharpened their search and knowledge acquisition skills. This observation is supported by Hammond (1998), who had observed that teachers liked the opportunity to articulate ideas and to seek clarification from peers. Preston (2001) however, makes some observations which are difficult to justify, considering that she is using a biased sample. For example, she claims that ICT increases the teachers' capacity for independent learning – could it be that the type of teachers in her sample are already independent learners, by virtue of the fact that they were already experts in ICT and routinely used it to search for knowledge? Apart from theoretical speculation, no other studies have been quoted to reinforce this claim.

In 1999 the Department of Education, Training and Youth Affairs in Australia (DETYA) carried out a survey of the computer skills of Australian teachers and pupils (DETYA, 1999). 1250 teachers in 400 Australian schools participated. Unfortunately, the report of the methodology used is not detailed enough, apart from indications that questionnaires and interviews were analysed to arrive at the generalisations claimed in the survey.

The survey indicated that there were strong trends by teachers to move towards changing current teaching practices to include integration with ICT usage. Most importantly, most school heads perceived teacher competence in the use of ICT as being more important than getting hardware, connectivity or student access to computers. These findings have also been supported by Coughlin and Lemke (1999), Russell *et al.* (2000) and Bigum (2000).

In America, the importance of teacher competence has led the Federal Government to designate professional development in ICT as one of the pillars of the technology literacy campaign. It is interesting to note that the constraints to full utilisation of ICT in schools remain basically the same in all different contexts world wide.

In addition to the constraints mentioned in the DETYA survey (DETYA, 1999), Russell and Bradley (1997) working in Australia, Hammond (1998) in the UK and Madzudzo *et al.* (2002) in Zimbabwe all identified the following constraints to teachers' use of ICT:

- a) Time constraints: teachers seldom have time to carry out meaningful ICT activities either in class or outside;
- b) Server reliability: This was identified as a major constraint especially when working with web-based materials. Most teachers citing this problem had difficulties in downloading materials from the Internet for teaching or their own continuing professional development;
- c) Skills acquisition: A difficulty in acquiring technical skills required for effective use of ICT was also identified;
- d) Physical constraints when using dial up networks.

The DETYA survey also revealed that computer skills were learnt at home as well as on the job. Pre-service training was not a significant factor in imparting computer competency. This is a curious finding as one would expect pre-service training to play a very important role in shaping attitudes to innovation and also in accepting innovation as is indicated by research findings (Verspoor, 1989 and Guskey, 1989; Borko and Putnam, 1996; Ball, 1996). One would therefore expect a big difference between teachers who had pre-service computer training – as part of initial teacher training for example – and those who acquired ICT skills after qualifying.

2.4.3 Benefits of ICT to personal growth

It has not been possible to identify any definitive studies in professional development linking ICT to personal growth and development of teachers, though some minor studies did reveal some linkages. For example, Madzudzo *et al.* (2002) claimed that teacher motivation was affected. Mushayikwa (1996) and Twining (2002) also made claims as to the development of positive attitudes and self worth as a result of ICT usage. However, these claims have largely remained unsubstantiated by further research. It is hoped that this study will provide insights into this aspect of teacher professional development, especially since the study focuses on teachers' perceptions. The study will enable the teachers to tell their own stories in their own words about the effects of using ICT, on their personal development

2.5 Summary: Benefits of ICT to teacher professional development

In the previous sections, research findings are discussed related to how the use of ICT by teachers provides benefits in the form of: i) access to information, ii) benefits for the profession and iii) benefits for teachers' personal growth.

Most of the available literature concerning the use of ICT to access information is mainly concerned with managed / organised groups of teachers. There is no indication how individual teachers use information accessed outside the framework of managed activities. These studies do not tell us anything about how teachers who are isolated initially will benefit from access to online resources or how they come to make decisions enabling them to benefit from these online communities.

The situation in Zimbabwe appears to indicate that rural teachers are isolated and information about how they use ICT would give an indication to how they are struggling to come to terms with their isolation. The author believes that teacher isolation in Zimbabwe is not limited to rural teachers only, but that even urban teachers find themselves isolated because of school ethos and cultural practices which promote competition between schools and among teachers. The study looked at both the reasons behind the teachers' use of materials as well as the ways in which the materials were used.

The study also attempted to evaluate how the teachers viewed supposed ICT benefits in the areas of professional development and personal growth, with a view to comparing them with those listed by other researchers mentioned above.

2.6 Issues arising from the literature

The literature review has raised several points. These are:

- a) Although a lot of research has been carried out on professional development in general, very little of it is concerned with self-directed professional development (see section 2.2, table 2.2). A lot of research has also been carried out on the impact of various aspects of ICT on teacher practice within structured programmes. None of the evaluation

has been applied to the self-directed professional development of teachers (see section 2.1.2).

- b) Research on teachers' continuing professional development has revealed that there are two types of impact: Competence and reflective practice. Competence impact is made manifest through observable criteria such as students' performance. Reflective practice impact is manifested through teacher perceptions of professional well-being. The current study is mainly concerned with reflective practice of the teachers. Therefore teachers' perceptions of impact were targeted.
- c) Professional development is a process and therefore impact studies should look at the whole process rather than concentrating on the perceived outcomes only (see section 2.2).
- d) Models assist in the understanding of professional development processes, but no one model can provide complete information. Therefore it is helpful to consider several models for a fuller picture of the impact of professional development on classroom practice (section 2.3).
- e) Professional development models have been applied to traditional professional development programmes supporting centrally initiated curriculum innovations, none have been targeted to the self-directed professional development of teachers (section 2.3)
- f) Comparable studies on the impact of specific types of ICT intervention on aspects of teacher development have been carried out in the framework of structured professional development programmes (section 2.5).

The points raised from the literature in these sections were used in designing the research instruments i.e. items of the questionnaire and some

guiding questions for the semi-structured interviews. However in the analysis of the data, literature was separately sought to support aspects and issues arising from the findings.

2.7 Research Questions

The literature review showed that ICT use in continuing professional development activities is wide spread. ICT has been used to cater for several key areas of teachers professional development activities such as subject content upgrading, practical skills transfer and professional collaboration.

As has been described in this chapter, professional development and ICT are dynamic – they are *moving targets* so it is difficult to assign a causal relationship between them. Professional development needs may initiate the use of ICT (the tacit assumption in the title of this research), and thus the impact of ICT on professional development can be evaluated, or conversely, developments in ICT may result in the development of professional development needs in which case the focus of the research would be how teachers develop professionally to acquire ICT skills for use in their practice. The focus of this research is on the use of ICT for professional development purposes, not on how teachers acquire ICT skills or how they use it in the classroom.

Since this study is concerned with teachers' use of ICT in self-directed professional development activities the perceptions of the teachers are of central concern to this study. The aim of the study is therefore *to investigate the perceived impact of ICT on the self-directed professional development of A-level science and mathematics teachers in Zimbabwe.*

As has been mentioned earlier, for the purposes of this study, "ICT" is limited to the use of computers for word-processing e-mail and Internet access

and excludes the use of other information communication technologies such as cell phones, satellite services and video links. “*Impact*” was taken to mean the effect that an innovation (ICT) has on the growth of professional behaviour and practice of teachers.

To be able to better organise the data from this investigation, the researcher has identified three research questions which focus on the different aspects of ICT and professional development. The first concern was to verify the prevalence of ICT usage among A-level science and mathematics teachers in Zimbabwe. The second issue borders around the professional concerns of A-level science and mathematics teachers. The third issue addresses concerns about the teachers’ classroom practice. In terms of Doyle and Ponder’s *practicality ethic* (referred to in section 2.2.2), the first research question strives to validate the use of ICT for professional development by teachers. Research Questions 2 and 3 address the practicality aspects of this usage.

It was hoped that by addressing these concerns, the impact of ICT use on professional development could be evaluated. The fourth research question sought to identify patterns of use from which a model can be developed and thus addresses the transferability aspects of the research. The four research questions are given below:

- 1. To what extent is ICT used by science and mathematics teachers in Zimbabwe for their own professional development?**
 - a. Who uses ICT among the A-level science and mathematics teachers in Zimbabwe?
 - b. How do science and mathematics teachers access ICT?
 - c. How frequently is ICT accessed by science and mathematics teachers?
 - d. For what purposes is ICT used by science and mathematics teachers?
- 2. How do teachers perceive the use of ICT as affecting their professional development?**

- a. Why do teachers use ICT for their professional development?
 - b. What aspects of professional development enable teachers to be supported by ICT?
 - c. How does the use of ICT enhance teachers' perceptions of their own professional development in terms of professional values, personal aspirations and effectiveness?
- 3. How do teachers perceive the use of ICT as affecting their classroom practice?**
- a. How do teachers use ICT-based materials in the classroom?
 - b. How does the actual use of ICT-based materials correspond with the teachers' intentions?
 - c. How does the use of ICT-based materials in teaching contribute towards teachers' classroom practice?
- 4. What model of effect of ICT – based professional development can be abstracted from the information obtained in 1, 2, and 3 above?**
- a. Are there any patterns in the way ICT impacts on teachers' professional development?
 - b. How can these patterns be explained?
 - c. How does this explanation (model) agree or disagree with any of the known models on teacher professional development?
 - d. What could contribute towards the differences or similarities observed?

The next chapter discusses how, guided by these research questions, the research was designed, suitable data collection methods were identified, data was collected and analysed.

Chapter 3: Research Design

3.0 Introduction

As can be seen from the research questions, this research was concerned with obtaining quantifiable data on the prevalence of teachers' use of ICT for professional development purposes, and the reasons why teachers chose this path to professional development. For this purpose, the researcher adopted a cross-sectional research design using the social survey as its main strategy, in order to look for patterns of association between teacher-characteristics for the use of ICT for their professional development.

Bryman describes a social survey as a strategy in which:

.. data are collected on more than one case and at a single point in time in order to collect a body of quantitative (and qualitative) data in connection with two or more variables which are then examined to detect patterns of an association.
(Bryman, 2001 p.42)

The researcher sought to reconstruct meaning from the interaction of individual teachers with ICT in pursuit of their own professional development. Wisker (2001) describes the social survey approach as hermeneutic and dialectical. Bryman (2001) describes hermeneutics as a form of interpretivism which emphasises the understanding of human behaviour by taking into account the social and historical contexts of the action. This approach seems appropriate as the research not only sought answers to the question why but also what, how and when. To be able to probe deeper into the relationship between ICT and teachers' professional development, Miles and Huberman advocate a research design that is hermeneutic, cyclical and alternating between qualitative and quantitative data collection:

.. beginning with exploratory fieldwork, leading to the development of a quantitative instrumentation, such as a questionnaire. The questionnaire findings can be further deepened and tested systematically with the next round of qualitative work. (Miles and Huberman, 1994 p. 41-42)

Such an approach would necessarily use different methods and strategies of data collection to provide answers to the research questions. Some researchers however, notably Smith (1983) and Smith and Heshusius (1986), strongly disapprove the use of multi strategy research, arguing that it “tends to transform qualitative inquiry into a procedural variation of quantitative inquiry” (Smith and Heshusius, 1986 p. 8). They argue that qualitative and quantitative research approaches belong to separate paradigms with distinctly separate epistemological and ontological commitments and should therefore not be integrated. Gilbert and Mulkey (1984) and other researchers however disagree with this view. They argue that both qualitative and quantitative researchers subscribe to the same empiricist ethos, that is; all knowledge must be grounded in evidence. Charmaz (2000) further suggests that current approaches to grounded theory, which has been associated with the analysis of qualitative data, fall within two distinct traditions and each of these traditions is based on the positivist world view of an objective external reality – a social world beyond the researcher. Johnson and Onwuegbuzle (2004) argue for a “third paradigm” which enables researchers to mix and match research design components that provide the best potential for answering their research questions. Thus these authors see *mixed methods research* as offering

.. great promise for practising researchers who would like to see methodologists describe and develop techniques that are closer to what researchers actually use in practice. (Johnson and Onwuegbuzle, 2004 p. 15)

Gorard and Taylor (2004) and Morgan (1998) contend that research methods are autonomous and their strengths in data collection and analysis can be harnessed to enrich the research. Platt goes further to argue:

Frequently methodological choices are steered by quite other considerations, some of a highly practical nature ... and in many cases general theoretical methodological stances are just stances: slogans, hopes, aspirations not guidelines with clear implications that are followed in practice (Platt, 1996 p275).

Thus Platt argues that the selection of research methods should be determined by other factors as well as the methodological approach. In the case of this current study, the selection and use of research methods was linked to the demands of the research questions.

The varied nature of the research questions identified in this study required a multi strategy approach. It was decided to collect data through a questionnaire with open and closed items, and through semi-structured interviews. It was hoped that the use of multi strategy research would enable the research findings from the questionnaire and semi-structured interviews to inform and facilitate the use of less structured interviews in the later part of the study.

From such contextual observations the researcher hoped that it would be possible to derive the underlying theoretical constructs of the teachers' behaviour patterns that could be used to develop a model of the teachers' professional development. Such derivation of a model from contextual observation would demonstrate the *transferability* of the constructs. Auerbach and Silverstein (2003) define *transferability* as the development of theoretical constructs that describe abstract patterns that can be applied to the whole population, even though these constructs arise from content described in specific subcultures. In order for the results of a study to be transferable,

Krathwohl (1993), Rubin and Rubin (1995) and Auerbach and Silverstein (2003) argue that the researcher should strive to justify the development of the constructs in a transparent, communicable and coherent manner, so that researcher triangulation can take place. Such an action would enable other researchers doing similar studies in southern Africa for example (similar context) to recognise the theoretical constructs in their own research.

Denzin and Lincoln (1998) and Rosenau (1992) suggest that one way which could be used later on to assist transferability would be by gathering culturally valid and authentic data. Guba and Lincoln (1989) define *authenticity* as including aspects of honesty, depth and richness of scope. Authenticity would also require that aspects of the research context be taken into consideration during the process of theoretical sampling (Auerbach and Silverstein, 2003; McKenney, 2001).

The researcher's association with the respondents, as a former member of the Science Education In-service Teacher Training (SEITT) team, called for a cautious approach, as respondents might be less forthcoming in their responses, if they perceived the researcher as an insider. In such a case, Krathwohl (1993) suggests the use of three triangulation criteria to ensure collection of high quality data. Krathwohl suggests varying data sources (timing, location and people); varying data collection methods (using different methods and formats) and varying data collectors (or assistant researchers – for example asking education officers to collect completed questionnaire at workshops would yield better results sometimes than the researcher collecting directly, because of perceived locus of power / authority). To increase the authenticity of the data, methodological triangulation was used for all the research questions.

Being perceived as an insider, it was impossible for the researcher to start the research without any external impressions on what to study since originally, interest had been roused through prior interactions with the SEITT programme and the potential participants in this research. As a result, it was deemed desirable to use a theoretical framework to provide ideas and guidelines on the possible points of interest during the collection of data. Such a design was chosen because it allows for a kind of progressive focusing on central themes that arise from the study.

This chapter describes the collection and analysis of data for this research. Section 3.1 looks at the sampling procedure used for data collection. Section 3.2 describes the research instruments used, the design of the instruments and how these instruments were related to the research questions. Section 3.3 describes the environmental variables and general background to the data collection process. This section will provide a reflection of the data collection process, the challenges met and how these were resolved. Sections 3.4 to 3.6 provide a detailed description of how the collected data was organised. Section 3.7 will describe the development of an analysis framework for the data from the questionnaires and interviews.

3.1 Sampling procedure

The rapid expansion of the Zimbabwean education system soon after independence has resulted in an increase of A-level schools (Mutumbuka, 1986 and Maravanyika, 1991). Zimbabwean high schools are broadly divided into two main groups which are easily distinguishable because of their characteristics. On the one hand, government and government-supported high schools are scattered all over the country. They are characterised by poor resources and large numbers of students. Within this group one can

distinguish sub-groups, these are urban schools (formerly well-resourced) and rural schools (mainly mission). Rural schools typically have poor facilities compared to the urban schools. On the other hand Independent (private) high schools do not receive any assistance from the government. They are generally well equipped – some with first world resources.

The number of schools offering A-level was being upgraded on a yearly basis. At the time of planning this study in 2002, there were 172 established A-level schools in Zimbabwe, of these, 48 were Independent high schools (Ministry of Education, Sport and Culture, 2000). Figure 3.1 shows the distribution of these schools around the country's nine educational regions. Note the varying sizes of the provinces and the disproportionate densities of the schools in each educational region..

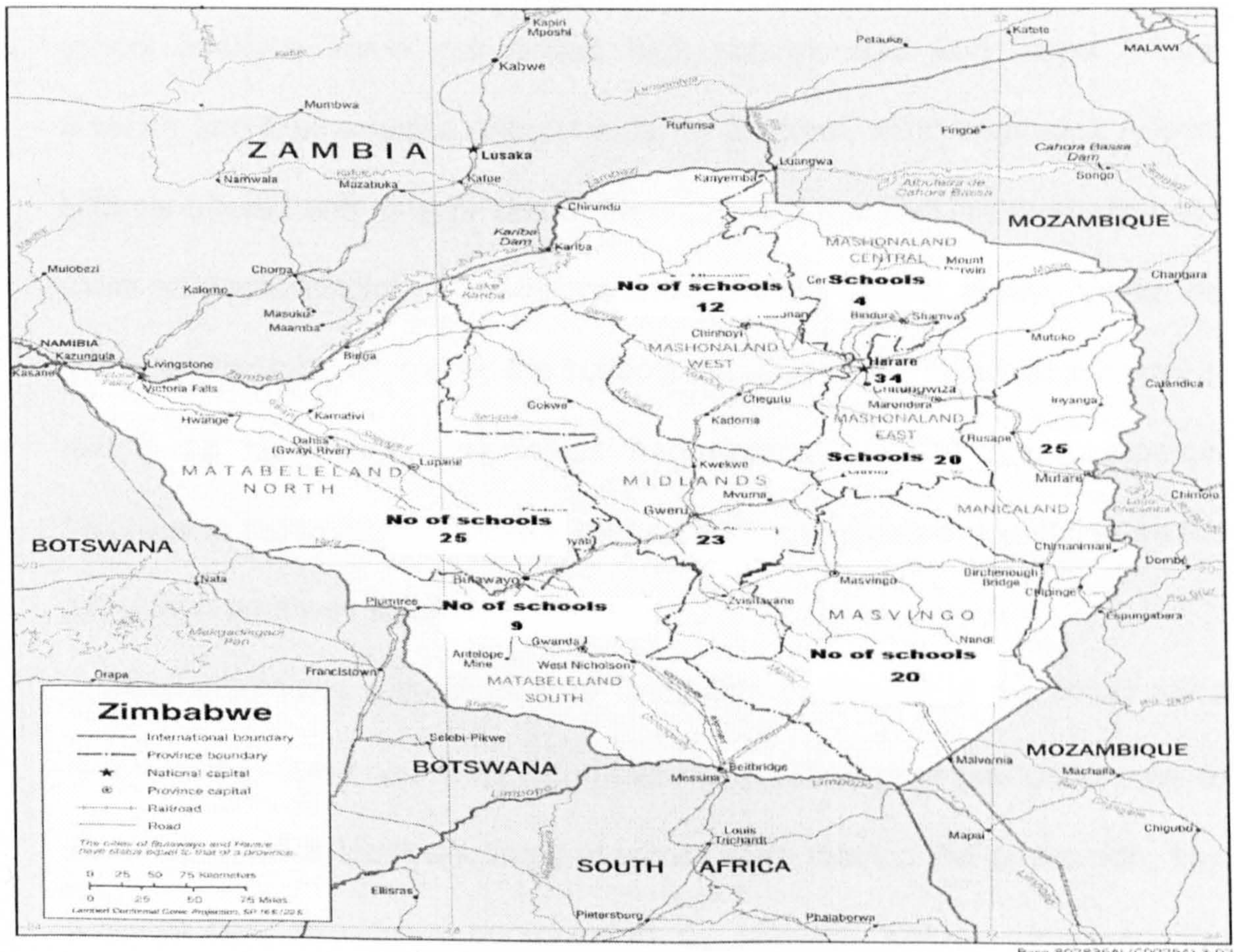


Figure 3.1: Distribution of A-Level Schools in Zimbabwe (Adapted from: Ministry of Education, 2001; Map courtesy of Zimbabwe Geophysical Survey, 2000)

The cities of Harare and Bulawayo have provincial status. Harare has the largest concentration of A-level schools (34), compared to the other provinces. This reduces inter-school distances when compared to schools in the Midlands or in Matebeleland South, which are further apart. For purposes of sampling the Bulawayo and Matebeleland North regions were considered as one. This was because at the time of planning, these two regions were still being administered as a single region. It was estimated that each of these schools has at least five Science and Mathematics teachers teaching at A-level. This provides a target population of at least 860 teachers.

By the time the research was conducted in 2003, the number of A-level schools had increased to 191 and the estimated number of teachers to 955. However, the number of teachers teaching A-level varied from school to school because some established high schools had very large A-level Science and Mathematics departments. In contrast, most beginning A-level schools offered only one or two of the subjects identified in the study – the exact sciences (Biology, Chemistry and Physics) almost always being the last subjects to be offered by the schools because of the expense involved in setting up laboratories, resources and getting qualified and competent teachers to teach them. Thus the researcher took targeted population as the population as it was in 2001.

Initial interviews with Ministry of Education personnel at the Head office revealed that there was a high turnover of qualified (and graduate) science and mathematics teachers, most of whom were leaving the profession. This problem has also been documented by Maringe (2005). However, this shortage was offset by the increasing numbers of new graduate teachers from the country's 11 universities. This meant that the actual target

population of teachers could have been higher than the estimated number quoted above. Tuckman (1994) suggests that a large population necessitates the need to have a large sample size in order to gain a representative sample and thus maximise the external validity of the study. However Tabachnik and Fidell (2001) argue that larger sample sizes tend to minimise the effects of outliers and thus reduce the effects of variance on statistical samples, which might result in false significance values.

Based on the estimates quoted above, table 3.1 shows the sample sizes that were used for the different research methods.

	Target Population	Estimated Sample	Actual Sample
Questionnaire	860	300	259
Interview	860	40	55

Table 3.1 Sample sizes used for the different methods

Since the study focuses on A-level Science and Mathematics teachers who are currently using ICT for their own professional development, three boundary conditions had to be considered in determining the samples:

Firstly, the first research question, among other things, seeks to determine the common traits of A-level science and mathematics teachers using ICT to develop themselves. It therefore calls for quantitative survey methods to identify this group's population statistics and distribution. Since Zimbabwe is a developing country, and ICT has only become recently accessible to the public domain (Cawthera, 2001; Jensen, 2003 and Business-Guide, 2005), it was expected that only a small fraction of the A-level Science and Mathematics teachers would be using ICT for their professional development. The target population for this research is the Biology, Chemistry, Mathematics, Geography and Physics A-level teachers. To be able to obtain a representative sample of these teachers, it was

necessary for the survey to reach as many science and mathematics teachers as possible. Bryman (2001) suggests that in such a case, increasing the sample size would lower the sampling error and thus increase the representativeness of the target group and this would be a desirable approach. By combining several strategies of collecting data as described in section 3.3, a high *response rate* (as calculated as the ratio of usable questionnaires divided by sample total minus unusable questionnaires c.f. see Bryman, 2001) of 86% was obtained for the questionnaires.

Secondly, the sample for the second stage of the research (addressing mainly RQs 2 and 3) was drawn from those teachers who indicated using ICT for their own professional development. In this case, sequential sampling was used because of data collection hurdles that were experienced. These problems are discussed in more detail in section 3.3. For convenience, the initial interview sample was drawn from regions where sizeable numbers of teachers were reportedly using ICT for professional development as exemplified by high daily attendances at the Science and Mathematics Centre. The sample composition also drew on information obtained from the feasibility and pilot studies at those centres. Convenient sampling was used because these centres are dedicated to supporting science and mathematics teachers and so provided a natural meeting place for the teachers. Appendix 3.1 provides an example of attendance registers at one of these Science and Mathematics Centre. Secondly, due to the limited time for data collection, and financial constraints, it was not possible to follow-up questionnaire results with new sampling for interviews. However, the researcher was aware that accessing ICT facilities through the Science and Mathematics Centre is just one of many paths available to teachers in Zimbabwe. For example, a

growing number of schools are becoming networked and have Internet facilities on site. Equally, Internet cafes are mushrooming in almost all the urban centres. In later phases of the data collection process, teachers were interviewed at their schools as well. Using this phased and converging approach, more teachers were eventually interviewed, than were originally planned for resulting in a response rate of 137%.

Lastly, consideration was also given to accessibility of the region as the first interviews took place at the Science and Mathematics Centre. Efforts were however made to widen the range of practices and experiences due to this convenience sampling by also targeting interviewees in accessible A-level schools with ICT facilities and those using public ICT facilities like cafes and WORLD Centres within selected regions.

As the study was concerned primarily with teachers who use ICT in the process of their professional development most of the interviews were held with those teachers who were regular users of ICT. However, where possible non ICT-using science and mathematics teachers were also identified and interviewed. It was hoped that comparisons between ICT users and non ICT users in the same school would provide illumination into the reasons and impetus for using ICT.

3.2 Design of Research Instruments

Although this study seeks to go beyond description, to understanding teacher behaviour and the underlying motives which drive them to behave as they do, it is still bound by the time limitations of a doctoral study. However, a multi-strategy approach was chosen for this study for reasons explained in section 3.1. The main data collection techniques developed for this study, were questionnaires and interviews. In addition, the researcher collected and

analysed documents, kept a research diary and made observations whenever it was possible to do so.

3.2.1 The Development of the Research Instruments

To address the issues of impact, discussed in the chapter 2, the following instruments were developed:

- a) One questionnaire targeting science and mathematics teachers.
- b) Semi-structured interview schedule for selected science and mathematics teachers.

The development of the research instruments was informed by impact studies carried out in the field of teacher professional development by researchers such as Joyce and Showers (1988); Wallace and Lauden (1998) and Reeves *et al.* (2001). These researchers are agreed that a good evaluation of impact should not only concentrate on the outcomes, but on the whole process, and how the components (inputs, implementation strategies/ cycles, outcomes) interact with each other. In addition, Impact in professional development should not only be examined from the point of view of student achievement, but also in terms of the teacher's personal development and professional growth i.e. not focusing only on competence, but also on reflection / reflective practice. Thus the research instruments that aim to evaluate impact must be able to establish the relationship between each of the components of the professional development process.

Table 3.2 below shows the general design scheme for the research instruments.

Table 3.2: Design of the Research Instruments

Research Question	Sub-question	Means of Verification
1. To what extent is ICT used by science and mathematics teachers in Zimbabwe for their own professional development?	i) Who uses ICT among the Zimbabwean A-level science and mathematics teachers?	Questionnaire Interviews: Resource Teachers, Education Officers Science and Mathematics Centre Records
	ii) How do science and mathematics teachers access ICT	Questionnaire Interviews: Teachers, Resource Teachers and Education Officers;
	iii) How frequently is ICT accessed by science and mathematics teachers?	Questionnaire Interviews: Teachers;
	iv) For what purposes is ICT used by science and mathematics teachers?	Science and Mathematics Centre Records Questionnaire Interviews: Teachers Resource Teachers
2. How do teachers perceive the use of ICT as affecting their professional development?	i) Why do teachers use ICT for their professional development?	Questionnaire Interviews: Teachers; Resource Teachers
	ii) What aspects of professional development enable teachers to be supported by ICT?	Questionnaire Interviews: Teachers;
	iii) How does the use of ICT enhance teachers' perceptions of their own professional development in terms of professional values, personal aspirations and effectiveness?	Interviews: Teachers;

<p>3. How do teachers perceive the use of ICT as affecting their classroom practice?</p>	<p>i) How do teachers use ICT-based materials in the classroom?</p> <p>ii) How does the actual use of ICT-based materials correspond with the teachers' intentions?</p> <p>iii) How does the use of ICT-based materials in teaching contribute towards teachers' professional development?</p>	<p>Questionnaire</p> <p>Interviews: Teachers;</p> <p>Interviews: Teachers</p>
<p>4. What model of effect of ICT-based professional development can be abstracted from the information obtained in 1, 2, and 3 above?</p>	<p>i) Are there any patterns in the way ICT impacts on teachers' professional development?</p> <p>ii) How can these patterns be explained?</p> <p>iii) How does this explanation (model) agree or disagree with any of the known models on teacher professional development?</p> <p>iv) What could contribute towards the differences or similarities observed?</p>	<p>Interview Analysis Framework;</p> <p>Interview Analysis Framework;</p> <p>Interview Analysis Framework;</p> <p>Interview Analysis Framework;</p>

From the scheme (table 3.2), it can be seen that the questionnaire was used to provide answers mainly to the first research question. Research Questions 2 and 3 required mainly qualitative data and interviews were used to provide this. Research Question 4 is a synthesis of the first three research questions and therefore would require both quantitative and qualitative data.

Like the questionnaires, the semi-structured interview schedule was divided into three sections focusing on the teachers' ICT skills, teachers' concerns when using ICT and the reasons for their decisions to use or not to use ICT in their professional development. However the interview schedule was more flexible and also looked at the broader issues of the teachers perceptions of professional development issues, the nature of their profession and their concerns. Semi-structured interviews were preferred to open interviews in this case to ensure cross case comparability.

The final development of the research instruments was informed by a preliminary feasibility study and a subsequent pilot study.

3.2.1.1 Preliminary Feasibility Study

A feasibility study was carried out in January 2002 to investigate:

- i) Whether there are ICT structures which can be used by teachers working in Zimbabwean High schools;
- ii) How accessible the structures are to teachers;
- iii) the types of resources that are available.

The study was carried out in eight of the ten Science and Mathematics Centres. Eight Resource Teachers at the centres were interviewed and a documentary analysis of the ICT resources and environment was carried out.

The study revealed that:

- a) Teachers were indeed using the Science and Mathematics Centre for their own professional development. Each educational region has one Science and Mathematics Centre, and one regional Better Schools Programme Resource Centre (BSP) and at least one World Links Resource centre in each district of the region. All these centres have ICT facilities but only Science and Mathematics Centre and World Links centres have Internet and e-mail connectivity.
- b) Most of the centres were accessible to the teachers but the ICT resources at the centres were inadequate. World Links centres are closest to the teachers but they provide support to all teachers in their district and as a result would not be ideal for meeting science and mathematics teachers.
- c) Science and mathematics teachers seemingly used a variety of ICT service providers such as schools, home, Internet cafes, the World Links Centres and the BSP centres to access ICT Resources.
- d) The Ministry of Education was supportive of ICT usage by teachers for professional development and had put in place mechanisms to enhance that support.

Results from the feasibility study suggested that there is a need to look beyond just the Science and Mathematics Centre to fully document teachers' experiences with using ICT for their professional development.

3.2.1.2 Pilot Study

In August and September 2002, a pilot study was carried out in Zimbabwe to test the research instruments and data collection strategies that had been designed for use in the main study. The purpose of the pilot study was:

- a) to verify the internal validity of the questionnaire and semi-structured interview instrument by checking such aspects as wording of the items, readability and interpretation.
- b) To check the quality and spread of responses to the questionnaire and interview.

The pilot questionnaire was completed by 32 trainee Resource Teachers at the University of Zimbabwe and 9 teachers at the Science and Mathematics Centre.

They were asked to make note of any problems they experienced interpreting the question. These problems were then discussed the following day after the questionnaires were collected. Recommendations from these teachers were then noted for consideration in the drafting of the final instrument.

Some questionnaire items on online conferencing were repeatedly skipped by most respondents. During discussions, some indicated that they did not understand the meaning of the terms used whilst others claimed that the events described were not relevant to them. Either way, such items had to be discarded or re-formulated.

It was noted that some of the A-level teachers taught subjects for which they had no formal specialisation. This was felt to be a possible significant aspect meriting consideration, but had not been anticipated in the original questionnaire.

During discussions it emerged that teachers felt it would be unnecessarily expensive and unproductive for the researcher to send postal questionnaires to all the targeted schools as the postal system was very inefficient. Some of these letters would never reach their destinations. In addition, the trainees suggested that teachers in the schools were heavily weighed down by professional and

economic stress, i.e. being poorly paid and overworked. It was highly unlikely that many would find time to respond to questionnaires let alone take the trouble to post back the documents even where the postage is included. Questionnaire fatigue was a strong aspect to consider.

Suggestions were made that the researcher should, where possible, utilise teachers' meeting places and gatherings such as the termly Science and Mathematics Centre workshops where questionnaires could be handed out, completed and returned during the 30-minute tea or lunch breaks. Postal questionnaires would then be sent to those schools whose teachers would be unlikely to attend these workshops. Science and Mathematics Centre records indicated that most teachers from private schools did not participate in the centres' activities. This was confirmed through interviews with Resource Teacher centre managers and Education Officers in charge of the centres' activities. The reasons given were that these schools have better resources even than the Science and Mathematics Centre and so teachers from these schools did not feel they could benefit from Science and Mathematics Centre activities. Thus a decision was made that in the main study, postal questionnaires would be sent to a selection of these private schools.

However, the researcher was aware that making use of existing connections (eg through trainee Resource Teachers) and adopting opportunistic data collection strategies (eg. Circulating questionnaires at workshops and Science and Mathematics Centre annual general meetings) would increase the number of respondents but at the same time may reduce the quality of responses since teachers might rush through the questionnaires and might not carefully consider their responses. So there was a need for the researcher to work out how to increase the validity of the data. This was done by distributing the

questionnaires at the beginning of the workshops and collecting them just before the teachers left at the end of the day. During the course of the day teachers were reminded periodically at break times to fill in the questionnaires.

Pilot interviews took place at Science and Mathematics Centre and the teachers selected were those who chose to come to the Science and Mathematics Centre on the particular day and agreed to be interviewed. The interviews were audio-tape recorded. Interviewees were asked after the interview to comment on the questioning technique of the researcher. During discussions teachers felt that whilst the Science and Mathematics Centre provided convenient venues for the interviews, they were noisy and teachers at the centres were always in a hurry or queue for access to ICT facilities. They suggested that these interviews be used as baselines for identifying teachers willing to be interviewed in their school settings. This suggestion, though noble, proved difficult to implement in the light of socio-political developments that unfolded just before the main data collection activities took place. These will be discussed in section 3.3.4.

Four of the ten teachers interviewed indicated that they did modify Internet materials for teaching and were positive about the follow up methods proposed.

3.2.2 The use of questionnaires

Likert type questionnaire items have been used to probe attitudes, motivation and values (Gardner, 1978; Kyriakidou *et al.*, 1999), whilst Oppenheim (1992) has supported the use of Thurstone type questionnaire items to probe information on behaviour, activities and responses to events. The Stages of Concern-about-an-innovation Questionnaire (SOCQ) (Hall *et al.*, 1986) was developed for the Concerns Based Adoption Model, to enable researchers to

collect data on teacher concerns. The SOCQ is an example of a Thurstone type questionnaire.

The questionnaire used in this study combined Likert type items with an adaptation of the SOCQ. The SOCQ questionnaire referred to the general issues surrounding the uptake and use of ICT by teachers and had to be modified to relate to science and mathematics teachers in particular. In addition, only items relating to the stages of concern and level of use were deemed to be useful for the current study. The adaptation was deemed necessary to provide a snapshot profile of teachers' concerns.

Cohen *et al.* (2000) and Blaxter *et al.* (2001) argue that using a questionnaire is in fact more difficult than using other research methods. This is because:

- a) due to their popularity with researchers at all levels, they have produced "fatigue" in respondents, with the result that few people are likely to be interested to respond to questionnaires. This was found to be true also in Zimbabwe where some teachers complained that they were inundated with questionnaires and so were reluctant to participate in this survey.
- b) questionnaires are difficult to design effectively and administer properly. Poorly designed questionnaires will not yield valid data. This problem was avoided by making use of a pilot survey to provide insights into the questionnaire items that teachers considered to be problematic. In this way, some teachers were also able to participate in the design of the instrument.

3.2.2.1 Development of the Questionnaire instrument

The main reason for using the questionnaire was to justify the extent to which the first research question could be answered using the sample of teachers identified.

Using feedback from the pilot study, changes were made to the format of the questionnaire, to increase readability and appeal. Questions were also simplified and clarified by getting rid of compound questions and improving the questioning style. Responses were varied as per suggestions made by the pilot interview respondents, to reduce monotony. Items identified by respondents as ambiguous were either removed or re-worded. The respondents appreciated the need to deal with response sets and acquiescence (Webb *et al.*, 1966). By changing the order of the response items, it would be easy to detect whether a respondent was just following a response set or whether they responded consciously.

To adequately answer RQ1, there was also a need to find out teachers preparedness to use ICT. Two items on the levels of use and adoption of ICT were added to the questionnaire. These items were taken from the standardised Stages of Concern Questionnaire (SOCQ) (see Hall *et al.*, 1986) and used the same style of wording as the one approved by the respondents during the pilot study.

The original questionnaire had 18 items, but with the additions and clarifications the final version of the questionnaire had 22 items. However because of the improved formatting and structure, the number of pages remains the same. Participants had indicated in the pilot study that the length of the questionnaire (number of pages) was adequate and not taxing on their time.

Table 3.3: Design of Questionnaire Instrument

PD Process	Model	Description	Characteristics	Rationale for inclusion
Context Items 1 - 12	TCS models (Steffy, 1978; Vonk, 1995)	General Biographical information and information pertaining to the ICT environment	Biography 1. Gender 2. Geographical location 3. School type 4. Classification of school 5. Subject(s) taught 6. Teaching experience 7. Qualifications 8. Training institution ICT environments 1. Computer facilities at school 2. Access to computers at school 3. Use of ICT in the last 12 months	<u>Biography</u> Provides data for the Teacher Career Stage Models and delineates the characteristics of the teachers thus making it easier to group them. <u>ICT environments</u> Provide insights into the dynamics of ICT access both at school and outside. Provides initial answer to Research Question 1
Inputs Items 20, 21	Concerns Based Adoption Model (Horsley and Loucks – Horsley, 1998)	Model quantifies the change process in teachers. It incorporates 7 stages of concern, levels of use and innovation. Treats change as a process	Level Concerns 1. Self i) Awareness ii) informational iii) Personal 2. task iv) Management 3. Impact v) Consequence vi) Collaboration vii) Refocusing	Provides input in the form of teachers concerns and provides basis for evaluating their professional development
18 a, b, d, e 19 a, b,	Teacher Development Model	Identifies 3 important areas of teacher development,	Social: 1. Isolation	Provides possible motivation for teachers

<p>18 c, 19 d, 18 e 19 c, e</p>	<p>(Bell and Gilbert, 1996)</p>	<p>i.e. social, professional and personal development. These areas can also be seen as areas of need / motivation centres</p>	<p>2. Collaboration Professional: 1. New ideas 2. Transfer to Classroom Practice Personal: 1. Self Critical 2. Coping strategy 3. Empowerment</p>	<p>initiating self driven professional development</p>
<p>Output 13 18 c, d, e 19 c, d, e</p>	<p>Pedagogical Content Knowledge (Shulman, 1987)</p>	<p>Model recognises the existence of four categories of knowledge for practitioners: Content knowledge; pedagogical knowledge; professional knowledge and at the union of these three is Pedagogical Content Knowledge (PCK)</p>	<p>1. Content knowledge i) Subject related knowledge e.g Physics content, nature of science / Scientific Method 2. Pedagogical Knowledge i) Teaching skills and strategies ii) Depth Required for e.g A-level 3. Professional Knowledge i) Curriculum design (Schemes) ii) Examinations iii) What it means to be a Science teacher. 4. PCK j) Integration of knowledge into new entity.</p>	<p>Useful when impact is assessed in terms of reflective practice as contrasted with competence in classroom practice. Independent components of PCK, existing on their own, would indicate low impact of the professional development process, on the individual's practice.</p>
<p>13 18 a, b, c, d, e 19 a, b, c, d, e</p>	<p>Professional Development Outcomes (Harland and Kinder, 1997)</p>	<p>Model tries to systematically provide a taxonomy of Professional Development outcomes based on teachers reflection upon their practice.</p>	<p>i) Material and provisional outcomes ii) Information Outcomes iii) New Awareness iv) Value Congruence v) Affective Outcomes vi) Motivation vii) Knowledge and Skills viii) Institutional Outcomes ix) Impact on Practice</p>	<p>Useful in providing items to assess outcomes in similar manner to the Gilbert and Bell Model.</p>

Table 3.3 provides a summary of the questionnaire design. The questionnaire items were informed by the models of professional development discussed in section 2.3. The relationship between these models and the structure and design of the questionnaire is evidenced in Table 3.3. The Questionnaire was divided into three sections. The first section was used to gather background information about the teachers and their context. The items in this section looked at the teachers' biographical details, their qualifications and their access to ICT. The second section focused on the teachers' ICT skills, how these were acquired and where they were used. The third section covered perceptions and concerns of teachers as derived from the information provided for by the process models, input and output models (Steffy, 1978; Vonk, 1995; Horsley and Loucks-Horsley, 1998; Bell and Gilbert, 1996; Shulman, 1987 and Harland and Kinder, 1997 respectively) as discussed in section 2.3.

Questionnaire section	Items	Focus	Research Question
A	1 - 8	Personal information	1.1
	9 - 11	Access to ICT (discriminator)	1.2
B	12 - 13	Training and competence	1.2
	14 - 17	Access issues	1.3
C	18 - 19	Concerns of using ICT a, b, e – professional dev. c, d, e – classroom practice	1.4
			1.4
	20 - 21	Teacher concerns	1.5; 1.6
	22	Classroom practice	1.4

Table 3.4 Structure of the questionnaire on use of ICT

Table 3.4 above shows the general layout of the 22-item questionnaire that resulted from this design. A copy of the final version of the questionnaire is presented in Appendix 3.4.

3.2.3 The use of interviews

In conjunction with questionnaires, interviews were used at two stages of the data collection. Semi-structured interviews provided information on the teachers' views, reasons for using ICT and reflections on their activities. They thus augmented the findings of the questionnaire survey. The researcher used the first set of semi-structured interviews at Science and Mathematics Centre to select teachers for more in-depth interviews in schools. 30 teachers, who were visiting the Science and Mathematics Centre, were interviewed. However, 8 teachers, who had visited the centres but could not be interviewed due to time constraints, were interviewed at their schools, bringing the total number of initial interviews to 38.

The second set of interviews was meant to gather in depth information about teachers' use of ICT. These interviews were held at schools and were more open-ended, allowing the teachers to address their particular concerns at the time and to explain their observed actions. 16 teachers were interviewed in their schools in January / February, 2004. Mason (1996) argues that allowing respondents to speak freely about their concerns helps to put the study into context.

Researchers are agreed that the interview technique makes up for its limited outreach with depth of coverage (Gillham, 2000b; Blaxter *et al.*, 2001 and Wisker, 2001). Semi-structured interviews have been hailed for increasing comprehensiveness of data while simultaneously being able to extract salient information (Kvale, 1996). Cohen *et al.* (2000) believe this type of interview technique is more systematic and comprehensive than other types of interview such as the informal or open interview and the standardized open ended interview.

As all the A-level mathematics and science teachers in Zimbabwe are graduates, mostly from universities that use English as the medium of instruction, they have adequate mastery of the English language. This means that English can be used as the language of data collection. However, where teachers felt more comfortable to express their views in the local language, they were encouraged to do so.

3.2.3.1 Development of the Interview Schedule

During the pilot interviews, most interviewees were able to answer most of the questions on the interview schedule. However they suggested that the researcher should avoid unnecessary repetitions during questioning. Analysis of responses seems to indicate that some of the questions were too shallow and there was a need to deepen the questions. In this respect, more questions and prompts were added to deal with the “how” and “why” questions rather than the “what” questions only.

As was the case with the questionnaires, the interview schedule focused mostly on the three aspects of ICT use:

- a) Background information and demographics: experience; subject taught; type of school; qualifications; level; Initial teacher training institution and (for Science and Mathematics Centre interviewees) reason for visiting the Science and Mathematics Centre;
- b) ICT access and Teacher Concerns: frequency of access; reasons for access; benefits of access; Identification of favourite sites, reasons, problems faced, possible solutions;
- c) Professional and classroom practice: services and materials accessed; and reasons for access; Use of resources and materials obtained from

the Internet; benefits to professional life; teaching; Quality and benefits of: downloaded materials and resources; professional communication.

d) ICT access problems / solutions, general comments.

A copy of the interview schedule is included in Appendix 3.5.

3.2.4 Other instruments used

In addition to the questionnaire and interviews, the researcher also collected logs from Science and Mathematics Centres and lists from Internet browser favourites on computers. These were analysed to provide a picture of the teachers' use of ICT within the Science and Mathematics Centres. This picture included the most popular Internet sites that teachers accessed. Document analysis provided factual information required by all the research questions. It was difficult to obtain individualized histories of sites visited by the teachers at the Science and Mathematics Centre as they were using public facilities. Teachers were able to indicate which sites they frequently used on an individual basis during interviews. The computer logs of Internet favourites provided an overall picture of the range of ICT activities that are carried out. In some centres, Science and Mathematics Centre managers kept lists of popular web sites so as to expedite teacher access to these sites.

Field notes were used to document how the teachers translated their downloaded materials into teaching materials. These field notes were taken as the researcher spent time with teachers in the staffroom before and after interviews. Field notes provided the basis for deeper, *post-hoc* interviews probing teachers' reasons for using or not using downloaded materials in their teaching at the school during the in depth studies.

Other documents collected for the in depth study included e-mail communications between teachers and their discussion groups. Some

worksheets downloaded from websites were also used to extract information on the use of downloaded materials by teachers. The documents provided insights into the ways the teachers modified and adapted the materials they obtained from the Internet for purposes of teaching and also for purposes of enhancing their own professional knowledge.

3.3 Data Collection

The activities carried out in this research can be viewed as having taken place in 4 stages. These were a) negotiating access, b) Questionnaire distribution and collection, c) Semi-structured interviews and d) follow up activities (follow up interviews and documents collection). Education officers and Resource teachers were interviewed to provide information on the context in which the teachers were operating, the limitations and expectations as understood by those in authority. As part of the contextual study, a research diary was kept where notes and reflections about research issues were noted down.

The main field work was carried out in 12 weeks, between April and July 2003, and then again in 3 weeks from mid to end January 2004. Table 3.5 below summarises the field activities that were carried out during this time. The table is organised according to weekly activities. The time line is organised in weeks of data collection activity. The research was disrupted twice because of Malaria infection.

Weeks 1 – 3 refer to week 2 – week 4 of April 2003; Weeks 4 – 8 were in May, and Weeks 9 – 12 were in June. In July, schools were preparing for Mid - year examinations, thus no data collection activities took place, though teachers

were still sending in some postal questionnaires. Weeks 13 - 15 refer to three weeks of January / February, 2004.

Activity week	Access Visits	Questionnaires	Interviews I	Interviews II	Documents	Research Diary
1	XXX	Postal to schools	XXX		XXX	XXX
2	Teaching At UZ	XXX				XXX
3		XXX				XXX
4	XXX	Delivery to Science and Mathematics Centres	XXX			XXX
5	XXX		XXX			XXX
6	XXX	XXX	XXX			XXX
7		XXX	XXX			XXX
8		XXX	XXX			XXX
9		XXX	XXX	School visits	XXX	XXX
10		XXX				XXX
11		XXX	XXX	XXX	XXX	XXX
12		XXX	XXX	XXX	XXX	XXX
13				XXX	XXX	XXX
14				XXX	XXX	XXX
15				XXX	XXX	XXX

Legend: XXX = data collection activity

Table 3.5: Field work time-line in weeks

In Table 3.5 above, all cells marked (XXX) represent the data collection activity marked at the top of the column. For example, in weeks 2 and 3, the researcher was teaching at University of Zimbabwe and therefore was only able to distribute and collect questionnaires locally and to make notes in the Research Diary. No interviews were held and the reason is explained in section 3.3.4.

3.3.1 Access issues

Recent events in Zimbabwe have curtailed to a certain extent, the freedom of expression that teachers may exhibit thus highlighting the need for fuller cooperation with Ministry of Education, Sport and Culture (MoESC) officials. Some teachers expressed disquiet at having to discuss problems they were facing in their schools, and they were equally reluctant to discuss how they used ICT facilities at Science and Mathematics Centre. It was therefore necessary for the researcher to allay their fears by obtaining written permission

to carry out the study, from the Ministry of Education Sport and Culture head office.

A full declaration of intent was lodged with the MoESC requesting for authority to carry out the research in the country's institutions. Copies of both the Application letter and the responses from the Ministry are included in Appendix 3.7. The Government requires all researchers to register with the Ministry before any work can be done in the schools.

The fact that the researcher was known and recognised as a past co-ordinator for the SEITT programme stood him in good stead, as the research was seen as part evaluation for his work, which the government had already approved. Thus in this case, the fact that the researcher was an *insider* in the research helped to facilitate access.

3.3.2 Ethical Issues

As reported at the beginning of this section, teachers had expressed concern that researchers were taking them for granted and not providing feedback to their contributions. This problem was also expressed by education officers and officials from the Ministry of Education, Sport and Culture, who gave their authority upon the condition that a copy of the study is made available to the ministry upon completion (see Appendix 3.5)

To ensure that participants' concerns were taken into consideration throughout the data collection and analysis of the results, the researcher sought guidance from the British Educational Research Association (BERA) which has adopted and published ethical guidelines for researchers (Gardner *et al.*, 2002). These guidelines relate to four main issues: a) confidentiality and anonymity, b) deception, c) protection of participants from harm, and d) informed consent.

- i) Confidentiality and anonymity

To ensure total confidentiality, questionnaires did not require identities of schools or individuals. A coding system was used to identify individual scripts. Unfortunately, ensuring total confidentiality meant that the questionnaires could not be used to select teachers for the follow up studies. However, in letters to school heads accompanying postal questionnaires, teachers were asked to indicate their willingness to be involved in the post – questionnaire study. The coding system for questionnaires is illustrated in Table 3.6 (page 99). Appendix 3.6 is a copy of the letter sent to school heads with the postal questionnaires. Similarly, interviewee confidentiality was ensured by the use of a similar coding system. The interview coding system is explained in Appendix 3.7. Participants' identity was protected in all reporting, especially in the interview transcripts, observation schedules and field notes. This meant that the coding systems had to enable the tracing of participant activities without compromising their anonymity. When participants were reassured about their anonymity, the researcher found that they felt freer to express their views.

ii) Deception

To protect the participants from inadvertent deception or misunderstanding of the aims of the research, the researcher took care to explain to the participants what the research was all about, both at workshops and in letters to the participants' schools. As a former member of SEITT, the researcher acknowledges that teachers may have participated in the research with heightened expectations of what their schools and regions could benefit from the study. However, the researcher did explain that a study synopsis would be handed over to the Ministry of Education Sport and Culture and the SEITT programme upon completion and it would be up to the two institutions to act upon whatever recommendations may be included.

iii) Protecting participants from harm

The unfolding socio-political environment posed a big threat to the outcomes of the research, as teachers were at one time so insecure that they could not participate in the interviews (as reported in detail in section 3.3.4). The issue of confidentiality became even more prominent as some teachers declined to be recorded on audio-tapes. The researcher was able to accept the difficulties posed by the political situation in the country and agreed to use interview notes where teachers were uncomfortable with recording.

iv) Informed Consent;

Informed consent was sought from all participants to be interviewed. In the case of teachers who are already using ICT for their professional development, this was not difficult to receive. However for schools participating in the in depth study additional consent was sought from the school heads and the individual teachers who participated. Some authors on research (Cohen *et al.* 2000; Bryman, 2001) concede that getting informed consent might be difficult if not impossible to achieve and that some participants will inevitably not have the whole picture pertaining to the implications of their participation.

The researcher was cognisant of the limitations that the *insider* status bestowed upon the research. As Vulliamy *at al.* (1990) note, familiarity with the system makes one impervious to some anomalies in teacher behaviour, which might be obvious to an *outsider* because there would be no basis for comparison, the researcher belonging and having been brought up within the same teacher culture. It was hoped that by making detailed observations and field notes, and sharing these with the supervisors, some of these instances might be captured.

3.3.3 Negotiating access

The researcher wrote letters to the University of Zimbabwe in late 2002 asking for assistance in facilitating access to schools through the University system. It was felt that with the University's blessing, it would be easy to gain access to the educational institutions as the University has various outreach programmes of which the researcher could be a part, and could carry out the research as a participant. These included the Post-Graduate Certificate in Education (PGCE) teaching supervision visits and the SEITT workshops.

The applications were well received. The researcher was advised to contact the Dean of Education upon arrival into the country.

Upon arrival in April, the researcher learnt that the Post-Graduate Certificate in Education programme had been suspended because both the university staff and high school teachers were on strike for better conditions of service. This was the first setback. However, the Resource Teacher training programme was still running but the university had few lecturers to staff the programme. The researcher agreed to assist on this programme, as it was an opportunity to distribute and collect questionnaires from the expected 44 teacher participants.

A letter was also sent to the Ministry of Education Sport and Culture, asking for permission to carry out the research in the country's educational institutions. The letter explained carefully the nature of the research and copies of the research instruments were attached to the application. The Ministry officials were quite upbeat about the study and permission was granted. The researcher was invited to the Ministry's Head office where letters of consent were delivered and also individual letters to the Regional Education offices stating that the researcher had permission to carry out the research were handed out. The researcher was able to collect documents on A-level schools in the country from the Head office.

Ministry protocol dictated that the researcher would have to present himself to the Regional Directors in each of the regions visited and hand in the letter, which would be stamped and signed as a sign of regional consent. The letters would then be taken to the individual schools in order to notify Heads that this was a lawful exercise. This routine was followed and no access problems involving Ministry authorities were experienced.

The major problems experienced however, related to the unstable socio-economic and political environment. The government was facing increasing dissent from civic and opposition groups within the country. In May and June, the government had just quashed a teachers' strike. New laws had been enacted and in particular one new law restricted access to information. The law affected all people and was difficult to interpret, so much so that though teachers wanted to participate in the research, they were wary and in most cases, refused the interviews to be recorded. In some cases, the researcher even received verbal cautions from Heads (especially in private schools), to desist from recording the interviews in case other arms of the Government did not approve.

The *negotiation-for-access* visits were carried out in early May. Six Regional offices were visited. In all regions, visits were also carried out to the Science and Mathematics Centre. The purpose of these visits (to Science and Mathematics Centre) was to get a feel of the context in which teachers who were visiting the centres were managing their professional development activities.

3.3.4 Questionnaire Distribution and collection

As a result of the pilot interview discussions with teachers, it had become clear to the researcher that postal questionnaires were not a worthy investment.

In the research diary, the researcher wrote:

Discussed with trainee Resource Teachers about distribution of questionnaires due to the on going go – slow; postal questionnaires out of the question. The trainees suggest that I catch up with teachers at regional workshops – but some are afraid that not many teachers will make it because of financial constraints, and this year SEITT is not supporting field activities. - Still trying to think of a suitable solution to this problem. (Research Diary, 23 April, 2003)

In the end, the researcher decided to use a three pronged approach to questionnaire distribution. The first strategy was to include the trainee Resource Teachers at the university during the residential period. These teachers were all experienced A-level Science and Mathematics teachers, they formed a convenience sample (Tuckman, 1994; Cohen *et. al.*, 2000).

For logistical reasons, the survey was conducted in 6 of the ten educational regions. Matebeleland South, Midlands and Mashonaland Central regions were not included in the sample because most of their schools are rural based and these regions have fewer urban schools that are easily accessible (see fig 3.1).

The second strategy evolved out of a discussion held with the Education Officers responsible for science / mathematics in one of the centres during one of the access negotiation visits. These Education Officers argued that, because of the general discontent and hardships, it was unlikely that teachers would be interested in professional development issues as they would most likely be more concerned with bread and butter issues. Therefore sending postal questionnaires would simply be unproductive as teachers were less likely to be interested. It was suggested instead, that the researcher take advantage of the SEITT activities and distribute questionnaires at the SEITT regional workshops

and collect them immediately after the workshop. This would cut down on the operating costs whilst at the same time ensuring a high yield in the form of completed questionnaires.

However, with the economic situation in decline, and the cost of transport quite high, concern was also raised over the possibility of teachers failing to turn up for workshops. In later discussion with colleagues at the University, it was suggested that if funds could be found to provide teachers with transport subsidies, more teachers could turn up and that would boost the yield. The researcher made calculations based on expected expenditure using the postal system compared to expected expenditure using the suggested alternative.

Although the latter method would be costly (Z\$ 300K compared to Z\$ 240K using the postal system – these being questionnaire costs – not including travel costs for researcher), it was felt that the benefits would be worth it, especially, since interviews could also be carried out during these workshops. The Researcher expenses were expected to remain constant, since the researcher was scheduled to re-visit these regions for face to face interviews anyway. Thus the expected overall effect of the suggested alternative would be to boost both questionnaire and interview outputs.

As a result, during the rest of the “access” visits to the regions, the researcher took the opportunity to give the Science and Mathematics Centre money for workshop support, having carefully explained to both the Education Officer in charge, and the Resource Teachers running the centre how the money was to be used. The money was drawn from the research grant provided by the sponsors of the research. Packages of questionnaires were also left at the Science and Mathematics Centre. The number of questionnaires in each package varied according to the number of expected workshop participants

calculated by considering the region's size (in terms of A-level schools), the Education Officer's advice on potential attendance and other factors such as geographical distance of the schools from the centre. It was reasoned that a region like Matebeleland South for example, which has sparse distribution of schools and no direct routes to the centre, would expect less people to attend workshops than in Bulawayo. In fact, it turned out that the teachers in Matebeleland South region opted to attend the workshop planned for Matebeland North since it was held in Bulawayo and was more convenient for them. This created confusion and thirty questionnaires that had been reserved for Matebeleland South, were lost.

The third strategy evolved out of the realisation that one group of teachers would be excluded from participation if only the Science and Mathematics Centre workshops were used as basis for delivery and collection of data. Postal questionnaires were sent to a randomly selected group of 20 out of the 48 registered private schools. Letters were sent accompanying the questionnaires to explain the purpose of the research and also to invite interested teachers from these schools to participate in the interviews.

To increase the response rate, follow up telephone prompts were used with the Heads of Department (HOD) of schools that did not respond after a month, to ensure that they send back completed copies of the questionnaires.

To resolve the possible problem of duplication, teachers who attended workshops and who came from these selected schools were not given questionnaires to fill in unless they specifically requested them on the grounds that they had not received any at school. Happily this situation arose only once in Mashonaland West. The teacher in question complained that she had not seen any of the questionnaires that the researcher had sent to her school.

Some of the teachers present at this workshop speculated that Heads of Departments at High Schools tend to distribute research materials to people whom they think are better qualified to answer the questionnaires perhaps, in this case, because of perceived interest in ICT (Research Diary, 11 July, 2003). If these teachers were right, such bias would have the added effect of increasing the number of teachers using ICT in the sample.

Although the researcher had determined that the minimum sample size was going to be 300 it was felt that there might be a need for more questionnaires to cater for those undelivered or lost. So to boost the number of returned questionnaires, 500 questionnaires were printed of which 408 Questionnaires were distributed using these three strategies, 259 were returned, providing a return rate of approximately 62%

The reason why the researcher was unable to use all 500 questionnaires was because the questionnaires had been shipped separately and one envelope containing 50 questionnaires went missing and had not been recovered by the time the researcher had to leave the country in September 2003.

Table 3.6 below summarises the Distribution Statistics of Questionnaires.

Centre	Sent Out	Returned	% R/S	Code
University	40	35	88	A
Bulawayo	50	29	58	B
Masvingo	50	38	76	C
Mutare	50	34	68	D
Marondera	50	38	76	E
Mat. South	30	0	0	G
Chinhoyi	31	31	100	H
Total W/shops	301	205	68	
Schools	107	54	50	K
Total Sent	418	259	62	

Table 3.6: Questionnaire Distribution Statistics

To be able to trace the questionnaires, coding was done before the questionnaires were distributed. Each educational region was assigned an

alphabet letter from A-J. The questionnaires that were sent directly to schools by post were all assigned a code K. The questionnaires were then numbered using the region identifier as a prefix. For example, Science and Mathematics Centre workshop participants in Masvingo region, all questionnaires would begin with the letter "C" and would be numbered sequentially up to the maximum (in this case "38"). Similarly, for a private school in Harare, all the questionnaires identity codes would begin with the letter "K" followed by the school identifier (between 01 and 22), followed by the sequential number of the questionnaire up to a maximum for the school. For each region, above 60% return rate was considered good. The table above shows that poor returns were experienced in Matebeleland South and in Bulawayo.

Although the researcher tried to take all precautions to ensure that most of the questionnaires distributed at workshops were returned, problems were still experienced such that some questionnaires remained unaccounted for. One of the problems was that teachers tended to consider any papers distributed at workshops as "handouts" and so were reluctant to give them back. This behaviour is not surprising as it is a reflection of the teachers' thirst for information, but it did mean that some questionnaires were lost. However, some questionnaires were sent by post to Harare by teachers who had inadvertently collected them during the workshops. The questionnaires were identified by their coding and it was a pleasant surprise for the researcher.

The questionnaires sent to the private and independent schools were placed in return self - addressed envelopes, with postage already paid. Initially, 20 schools each received 5 questionnaires. 12 schools responded. Later, two teachers also requested additional questionnaires to distribute at their schools. Although these were not originally selected, their returns helped to boost the

postal questionnaires. Thus although the questionnaire return rate was just 50% for the postal questionnaires, the number of schools that participated was quite encouraging. The researcher feels confident to claim that private schools were well represented in this sample.

Despite the fact that the context in which the research was carried out necessitated a change in the data collection strategy from random to convenience sampling as described above, the researcher believes that the data obtained through the strategies described above can be generalised for the A-level science and mathematics teacher population in Zimbabwe. Bryman (2001), argues that convenience sampling is difficult to generalise to the whole population of teachers as it is based on “opportunity”. However, considering that in Zimbabwe, all A-level public school science and mathematics teachers were expected to participate in regional workshops and that the sample covered six out of nine educational regions, and 68% of those who participated at the workshops actually also participated in the survey, the researcher believes this sample is representative of the public school science and mathematics A-level teachers. Similarly, approximately a quarter of the A-level science and mathematics teachers in private schools participated in the survey. As these were drawn randomly across the country, the researcher is again inclined to believe that the sample is representative of private school teachers in the country.

However, the researcher also recognises that selection of the questionnaire samples was neither systematic nor randomised in a statistical sense, and does not make for an ideal probability sample. Nevertheless, because of the reasons given above, the researcher believes that the overall sample of teachers used in

the study is representative of the teacher population in the country and statistical methods can be applied to the sample with confidence.

3.3.4.1 Coding of received questionnaires

Once the questionnaires were received, the questionnaire items were coded onto an SPSS spreadsheet, beginning with the identifier. However initial inspection revealed that some questionnaire items had received poor responses, for example in item 2, very few teachers selected the option for *college*. The researcher thought that this could have been because in the respondents mind, this category was meaningless as teachers considered themselves as teaching at either, a private school, a government school or a mission school, regardless of what label the school was given. Thus the term college was dropped from the analysis and this choice was subsumed into the category of private schools, since most of the “colleges” have independent funding.

Items 4-7 were free-response items and this was meant to provide the respondents with wider flexibility to air their views. However, this also presented problems for encoding, as some of the choice ranges were too wide. Logical categories had to be chosen to include these choices.

Items 5 and 6 were initially coded separately to reveal the training and teaching subject characteristics of the sample. However the researcher was also interested to find out whether teachers were teaching subjects for which they were trained, and so the two sets of responses were combined to form new fields which were; *Trained and teaching / not trained but teaching* for each mathematics / science subject. Furthermore, it was realised that A-level mathematics / science teachers had been prepared to teach at least two subjects at university, so the subject field had to be subdivided into the five separate categories to enable encoding choices for each individual teacher.

For questionnaire items 7 and 8, logical categories were chosen to reflect teaching experience and initial training respectively. For teaching experience, the categories were based on Vonk's experiential Professional Development Model (see section 2.3.2.1). Beginning teachers were classified as those with less than two A-level teaching cycles, i.e. one cycle comprises of lower and upper sixth teaching. Middle career teachers had teaching experience of up to 7 cycles whereas experienced teachers had more than 7 cycles. In terms of the questionnaire codes, these categories translate to: *3 yrs, 3.1-8 yrs, more than 8 years.*

Item 8 required information on initial training. A very wide range of teacher training institutions were cited. In the end the researcher decided to divide these into two categories: *Institutions within Zimbabwe, and institutions outside Zimbabwe.* It was felt that categorising responses in this way would allow for meaningful cross-tabulations.

Items 9-11 pertained to categorical statements about computer access. These were encoded individually but then the researcher found that it was also interesting to combine the responses to reflect teachers who:

- i) had computer facilities at school, had access to these facilities and had used ICT in the last 12 months.*
- ii) had computer facilities at school, had access to these facilities but had not used ICT in the last 12 months*
- iii) had computer facilities at school, did not have access to these facilities but had used ICT in the last 12 months*
- iv) Did not have computer facilities at school and had not used ICT in the last 12 months*

- v) *Did not have computer facilities at school but had used ICT in the last 12 months.*

These additional categories were added in SPSS as a separate field to allow for easier cross-tabulations.

In item 12, teachers were asked to indicate where they acquired their ICT skills. Six responses were suggested. However upon inspection, it was found to be easier to divide the responses into two mutually exclusive categories, those who went through *formal / informal* ICT training. Both the World Links and the Science and Mathematics Centres offered ICT training so choices in this category were ascribed to *formal* training. Internet cafes and “self taught” are examples of *informal* training.

Each of the sub-items in no 13 had 4 options. Upon inspection of the received questionnaires, it was found that only two fields were required for these options. Teachers could be considered to be experienced (*having moderate-extensive experience*) or inexperienced (*none-minimum experience*). It was felt that this grouping could assist in identifying trends in cross tabulations of individual teachers.

Items 14-17 were concerned with access to ICT facilities. Item 14 was free response. The researcher saw fit to categorise the responses into four groups: *home access, school access, resource centres access and commercial services access*. Although school and resource centre access could be called educational services, the researcher wanted to distinguish between the two because in most cases teachers had to travel to resource centres, so it was felt that keeping this field separate in SPSS would make it easier to identify any trends associated with distance from access points.

Item 15 was likewise coded into two groups: *frequent access*; at least once a week, and *infrequent access*; less than once a week.

Item 16 was another free response item and the teachers' responses were grouped into three categories of distance, *0-2 km* which could be taken as *in loco*, meaning that teachers did not need to travel to access the facilities. *2.1-10km* which implied that the facilities were within walking distance from the school and *more than 10km*, whereby teachers would have to board buses to get to the ICT facility location. While this categorisation was useful when considering teachers in rural schools, the researcher realised that in urban areas distance to the ICT facilities was not very important as in most cases ICT facilities, schools and homes are within easy reach of each other. For example, in rural areas, the chances were that teacher lived on the school campus, so if one had a computer, the distance would be in the first category (*0-2 km*). On the other hand, a teacher staying in town could live far away from the school so that if one had a computer at home, the access distance would still be greater even though the teacher was not expending special effort to reach the ICT facilities.

The free response aspect of item 17 was not coded into SPSS but would be presented separately as a list of common problems, because the problems were too varied to allow grouping.

Items 18 and 19 and their sub-items were Likert type and the coding used was standard, i.e.: *Useful (1 and 2)*, *Undecided (3)*, *Not useful (4 and 5)* and *Don't know*. These were re-coded 1-4.

Item 20 was a Thurstone type and was coded as according to the categories of the CBAM (see Loucks-Horsely *et al.*, 1991) model discussed in the literature review. The coding was as follows: *awareness; responses 1 and 2, self*

orientation; responses 3 and 4, task orientation; responses 5 and 6 and impact on practice; responses 7 and 8.

Similarly, item 21 was coded against CBAM's level of use categories, i.e. as *non users; responses 1 and 2 and users; responses 3 -6.*

Item 22 was a free response item in which teachers were invited to make comments on how they used Internet materials for teaching. This list and explanations that they gave were further inspected. Two fields were thus created. One field was concerned with uses of the materials for teaching. 5 categories were generated in this case: *non use; 1, teaching resources; 2, learning resources; 3, assessment resources; 4 and communications; 5.*

The second field concerned how teachers perceived the benefits of using ICT on the teaching / learning process. The two categories in this case were: *1; benefits to the teacher, and 2; benefits to the student.*

The two fields were chosen because it was felt that they could be used to investigate trends across the various groups and teacher characteristics.

3.3.4.2 Testing for reliability of the transferred codes

After setting up the codes, it was necessary to check for their reliability and validity. This was done in consultation with the researcher's supervisors. Firstly, frequency tables were constructed in SPSS and meaning was drawn from them. Codes which produced frequency tables which were ambiguous were discarded and new reinterpretation of the responses was attempted. Some of the code changes described above were a result of this sense making process.

Secondly, related items were cross checked to test for the reliability of the responses. For example, items 9 and 10 were cross checked to eliminate contradictions. If a teacher responded with a *no*, to item 9, they could not respond with a *yes* to item 10. Likewise, a teacher who earlier indicated that he

/ she accessed ICT frequently could not be expected to claim in item 20 that they had little or no knowledge of ICT use.

Thirdly, the responses to all open-ended items were coded independently against the agreed coding grid by at least two researchers. The few differences were discussed and reconciled indicating a high inter-coder reliability.

3.3.4.3 Cleaning up of data

The returned questionnaires were checked for incorrectly filled responses. For example when a batch from a school was inspected, it was found that one script had been completed by an English teacher. This script had to be discarded because it did not belong to the targeted audience.

A few teachers left items 9, 10 and 11 blank and did not proceed to section B. In this case the assumption was that he did not have computers at school and had not used them. A trickier case however was provided by a teacher who filled item 11 negatively, that is, suggesting that he had not used computers in the past 12 months, but then went on to fill the rest of the questionnaire in a way that suggested that he was a regular user of computers. By cross checking with item 15 it was possible to determine that the teacher had filled out item 11 negatively in error and had meant it to be positive. Where the contradictions were irreconcilable, the questionnaire script was discarded. In total, 5 scripts out of the 259 questionnaires were discarded, representing a 2% error margin.

3.3.4.4 Treatment of missing cases

Sometimes teachers neglected to fill in some responses and thus handed in partially completed questionnaires. The missing cases were reported and taken into consideration in the analysis. High percentage of missing cases could

mean that the particular item was confusing to the respondents and not much value could be ascribed to it.

3.3.5 Semi-structured Interviews

In total 38 semi-structured interviews were carried out initially and were followed up with 16 more open interviews. Altogether, 55 teachers were interviewed. Two teachers were interviewed together, because they both happened to be free at the same time and it would have been difficult to organise an alternative time.

The first group of interviews was done between May and July 2003, and the second group in January / February 2004 as mentioned in section 3.2.1, will be discussed in greater detail below:

- a) The first set of interviews took place at a time when there was a lot of civil unrest and disruptions in the country, as a result of local and international disagreements on the outcomes of the presidential elections. Teachers were the worst affected because they embarked on a two month period of industrial action for better working conditions in May and June.
- b) Although situation improved in July when the teachers' dispute was resolved, and a few schools allowed the researcher to interview teachers. However, July is the busiest period on the teachers' calendar in Zimbabwe as they are involved in assessment and writing up of end of term reports, in preparation for the mid year holidays.
- c) Most teachers were reluctant to be interviewed, fearing for their safety.

So it was not possible to meet more teachers because of these constraints. It was therefore felt necessary for the researcher to revisit the schools in January and early February, 2004 when the situation had stabilized, and hold

more interviews. This time three methods were used to select teachers for the interviews:

- i) Resource teachers and education officers provided names of prospective interviewees. They had selected these teachers based on their own knowledge and experience of working with them, and also their knowledge about the teachers' participation in professional development programmes. In other words, in most cases, the selected teachers were regarded as "expert masters", or teachers in the renewal stage of their professional development (Steffy *et al.*, 2000).
- ii) Some teachers who were interviewed under the restrictive conditions at Science and Mathematics Centres had expressed a willingness to participate in further interviews at their schools. In most cases these teachers were upbeat about their use of ICT and wanted to share some of their "discoveries". These interviews were considered as follow-up interviews and were coded as one with the original interview. However, note was taken of the dates for the interview.
- iii) Thirdly, using the snowball effect; during interviews, some teachers would recommend colleagues whom they knew to be knowledgeable about ICT use. The researcher would phone these teachers and ask for an interview.

3.3.5.1 Interviews: May-July 2003

The first interviews were therefore held at Science and Mathematics Centres during the teachers' workshops. This was not an ideal strategy as the teachers were busy. As mentioned before, the socio – political environment at this time precluded the use of tapes during interviews so the majority of the discussions were recorded through notes. Because of the time constraints and the need to

have views of as many teachers as possible from different schools, the interviews were much shorter, lasting approximately 20 to 25 minutes on average.

Though the teachers were guarded in their responses and avoided commenting much on their feelings pertaining to job satisfaction, they did provide useful insights as to why they turned to ICT in their bid to develop themselves.

From mid June to end of July, the researcher interviewed some of the teachers at their schools. These teachers had indicated an interest in the research either during the initial Science and Mathematics Centre and school interviews. Usually, once the researcher visited a school, he tried to ask for interviews with other members of the science and mathematics departments who had not been at the Science and Mathematics Centres, to try to find out if and where they accessed ICT.

While the Heads permitted the researcher to interview teachers in their schools, some of the teachers were clearly uneasy and nervous because of the unstable political climate. They tried to limit the interviews to the shortest time and in cases where multiple interviews had to be held at the same school, teachers tended to disappear from the staffrooms if the interview was too long.

Teachers from Private schools proved to be more amenable to being interviewed. The teachers interviewed in this case, were mainly those who had indicated on their questionnaires that they wanted to discuss their experiences on the use of ICT with the researcher. The teachers were more open and frank and allowed the researcher to record the interviews on tape.

The first set of interviews highlighted some issues. For example, it became clear that teachers had different operational definitions of professional

development and who they considered to be responsible for their professional development. The first schedule had been drawn up on the assumption that teachers considered themselves to be responsible. This was found not to be the case in many interviews prompting the researcher to opt for a more open interview approach, to tease out more of the teachers' views on these wider issues.

Some of the interviews that could not be recorded contained data that the researcher considered rich and illuminating. The researcher attempted to note views verbatim, especially in instances where the interviewee made an "unusual" assertion or expressed a more view very succinctly. However, the researcher was always aware that the possibility of missing significant comments was greater when trying to listen and write notes at the same time. The researcher therefore asked some of these teachers for follow-up interviews.

3.3.5.2. Interviews: January / February 2004

The second set of interviews was held at a time when the socio-political environment was stabilizing and teachers were more tolerant towards being recorded during interviews. The researcher believes that this change in attitude arose, not as a direct result of the thawing socio-political climate *per se*, but also as a result of the good working rapport struck between these teachers and the researcher. Using the selection methods outlined in section 3.3.5 above ensured that the researcher was in contact with those teachers who shared his beliefs about the importance of the study and were prepared to contribute to his efforts by adding their experiences.

During the second set of interviews, the researcher took the opportunity to revisit some interviewees, who had provided good but un-recorded interviews previously, at their schools and ask for follow-up *recorded* interviews.

More open ended interviews firstly focusing on the teachers notions of professional development and their use of ICT were used to elicit ideas. Where possible, the researcher made observations and collected documents which were used to support the emerging picture of teachers' use of ICT. However, the researcher's awareness of being an insider made him cautious not to make assumptions about the context under which the teachers were operating. Rather than trying to deny his experience, interest or bias in the matter of ICT usage, the researcher took comfort from Auerbach and Silverstein's argument that, though reflexivity poses a threat in qualitative research, it is difficult to eliminate, therefore it is better for researchers to understand the effect it has on the research (Auerbach and Silverstein, 2003).

The researcher's own interest in ICT and experience in its use acted as a useful guide in open discussions with teachers. To ensure that authentic data was collected, it was necessary to be aware of the context in which the teachers were operating, the pressures and incentives that may have contributed to their desire to use ICT for professional development purposes. Three teachers in three schools in two regions had extended contact with the researcher, to provide deeper insights in the way ICT was used by the teachers for their own professional development. These teachers were selected because they were more open and enthusiastic about the research and were even prepared to show the researcher what they had done with ICT material they had accessed. So these teachers were all interviewed more than once at their schools.

Table 3.7 below gives a summary of the interviews held, the venues and the number of teacher participants.

Region	Interviews		Total Participants	Total No. of schools visited
	Science and Mathematics Centre	Schools participants		

	participants			
Bulawayo	4	4	8	4 school
Masvingo	7	8	15	3 schools
Mutare	4	5	9	3 schools
Marondera	7	7	14	3 schools
Chinhoyi	2	1	3	1 school
Harare	0	6	6	3 schools
Total	24	31	55	17 schools

Table 3.7: Summary of semi-structured interview participants

Interviews held at Science and Mathematics Centres included most teachers from all the traditional science and mathematics subjects except Geography. Geography teachers were mainly interviewed at school. Where the researcher had to choose between interviewing Geography teachers and interviewing science teachers, the science teachers tended to be chosen, because it was easier for the researcher to identify with issues and concerns arising from the science / mathematics field, having been involved with these subjects for a longer period.

3.3.5.3 Transcription and coding of interview data

After recording or note taking the interview transcripts were typed into a word document. Line numbers and comments formatting style was added to the document. As in the questionnaires, identifier codes were used. These consisted of the region identifier, followed by the transcript number followed by a school identifier. For example a Harare teacher teaching at Lord Malvern High School and who was the third to be interviewed overall would have the transcript designated as H 03LM (H – Harare, 03 – transcript number, LM – school name (Lord Malvern)). This system of coding gave each individual transcript a unique identity and made it possible to track interviews and make follow up calls, if need be. In the transcript itself, the teacher was identified only by initials. The full list of the Interview coding system is shown in Appendix 3.6.

However, note that there are 54 transcripts even-though 55 teachers participated, as was explained on page 112.

3.3.5.4 Contextual Study

The contextual study was carried out simultaneously with the access and workshop visits. Data was collected in the form of a research diary and open ended interviews with Education Officers and Resource Centre Managers. Science and Mathematics Centre log books were analysed to get the frequency of teacher visits and also the purposes of the visits. Two interviews were held with Education Officers and three interviews with resource centre managers. All these interviews were recorded on tape.

One challenge presented by the context of A-level science teaching in Zimbabwe, was that the researcher quickly discovered that some of those teachers who, from the Science and Mathematics Centre records, showed high consistency in the use of ICT, had moved on to other professions or moved out of the country during the study period. This was a draw back because it meant that at the individual level the researcher had to continue to negotiate access with different teachers at each visit.

3.4 Data Analysis

As in the methodology, a hermeneutic approach was used in the data analysis process. Analysis of pilot study responses enabled the development of more robust analysis frameworks for the questionnaires and the interviews. These analysis frameworks were further developed and modified in the light of changes made to the data collection instruments, to accommodate the new types of data generated during the main study. This modification process was aimed at strengthening the analysis frameworks and also at increasing their

validity by ensuring their continued relevance to the research questions and the data analysis process.

This process can best be visualised in the following linear-flow diagram as shown in figure 3.2.

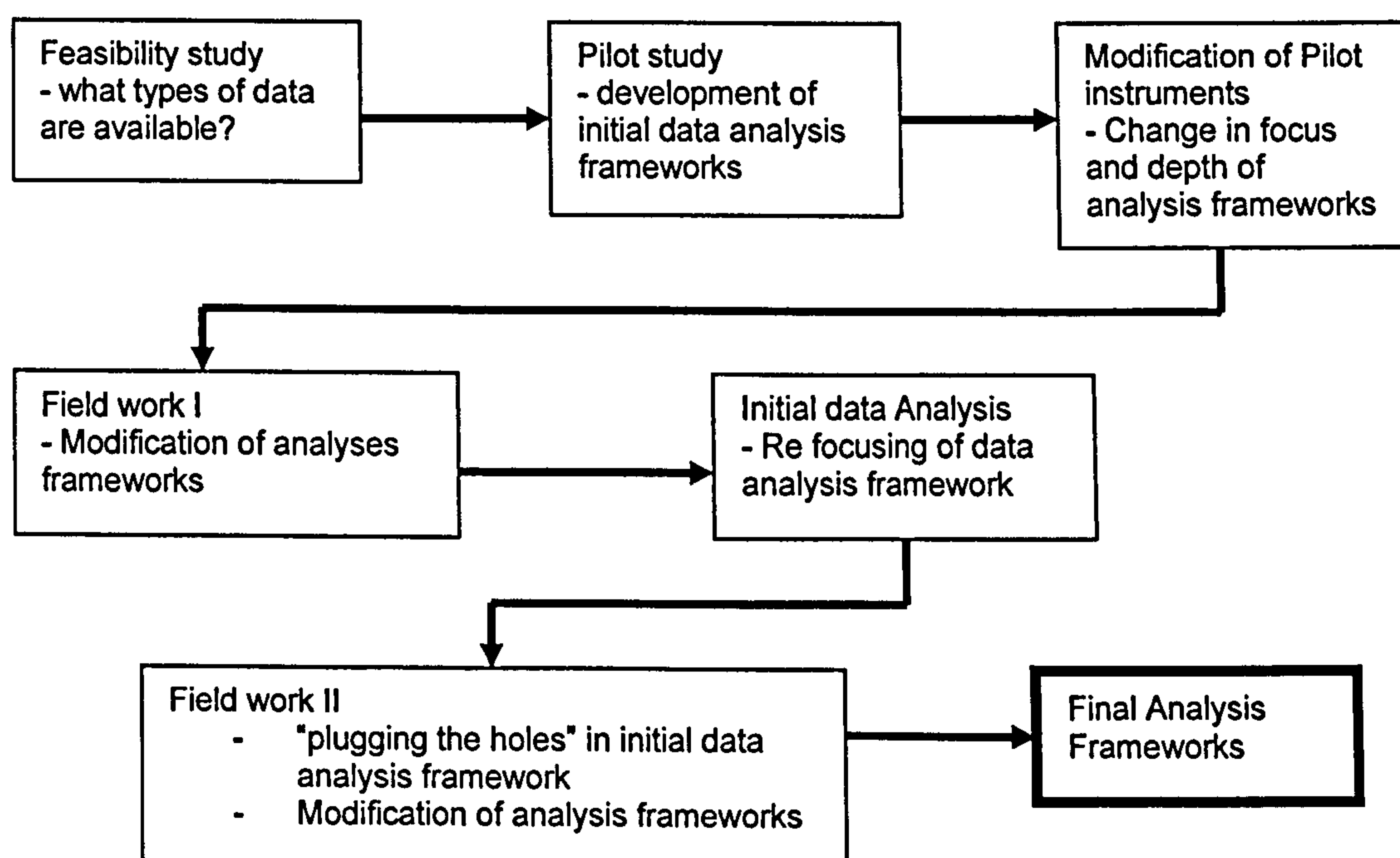


Figure 3.2: The data analysis iterative process

Miles and Huberman (1994) advocate simultaneous data collection and analysis to reduce data overload in qualitative research studies. For this research it was impractical to follow this route as changes in the research design made it impossible to use data from the preceding data collection instruments in making decisions on the selection and implementation of the next stage. For example, both questionnaire and interview data were collected simultaneously throughout the main field work period. Initial analysis of data from the first interviews was used to determine the selection of the participants for the second more in-depth interviews.

3.4.1 Analysis of Questionnaire Data

Uni-variate analysis methods were used to determine majority opinions. Frequency tables and graphs were used to explore biographical and geographical distribution statistics of the teacher sample.

To determine the relationships between variables in the sample, contingency measures were used. The significance of the relationships was calculated using *Chi-square* and Spearman's *rho*. Factor analysis was used to develop statistical models of the relationships.

As stated earlier, the questionnaire was designed to provide solutions to the first research question (RQ): *To what extent is ICT used by Science and Mathematics teachers for their own professional development?* It also provides part of the evidence for answers to the second RQ: *How do teachers perceive the use of ICT as affecting their professional development?* To find answers to these questions, the following methods were employed:

Frequency tables and charts were used to display uni-variate statistics in an easily comprehensible way. To enable easier comparison of values, percentages were used together with frequency counts.

Since most of the questionnaire data was concerned with non-parametric measures, χ^2 (*Chi-square*) test of significance was used instead of the t-Test.

Table 3.8 below summarises the analysis strategy used.

Test		Description	Comment
1.	Univariate Statistics	Items 1-11	Using frequencies and percentages to provide basic population and distribution statistics on Mathematics and Science Teachers and ICT usage in Zimbabwe
		Item 11.	Used as discriminator / selector for those using ICT for professional development
	Word Lists	Items 17 and 22	Follow up opportunities for RQ4 and supplementary support for interviews

2	Bivariate statistics. Contingency tables using χ^2 ,	Items 1, 11,9,17, and 10 contrasted with 2,3,4,5,6,7,8,12,13,14 ,15,16,18, 19,20, and 21	Using cross-tabs to investigate relationships. χ^2 was used to calculate the significance of the relationships
3	Factor Analysis	Items 18 and 19	To find out whether there are any discernable patterns or relationships in the way teachers use ICT for professional development.

Table 3.8: Summary of analysis strategy used for the Questionnaire

Tabachnick and Fidell (2001) describe the χ^2 -test as a comparative analysis between expected frequencies and observed frequencies in a variation. When χ^2 is small, there is little variation between expected and observed frequencies, this then means that differences between variables could arise by chance; i.e. there is no significant relationship between the two variables being investigated. When χ^2 is large, there is a large variation between the expected and observed frequencies, and this means that differences between variables could *not* have arisen by chance; i.e. the variables being investigated are related.

3.4.2 Analysis of Interview Data

3.4.2.1 Interview transcript coding and analysis

Data from the interviews was analysed using grounded theory principles to determine the major tentative themes of impact of ICT on teachers. Proponents of grounded theory, Glaser and Strauss (1967) and Charmaz (1983) argue that theory should develop out of the data collected and that the process of theorising involves repeated cross-referencing between emerging theory and the data collected.

The researcher recognized that the strength of the grounded theory approach lay in its ability to abstract theory from data and this strength was what the researcher sought to exploit.

Two strands of grounded theory have since emerged: The Objectivist approach (Glaser, 1992) holds the view that qualitative data can be objectively analysed through a process of coding, saturation and comparisons. Objectivists believe the data can be analysed just as objectively as quantitative data. In contrast, the Constructionist / Constructivist approach (Strauss and Corbin, 1998) ascribes the value of coding in grounded theory to the construction of meaning. In other words, constructionists are not trying to objectify qualitative data, but place more emphasis on seeking meaning from it (Bryman, 2001).

In this research, the latter strand of grounded theory was considered appropriate. The interview data upon which the analysis was based could not be generalised to the population of science / mathematics teachers, but would be useful to provide deeper insights and better descriptions of the sample teachers' activities. The theories derived from this analysis could serve as a basis for more extensive studies. The coding process took place in five stages:

- i) Interview transcripts and summary notes were typed. Line numbers were added onto the transcripts and relevant text was highlighted by the use of the Microsoft Word[®] *comment* function;
- ii) Initially, *repeating ideas* were identified through open coding the pilot interview transcripts. These ideas were then modified and applied to the main interview transcripts and notes. Repeating ideas were identified through the participants' use of similar words to express an idea, or their use of alternative wording. Repeating ideas formed the basic ideas related to the research questions;
- iii) Groups of repeating ideas were categorised into *issues* by linking the ideas to implicit topics or "organisers" (Auerbach and Silverstein, 2003). These issues were also modified using the data from the main

field interviews. The relationships between the provisional concepts in each theme were established using *in vivo codes* (Strauss, 1987: terms derived from the language of the participants to capture both their context and meaning). For example, from going through the transcripts, it is easy to note that the word “professional development” as used by the participants has a different meaning to the way it was understood by the researcher. Yet the participants all seemed to understand this contrived meaning. Post-modernists (Manning, 1995; Denzin, 1994) stress the importance of cultural immersion of research and the need for researchers to see the world from the point of view of the participants. They argue that cultural immersion allows multiple voices to be heard in research and encourages reflexivity among researchers, as the focus moves from mere data collection, to the active role of the researcher as a co-constructor of knowledge;

iv) *Issues* were in turn organised into larger more abstract ideas called *Themes*. Axial coding was applied to the emerging themes to determine their relationships with each other. This process was supported by the use of more focused open interviews to provide more relationships and also to reveal gaps which were then filled in by further probing to the point of saturation;

v) *Themes* were in turn organized through axial coding to reveal underlying uniformities linking to the major goals for using ICT and thus form the basis for the construction of a theoretical framework of teachers' use of ICT for professional development and the issues impinging on such use. This framework was compared with the existing models on Teacher professional development. This comparison provided the

solutions to RQ4. Figure 3.3 provides a summary of the process of coding and analysis framework development.

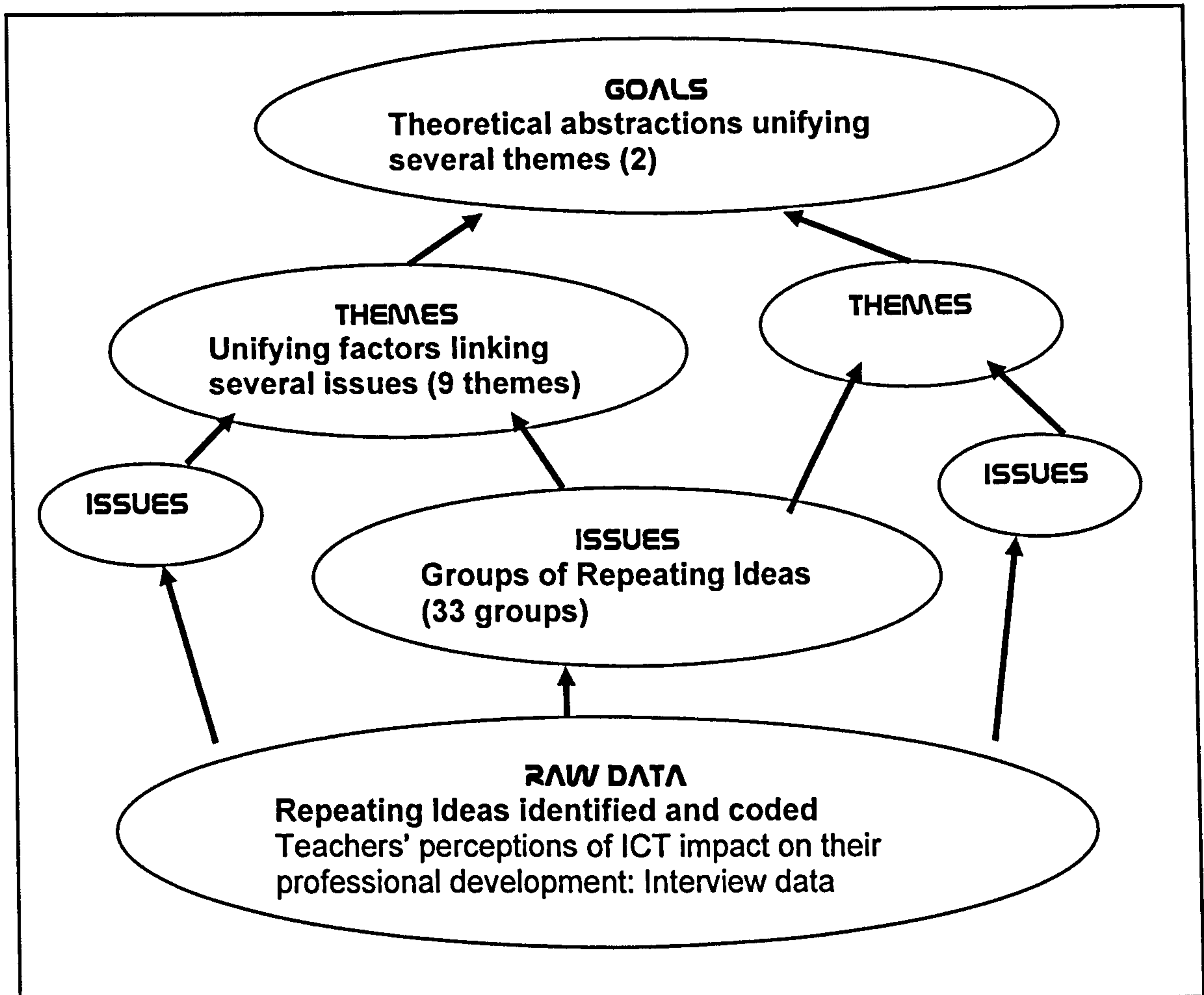


Figure 3.3: Development of the Analysis Framework using Grounded Theory Principles

3.4.2.2 Development of the analysis framework for the Interview

The transcripts were read several times. Recurring (repeating) ideas across transcripts were then coded for all the transcripts. *In vivo* codes were used to mark up transcript sections where repeating ideas were identified. On the transcript itself, using the “comment” function in the word-processor, the text containing the repeating idea was highlighted and a comment in the form of a code was inserted. The ideas consisted of single words or phrases expressing some attribute of the teacher’s perception of the influence or impact of ICT. These single words and ideas were further grouped according to the aspect that

they described. For example, some teachers talked of the use of ICT as increasing their self esteem (M33S), whilst others claimed that the use of ICT increased their self confidence (MAS01M), or made them feel empowered (MN50Ma). *Self esteem, self confidence, self respect and empowerment* are terms that can be said to describe a person's state of well-being. Thus the first group of repeating ideas was coded as "well-being". The notion of "well-being" was found to unify the repeating ideas and was therefore called an "analysis issue". Thus repeating ideas were organised into unifying "issues". The issues were similarly organised into "themes" by identifying unifying factors across the constructs. The resulting framework was the chief instrument to be used in analyzing the data.

During the coding process, each code was defined to be made up of a number for the issue and another number for the theme. Thus in the above example where teacher MAS01M described how the use of ICT made her *more confident* in her teaching, the *confidence* falls under the first issues of *well being*. The issue, *well being* also falls within the first theme, which is to do with the *perceived professional identity* of teachers. Thus on the transcript, a coding of 1.1 would be entered.

Several times the framework was put aside and the researcher worked through the transcripts redeveloping the framework anew, to see whether the new framework contained categories and groups similar to the original framework. This was done to check whether the model fitted the evidence available. In particular, care was taken to avoid using two different codes for the same issue. This meant that the coding had to be exclusive and very clear. Several versions of the analysis framework were tried and modified. In trying to keep the framework categories exclusive, attempts were also made to keep the

framework as short and simple as possible. The completed framework was then compared to the original and variations in the issues and themes were clarified and re-assigned. The final coding framework was thus developed. Appendix 3.8 shows the final coding framework.

The final coding framework also shows the research question targeted by each theme. The researcher admits that some of the themes could have information that is valid for different research questions, but after careful analysis and re-analysis, the researcher is satisfied that the themes have been organized so as to provide substantial solutions to the targeted research questions.

The researcher however continued to check reliability by coding and re-coding the same script after a few days, and comparing the rate of coding agreement. By the end of the framework development, the agreement rate was close to 95%.

To ensure the reliability of the use of the coding framework the repeating ideas were coded and recoded until saturation was achieved, when no new codes could be identified from the raw data. At the early stages, independent coding was also carried out by the researcher's supervisors,, to compare whether the issues and themes were concise and mutually exclusive and the hierarchy of issues and themes were logical. With the help of comments from the supervisors, the descriptors of issues and themes were revised again and again until the researcher was satisfied that the coding description was clear and mutually exclusive. For the final draft of the framework, two copies of the same script were independently coded by the supervisors and the researcher, using the coding framework. The codes were then cross checked to determine the reliability of the framework. A high coding reliability of 80% was achieved.

The transcripts and interview summary notes were revisited and re-coded using the final analysis framework. Colours were used on the transcript to identify text that was coded and text which identified issues that were outside the coding frame. These issues could be contextual or epistemological – relating to the way teachers perceived or defined themselves in general – not directly related to their use of ICT for their professional development but nevertheless exerting an influence on how the teachers viewed such use. For example, issues such as who has responsibility for teachers' professional development, the nature of the teaching profession and gender conflicts had not been accommodated in the analysis framework, and yet they were found to recur, and in some cases to influence the teachers' use of ICT. Thus when such issues appeared in an interview script, they were highlighted in a different colour, to enable them to be identified easily later.

Although the interview questions were posed in English, several teachers tended to use code-switching during their discussions. The researcher saw this as a sign that teachers wanted to convey their feelings more accurately, and allowed the use of the mother tongue wherever the teacher felt this would convey more accurately, what they wanted to say. In the transcripts, the original expressions were preserved. Translations were only made when the script was being quoted – the original script was presented along with the translation in brackets.

3.4.2.3 The development of the interview coding matrix

Once all the transcripts including the notes, were coded using the methods described above, the codes were transferred to a Microsoft Excel spreadsheet and tabulated. The table matrix contained headings with interviewee demographics such as identifier, gender, subject taught, experience and qualifications. The date of the interview was also indicated. The remaining

columns indicated the issue headings denoted by theme number and issue number as described above.

Once encoded, consistency and reliability checks were made as described in the case of the questionnaire. Particular attention was paid to the accuracy of the line numbers and the codes ascribed to them.

Table 3.9 illustrates the coding matrix.

Interview Analysis								
Teacher	Gender	Qualification	Subject	Experience	Date of interview	1.1	2.1	3.1
MAS01M	Female	BSc and GradCE	Mathematics	0 - 4yrs	15/05/2003	line 53	line 26	line 7
							line 71	line 17
								line 32
								line 72
MAS02M	Male	BSc and GradCE	Biology	4.1 - 10yrs	15/05/2003		line 35	line 6
							line 43	line 24
							line 81	line 38
								line 86
MAS03M	Male	Licentiate	Chemistry	4.1 - 10yrs	15/05/2003			line 6
								line 15
								line 26
								line 48
								line 53
MAS04V	Male	BSc and GradCE	Physics	4.1 - 10yrs	15/05/2003			line 7
								line 27
								line 77
								line 92
								line 94
MAS05V	Female	BSc and GradCE	Mathematics	4.1 - 10yrs	16/05/2003		line 52	line 10
							line 75	line 12
								line 16

Table 3.9: Sample of the Interview coding matrix

3.5 Conclusion

This chapter has traced the design and development of this study highlighting the processes and events that influenced the methodology used. The main research methods used were the questionnaires and interview schedules,

though the researcher also kept a research diary, collected and analysed documents and made some observations where possible. 254 valid questionnaire responses were collected and 54 interviews were held in an environment that was fraught with difficulties.

The chapter also offers indications as to what happened to the collected data and how it was prepared for analysis. Chapters 4-6 discuss the analysis of this data in relation to the first three research questions.

Chapter 4: To what extent is ICT used by science and mathematics teachers in Zimbabwe for their own professional development?

Some teachers remain trapped in underlying beliefs and notions of teaching, often continuing to teach in ways in which they were taught, while others develop in more counter-intuitive ways and begin to see teaching and learning in a new light (Sawyer, 2001 p39).

4.0 Introduction

Chapters 4 to 7 will report on the data which answers the research questions posed in the study. A short summary of the most important answers to each question is presented at the end of each chapter. Chapter 4 deals with the first research question. It is necessarily a survey on ICT use, and presents a broad picture of the issues pertaining to the access and use of ICT as perceived by A-level science and mathematics teachers in Zimbabwe. The main data collection method for this research question was the questionnaire. However, interview and other data (Science and Mathematics Centre documents) were used to complement and provide insights into the interpretation of the questionnaire data.

Each section deals with the sub-research questions, and the concluding section summarises the main findings and discussion arguments relating to the research question.

4.1 Who uses ICT among the A-level science and mathematics teachers in Zimbabwe?

Almost 40% of the teachers (101 of the 254 teachers) who participated in the questionnaire survey indicated that they have used ICT in the last 12

months. This sample size (101) is large enough to justify further analysis of the subcategories in this group.

4.1.1 Demographic variables and ICT use

Table 4.1 shows the demographic variables of the questionnaire participants grouped according to their use of ICT.

Demographic characteristic	Variable	Used ICT in last 12 months		Did not use ICT in last 12 months		Total N
		n	%	n	%	
Overall		101	39.7	153	60.3	254
Gender	Male	77	37.9	126	62.1	203
	Female	24	47.1	27	59.9	51
Type of School	Government	30	36.1	53	63.9	83
	Mission	32	32.0	68	68.0	100
	Private	39	54.9	32	45.1	71
School Location	Urban	53	50.0	53	50.0	106
	Peri-urban	29	35.4	53	64.6	82
	Rural	19	28.8	47	71.2	66
Initial Training Institution	Zimbabwean Universities	65	37.8	107	62.2	172
	Foreign Universities	32	41.0	46	59.0	78
Teaching Experience	0-4 years	39	44.8	48	55.2	87
	4.1-8 years	26	37.1	44	62.9	70
	Over 8 years	36	37.1	61	62.9	97
Subject Taught	Biology	14	37.8	23	62.2	37
	Chemistry	15	37.5	25	62.5	40
	Geography	7	19.4	29	80.6	36
	Mathematics	29	34.1	56	65.9	85
	Physics	14	50.0	14	50.0	28
	Combination	22	78.6	6	21.4	28
ICT Facilities at school	Yes	91	45.0	111	55.0	202
	No	10	19.2	42	80.1	52
Can access ICT at school	Yes	80	50.6	78	49.4	158
	No	21	21.9	75	78.1	96

Table 4.1: Demographic characteristics of users and non users

Table 4.1 shows that almost 40% of the teachers who participated in the questionnaire had used ICT in the last twelve months. By inspection, It was also noted from the table that the variables "gender", "Initial training institution", "ICT

facilities at school and *Teaching experience* characteristics, had variables containing more than half of the teachers as *non-users* of ICT. All the other demographic characteristics contained variables which had more *users* than *non-users*.

An interesting observation was that 80% of the questionnaire respondents were working at schools that had ICT facilities, yet less than half of these teachers had accessed ICT in the last twelve months. Another interesting observation linked to ICT facilities at schools was that only half of the teachers who had ICT facilities at school could access these facilities. These and other observations are discussed in more detail in the sections that follow.

Cross-comparisons of item 11 (*use of ICT in last 12 months*) with the demographic variables stated in table 4.1 were made to determine the extent of significance of these associations. SPSS software was used to analyse the data and make the comparisons. Table 4.2 below summarises the results.

Table 4.2: Comparison of ICT use with demographic variables

Variable	N	X ²	df	significance
Gender (using Fisher's Test)	254	1.418	1	0.26
Type of School	254	9.788	2	0.00
School location	254	0.978	1	0.01
Teaching Experience	254	1.409	2	0.49
Initial Training Institution	250	0.237	1	0.36
Teaching subject	254	26.573	5	0.00
ICT facilities at school	254	11.51	1	0.00
Can access ICT at school	254	20.62	1	0.00

Exact significance values are quoted in line with the recommendations made by Neie, (1974) and Sanders, (1995) who argue that since significance levels are arbitrarily defined by statisticians, researchers should quote actual *p*-values to enable critical readers to make informed judgements on the significance of their work.

No significant differences in ICT use were observed, using a 5% probability cut-off point with respect to *gender*, *teaching experience* and the *teachers' initial training*. Studies conducted elsewhere (eg. Anderson *et al.*, 1979; Preston, 1999; Kyriakidou, 1999 and Bowskill *et al.*, 2000) have also shown that there is very little gender bias in the teachers' predisposition to use computers. Female teachers were as likely to use them as their male counterparts. Similarly, no studies have linked teachers' use of computers to their initial training institutions or their teaching experience.

ICT use by the teachers in the sample was found to be related strongly to the "*type of school*", "*school location*", "*teaching subject*", "*ICT facilities at school*" and "*access ICT at school*". Table 4.1 shows that more than half of the teachers from private schools (~55%) had used ICT in the last twelve months, compared to approximately one third of the teachers from government and mission schools. Mission schools had the lowest number of teachers who had used ICT in the last twelve months.

This result was not unexpected because until recently, government A-level schools on the one hand, tended to be concentrated in the urban centres where there was relatively easy access to services such as electricity. Mission schools, on the other hand, tended to be situated closer to the laity – in the rural areas. Mission A-level schools are mainly boarding schools, providing accommodation to both students and teachers on location. This means that teachers working at these schools do not have to commute. Thus if the school has no ICT facilities, the chances are greater that these teachers will not come into contact with ICT facilities until they pass through town. In addition, due to the economic reasons mentioned in chapter 1, these visits to towns are most likely to be infrequent, and hurried, such that teachers will barely find time to visit the Resource Centre

or Internet café unless they really need something there. Even if the schools do manage to acquire ICT equipment, the mission school clientele are drawn from peasant farmers who in most cases cannot afford to contribute the money required to invest, maintain and run ICT facilities efficiently. The aid (per capita grants) received from government is in most cases not enough to meet the schools' needs even for telephone services necessary for communications.

Urban-based government schools on the other hand draw their patronage from workers, who are better shielded from economic hardship by the fact that they earn money every month and therefore can afford to supplement government's efforts by providing fees and even helping to raise funds for the school through donations and projects. In addition, these teachers have easy access to Resource Centres and Internet cafés, both of which are normally located in town. The fact that 64% of these teachers still did not access ICT facilities is an indication that proximity to ICT facilities on its own was not the only factor influencing teachers' use of ICT (see table 4.1).

Private schools, being completely independent, attract well-to-do clients who are prepared to pay for their children's education even though they receive no assistance from Government. These schools can generally afford to purchase and maintain ICT facilities. As shall be seen in chapter 5, these schools also have excellent relations with local business. Chapter 5 will also confirm that ICT use in these schools is integrated into the curriculum.

Table 4.3 below shows a comparison of the type of school and whether or not these schools had ICT facilities, and whether or not teachers were allowed to access these facilities.

		Gvt. Sch.	Mission Schools	Pvt. Sch.	Totals	Chi-SQR X^2	Degrees of freedom	Sig. P
ICT facilities at school	Yes	58	82	62	202	7.77	2	0.02
	No	25	18	9	52			
Access facilities at school	Yes	41	60	57	158	15.87	2	0.00
	No	42	40	14	96			
Use of ICT	Yes	30	32	39	101	9.79	2	0.07
	No	53	68	32	153			

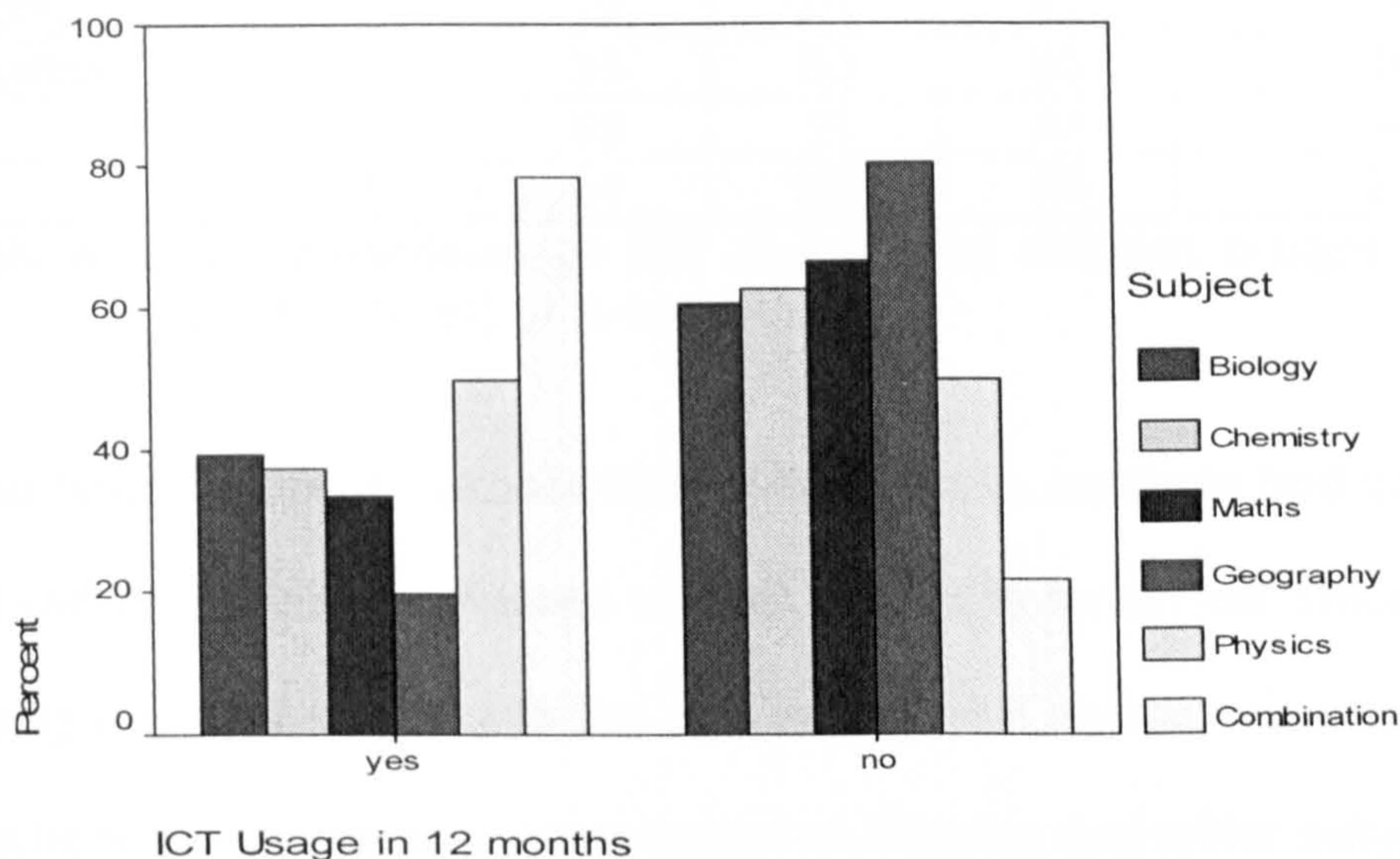
Table 4.3: Comparison of *type of school* and *ICT facilities at school*

Table 4.3 above, shows that 87% (62/71) teachers teaching in private schools; 82% of teachers from mission schools; and almost 70% (58/83) of the teachers from government schools; have ICT facilities at their schools. Yet in all cases, fewer teachers were able to access these ICT facilities at school. All these observations are highly significant, suggesting that this is a strong pattern, which suggests that there could be other factors that influence access and use of ICT facilities at school. These factors are explored in the next section (section 4.2).

Table 4.3 also shows that there is a significant relationship between teachers' use of ICT and their teaching subject. A graph of teaching subject versus ICT usage in 12 months was plotted as in figure 4.1 below in a bid to explore this relationship further.

The graph shows that almost 80% of science teachers teaching a combination of subjects at A-level had used ICT in the last twelve months. i.e. ICT was used more frequently by teachers teaching more than one A-level subject than among teachers of single subjects. Secondly, ICT use appears to have been more common among physics teachers than among teachers of the other subjects since almost half of the Physics teachers had used ICT compared to less than 40% for the other subjects.

Figure 4.1: Variation of teaching subject with teachers' ICT use in the last twelve months



On the other hand, less than 20% of geography teachers had used ICT in the last twelve months, but this observation is not significant because of the small number of Geography teachers who participated in the survey.

Table 4.4 shows the breakdown of subjects combinations taught by those teachers who had more than one A-level teaching subject.

Combination	N	%
Biology / Chemistry	4	14
Biology / Mathematics	4	14
Mathematics / Physics	6	22
Physics / Chemistry	14	50
Total	28	100

Table 4.4: Teacher distribution by subject combination

From table 4.4, 72% of the teachers teaching a combination of subjects at A-level were teaching Physics and another subject. ICT usage was compared with the subject taught and re-tabulated. The results of shown in table 4.5 below:

Subject	ICT usage in twelve months				Total (N)
	n	Users %	n	Non Users %	
Biology	18	43	24	57	42
Chemistry	25	48	27	52	52
Geography	7	19	29	81	36
Mathematics	33	35	60	65	93
Physics	28	60	19	40	47
Total	111	41	159	59	270

Table 4.5: A comparison of ICT usage and subject taught (including combinations) at A-level.

From table 4.5 above, almost 60% of the Physics teachers had used ICT in the last twelve months, compared to less than 50% for all the other subjects. Combining this observation with the one in table 4.5 above, one can postulate that teachers of Physics or a combination of Physics and other subjects in the sample, were more likely to have used ICT in the last 12 months. This is a curious finding since none of the literature the researcher had consulted had suggested that there could be differences in ICT use based on subject. Most of the research that has been carried out to date, has concentrated on structured professional development programmes in which science and mathematics teachers have been introduced and encouraged to use ICT as part of the programmes. Examples of such programmes are the school-net programme in Canada (Bracewell et. al., 1998; CSCE, 1999) and the Miranda-net, in the UK (Kyriakidou, 1999). However, none of these programmes have investigated the possibility of teaching subjects, as exerting an influence on teachers' choices to use or not to use the Internet. A comparison of ICT use by subject will be revisited in chapter 6 to try and provide possible explanations of the observations from interview data.

When teachers were asked to describe how they used the ICT resources they had accessed in the last twelve months, more physics teachers claimed to use the facilities to access teaching resources over the Internet, than other

subject teachers. During interviews, teachers indicated that the resources sought ranged from simulation programmes for use during teaching (MAS04V, ME12M), Assistance in identifying pupil misconceptions during teaching (ME14N, MN47M) to the setting up of design practicals (MN50Ma, MN43L).

This seems to imply that ICT use was tied to the particular demands of the subject taught. In Zimbabwe this observation would be plausible, considering that Physics laboratories are the most expensive investments in the school budget, as evidenced by the fact that the subject tends to be introduced last into the school curriculum after upgrading to A-level status. In most cases, schools cannot afford physics equipment for such topics as “*electricity*” and “*magnetism*”, “*waves and optics*” and “*modern physics*” and the teachers may have to rely on the use of simulations and demonstrations. It then becomes very important for the teachers themselves to have good understanding of the basic concepts involved, for them to be able to help their pupils to understand the abstract concepts and processes involved. In addition, physics textbooks are very expensive in Zimbabwe. For example, teacher ME26N has recently moved to his new school where he teaches A-level Physics. After highlighting the problems he faces in his teaching as a result of shortages of textbooks and equipment at his new school, he made this remark:

I have downloaded detailed examples and demonstration notes on topics such as electronics, which really improved my presentation to students... the notes from the Internet, for example, pertaining to the gain in operational amplifiers were much more detailed and practical.... The quality was good especially for electronics, it was at the right level for my students and was presented in a very simplified way that is easy to understand, with lots of practical examples (ME26N, lines 35-46)

For this teacher, the Internet acted as a resource for practical teaching ideas that he could use in class to compensate for the absence of expensive Physics textbooks.

4.1.2 Access to ICT facilities

Four out of every five teachers who responded to the questionnaire indicated that they worked in schools which had ICT facilities. However, slightly more than three quarters of these teachers had access to ICT facilities within their schools.

To provide a better picture of the access dynamics to these facilities in schools, responses to questionnaire items 9 (*ICT facilities at school*), 10 (*can access ICT facilities at school*) and 11 (*used ICT in last 12 months*), were combined. By making this combination it was possible to determine for example, how many teachers came from schools that had ICT facilities, how many of these teachers could actually access these facilities, and above all, the proportions of teachers, who had access to IT facilities at school, and had used ICT in the last 12 months. Such a combination would provide insights into the dynamics of access and use of computers by teachers.

Using these combinations, it was possible to divide questionnaire respondents into six categories thus:

Category A: teachers who had access to ICT facilities at school and had used ICT in the last twelve months

Category B: teachers who had access to ICT facilities at school but had not used ICT in the last twelve months

Category C: teachers who had no access to ICT facilities at school but who still managed to access ICT in the last twelve months

Category D: teachers who had no access to existing ICT facilities at their school and had not used ICT in the last twelve months

Category E: teachers who came from schools that did not have ICT facilities, but did manage to use ICT in the last twelve months

Category F: teachers who came from schools that did not have ICT facilities and did not use ICT in the last twelve months.

Table 4.6 summarises the availability and access information described above.

	Access and Usage	Category	Number of Participants	Percentage %
ICT USERS	Have facilities at school, Can access these facilities, have used ICT in last 12 months (YYY)	A	80	32
	Have no facilities at school, but have used ICT in the last 12 months (NNY)	E	10	4
	Have facilities at school, cannot access these facilities but have used ICT in last 12 months (YNY)	C	11	4
ICT NON-USERS	Have facilities at school, cannot access these facilities and have not used ICT in the last 12 months (YNN)	D	33	13
	Have facilities at school, Can access these facilities but have not used ICT in the last 12 month (YYN)	B	78	31
	Have no facilities at school, and have not used ICT in the last 12 months (NNN)	F	42	17
	Total		254	100

Table 4.6: Access of ICT facilities at school

From table 4.6, the six categories of teachers can further be grouped into users and none users. Categories A, C and E are the users and these constitute 40% of the sample. Categories B, D and F are non-users and they constitute 60% of the sample. The rest of this section will discuss the important characteristics pertaining to these two groups.

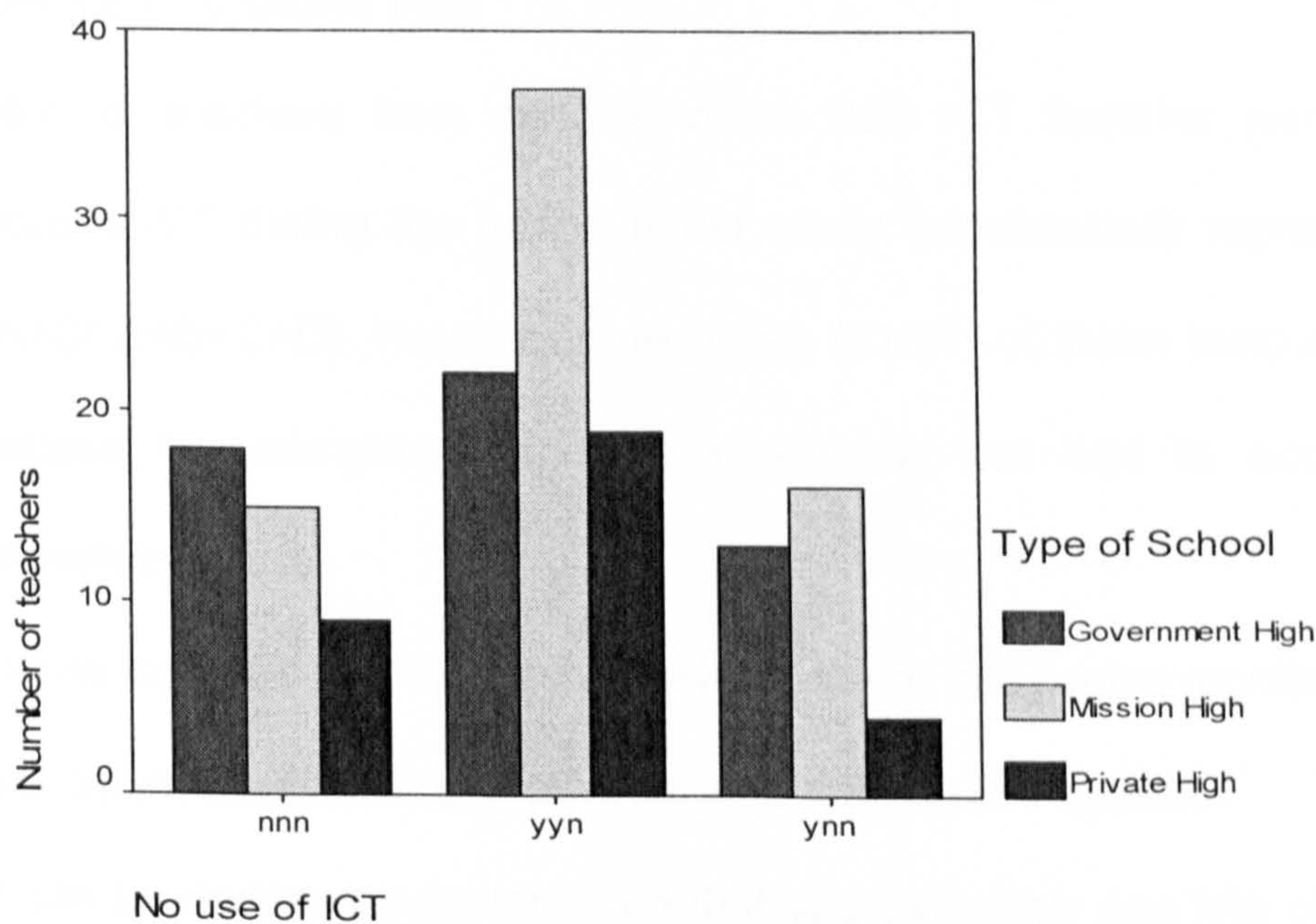
4.1.2.1 The non users

From table 4.6, it can be deduced that:

1. almost half of the teachers who can access ICT facilities in their schools $[B / (A+B)]$, have reportedly not used the facilities in the last 12 months.
2. Despite the fact that four out of every five teachers who participated in the questionnaire came from schools that had ICT facilities, almost two – thirds (~60%) of the teachers in the whole sample had not used ICT in the last 12 months.
3. Ironically, among the non users group, more than two- thirds (111/153) of them came from schools that had ICT facilities, and 70% of these teachers could access computers at their schools, but chose not to.

In order to better understand the challenges and reasons why teachers who had access to facilities at school, had not used ICT in the last twelve months (YYN), an analysis of their geographical distribution was undertaken. Though statistical analysis did not yield any significant results, figure 4.2 below shows almost half of these teachers (47.4%) reportedly work in mission schools.

Figure 4.2: Variation of non ICT users with the type of school



As has been mentioned above (in section 1.1), mission and government schools rely heavily on donations. They receive a little funding from government,

and parents are too poor to contribute much. However, donor organisations and individuals do sometimes donate equipment to the schools (see, Herald, 2005; Zim-Online, 2005). Donated ICT equipment could well account for the majority of the ICT facilities referred to by these teachers. It is quite possible that some of these donations did not involve training of the staff to use the equipment so that some of the equipment, though available to those who have the skills, remains unused because of shortages of skills among the intended beneficiaries.

An implication that can be deduced from figure 4.2 is that providing teachers with ICT facilities was no guarantee that they would use them. This opinion was demonstrated by the group of teachers who were allowed access to computers at school, but did not manage to use them in the last 12 months (YYN).

4.1.2.2 The users

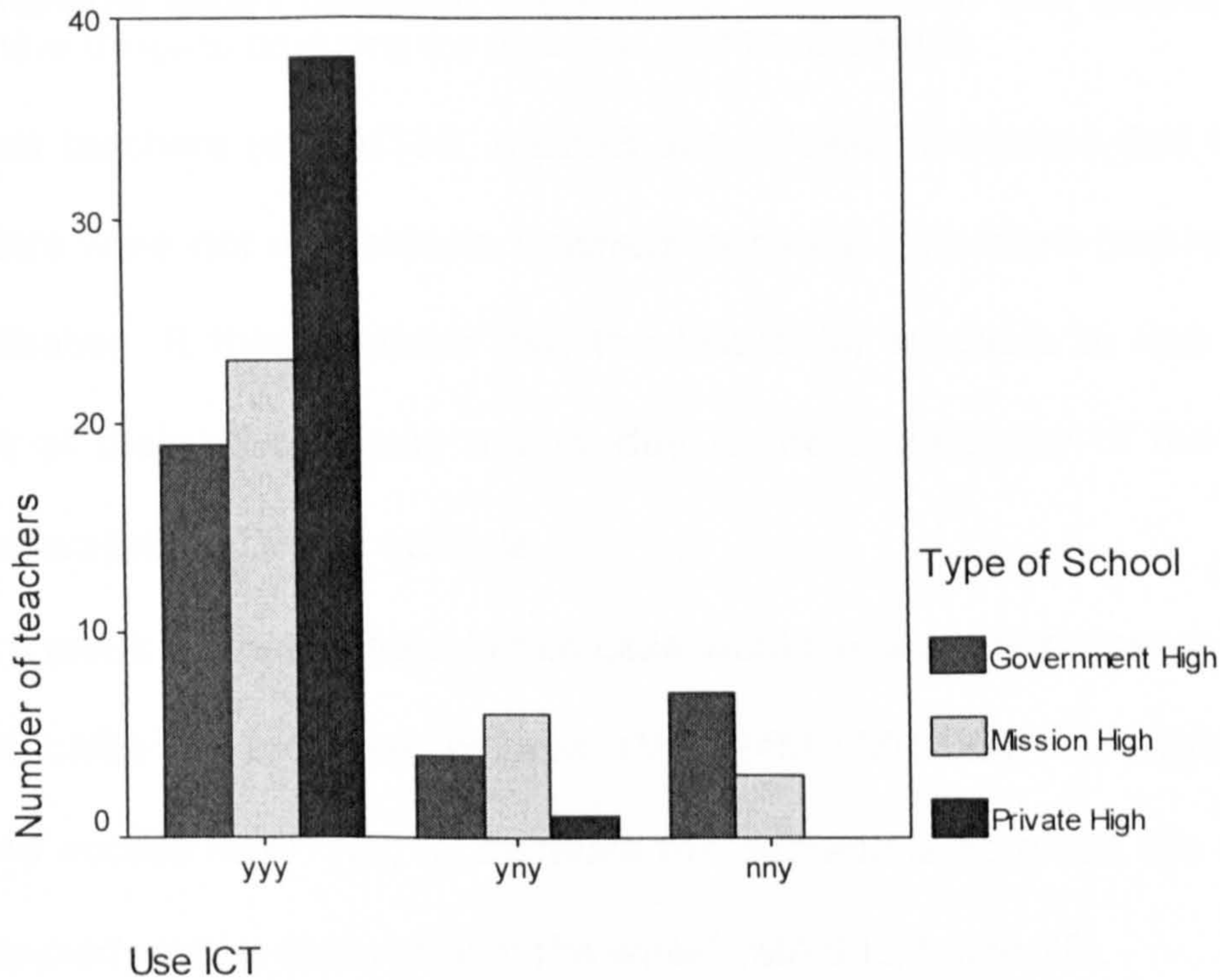
Table 4.6 also shows that:

1. 45% of teachers from schools which had ICT facilities were able to access ICT during the period under study (algebraically represented as $(A+C/A+B+C+D)$). However, one eighth (11/91) of these teachers did not access the computers from their schools, but had to access them elsewhere.
2. Of the teachers who had accessed ICT in the last twelve months ($A+C+E$), one in ten teachers came from schools with no ICT facilities.
3. It can be deduced from table 4.6 that approximately one fifth of the users did not access computers from their schools ($C+E/A+C+E$).

An analysis of the demographic distribution of these teachers is shown in Figure 4.3. The bar chart confirms the fact that almost 80% of the teachers in

the questionnaire sample who had used computers in the last twelve months, had used them at school. Teachers from private schools accounted for 47% of the users in this category.

Figure 4.3: Variation of ICT users with the type of school.



From table 4.6, one in five teachers teaching at schools where ICT facilities are available were not able to access ICT at their schools in the last year $[(C+D)/(A+B+C+D)]$. A quarter of these teachers however did access ICT elsewhere. This is quite surprising as it appears illogical that schools would invest in computers to which the teachers would be denied access to them. The interviews both confirmed this situation and suggested reasons why this was the case. Whilst most of the public school teachers interviewed indicated that their schools had acquired computers, the distribution, location and quantity of these computers were limiting factors in terms of access. For example, interviewee MW43L, reported that his school had acquired three computers and these were located in the library. The limited number of computers and the openness of their location would result in a high demand for the ICT resources

and intense competition for access. When one Harare Physics teacher was asked why he did not access computers at his school, he replied:

We have five computers in the school. There is a great demand for them and I have seen teachers competing with students for access to the Internet because here it is provided for free. The computer lab is therefore always occupied, and I do not have time to wait around. I have things to do during my free time. (H45Q, lines 6-8)

Other teachers (e.g. M33S, ME25B and MN49E) indicated that the school computers were not available to teachers because they were reserved for the administration. It thus appears that the failure for teachers to use computer facilities at their schools was mainly due to the inadequacy of the computer facilities available at these schools.

As a result some teachers in this case would lessen the pressure by visiting Internet cafés or resource centres (MAS24M, ME25B), or negotiating for weekend access (MW17S), “...because the demand is so great, the computers are occupied all day, every day of the week” (MAS03M, line 29).

In contrast to the mission and government schools, the 13 teachers from private schools who were interviewed generally enjoyed better access to ICT facilities. These schools were characterised by a wider distribution of ICT facilities available for teachers. For example, Interviewee M08H, from a private school in Manicaland said, “we have a computer science department and we also have computers in the science and mathematics departments” (line 4). Teachers from a private school in Harare also painted a positive picture about computer facility distribution within their school. They highlighted that the school has departmental computers that are networked with the rest of the computers in the school and also that are connected to the Internet (H28G). One of the teachers also mentioned that in addition, the school has two computer labs, one for staff and the other for students (H29G). Another teacher from the same

school revealed that the library is also networked (H30G) thus completing the picture of a highly computerised school. A similar picture emerged with respect to another private school in Marondera, where one teacher indicated, in addition, that they had the direct support of the managing director of MWEB, which is a leading Internet services provider in Zimbabwe (ME37W).

From the foregoing discussion, it appears that teachers at school also face constraints that limit their use of ICT for professional development purposes and in some cases, have necessitated the need for teachers to use other service providers to satisfy their professional development needs. ICT resource distribution has been found to be closely linked to the type of school, with teachers from private schools enjoying better access than teachers in government and mission schools.

Another interesting observation from table 4.6 is that four out of five teachers using ICT within the past year have used it at school. This observation seems to point to the fact that A-level schools in Zimbabwe are investing in computers and these are largely accessible to teachers. Evidence for such a trend was also corroborated by interviewees as well as the media in Zimbabwe. Out of the 55 teachers who were interviewed, only 7 (13%) had no access to computers at school. Recent media reports have also highlighted the fact that it is now fashionable for politicians in Zimbabwe to woo the electorate by donating computers to schools in their communities (The Herald, 2005) – even in situations where these schools do not yet have electricity – as one reporter commented:

"The computers were there but we could not use them because there is no electricity at the school" says Fungayi. "We have no electricity and we cannot even dream of science laboratories and now you tell me, of what use would be a computer to our students?" (Zim-online, 2005)

In relation to the question “*Who uses ICT among the A-level science and mathematics teachers in Zimbabwe?*” posed at the beginning of this section, this research has established that:

- a) Almost two-fifths of the teachers who participated in the questionnaire survey had used computers in the last twelve months. Teachers from independent schools tended to use ICT more than teachers from mission and government schools.
- b) Although there was evidence that 80% of the teachers who responded to the questionnaire were stationed at schools which had ICT facilities, 54% of these teachers had not used ICT in the last 12 months. ICT use appears to be dependent on factors such as availability of computers, basic infrastructure and networking.
- c) ICT use appears to have been dependent on the subject, with significantly more physics teachers reportedly using ICT than the other subject teachers. However, this trend has not been explored in other countries.

The implications of these three findings are further explored in the next sections.

4.2 Teacher access and frequency of use

This section combines answers to the sub-research questions 1.2 (*How do science and mathematics teachers access ICT*), and 1.3 (*How frequently is ICT accessed by science and mathematics teachers?*). The reason for this decision was to avoid repetition as preliminary analysis of the questionnaire results indicated that these two sub-questions were related.

The research established that teachers had three main avenues for accessing ICT; at school, at educational resource and commercial centres, and

at home. At school, teachers' access was limited by constraints or conditions of access imposed either by administration or by the physical state of the equipment.

Teachers who were interviewed revealed that most of the computer equipment in their schools and Resource Centres was donated. For example, teacher MN48M, a Resource Teacher with the World Links programme in Bulawayo described how the programme used second hand computers sourced from donor agencies to the World Bank. Of the three donated computers, only one was operational at the time of the interviews. The SEITT Resource Centres were equipped with second hand computers from the Netherlands (MN16S). Indeed, the antiquity of the donated ICT resources could add to the teachers' access frustrations. One teacher complained, "*There is only one good computer at the Science and Mathematics Centre. The others have not been working for some time now. The one that is working is always busy since many other teachers also want to use it* (ME13M, lines 18-20). 40 of the 55 teachers interviewed, complained that the ICT services were too slow, for example, teacher ME12M stated that he used the Internet for not less than 1 hour at a time because "*our server is very slow so we get materials very slowly*" (line 21).

In some Private schools, although teachers were able to access the computers, their access rights were dependent on them acquiring formal ICT qualifications like the International Computer Driver's Licence (ICDL), in some cases, at a cost to themselves:

You are also required to enrol for an ICDL course with computing academies in Harare. Now even our recruitment policy requires a person applying to for teaching here to have an ICDL certificate because we saw that it saves us time. (ME37W, lines 13-16)

On the other hand, those teachers who accessed computers at the Internet cafes were generally satisfied with the quality but complained of the expenses involved:

Sometimes I go to the World Links centre at Mutare Teachers College and sometimes I go to the Internet cafes. Both places charge some money for accessing and computer use and during these days of hardships, it is quite expensive, so one tends to limit their access to essential or urgent business" (M09M, lines 17-20).

Teachers' access was also affected by the support they received from the administration. This could be in the form of incentives set up by the school or ministry and also the pathways available to assist them to overcome problems of access.

For example, one teacher mentioned that the school had not subscribed to use the ICT resources at the SEITT centre because the school was unable to pay subscription fees and the head was not happy with the centre's management (MAS01M). Other teachers complained that the network services at the SEITT resource centres were slow, while others were non functional. On the other hand, some private school heads were taking a proactive role by insisting that teachers should undergo ICT skills training as part of the professional development programme at the school:

New teachers undergo staff development training workshops ... led by IT teachers and they (the workshops) are moulded along the lines of the ICDL (International Computer Driving Licence). At the end of these workshops (the) teachers are expected to make use of the facilities available.. (H30G, lines 16-9)

In the absence of a national policy on ICT use in education, school policies like the one above acted as motivation for teachers. ICT training skills are perceived as transferable skills as once mastered they can be used in different settings. Thus as teachers mastered ICT skills, they were provided with the freedom to apply these new skills to enhance their professional development.

4.2.1 ICT skills training

An analysis of the questionnaire results revealed that ICT users among the teachers fell into two main categories: Those who had undergone formal ICT training (48%) at initial teacher training colleges and universities and those who had to teach themselves how to use computers (52%). In the latter group, about 31 teachers (60%) claimed that they taught themselves how to use computers but did not specify where this training took place. 5 teachers (10%) acquired their skills at Internet cafes and the remaining 15 teachers benefited from training programmes run by resource centres such as the World Links and Science and Mathematics Centre. The high number of “self-taught” teachers appears to suggest that the current resource centre programmes have been ineffective as far as training teachers to use ICT effectively is concerned.

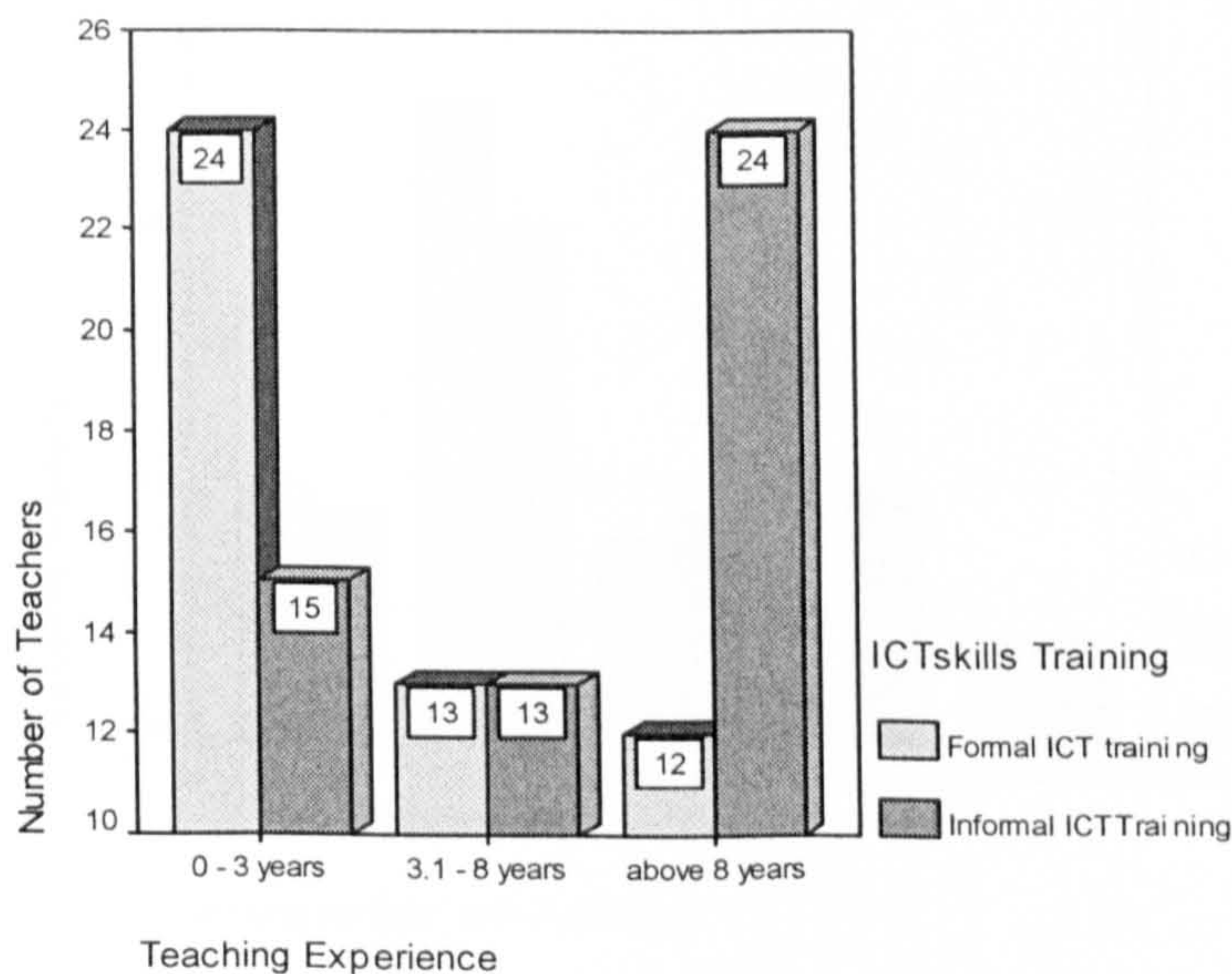


Figure 4.4 Variation of teaching experience with ICT Skills Training (N = 101; $\chi^2 = 5.99$; df = 2; $p < 0.05$)

Figure 4.4 shows that significantly more new teachers acquired their skills through formal training. In the same manner, as the teaching experience increased, the method of acquisition shifted from formal to informal training. In

fact, 46% of teachers with teaching experience over 8 years (more than 7 A-level cycles) reported to have acquired their ICT skills through informal means.

The above observations also seem to suggest that formal ICT training in academic institutions responsible for the training of teachers has only become part of the curriculum recently.

Another observation which seems to provide evidence to the growing use of ICT by teachers was made when frequency of ICT use was compared with the way teachers had acquired their ICT skills. Figure 4.5 shows that teachers who underwent formal training (mainly the younger teachers) access ICT facilities more often than teachers who underwent informal training (older teachers) with more formally trained teachers accessing ICT daily and weekly, than informally trained teachers.

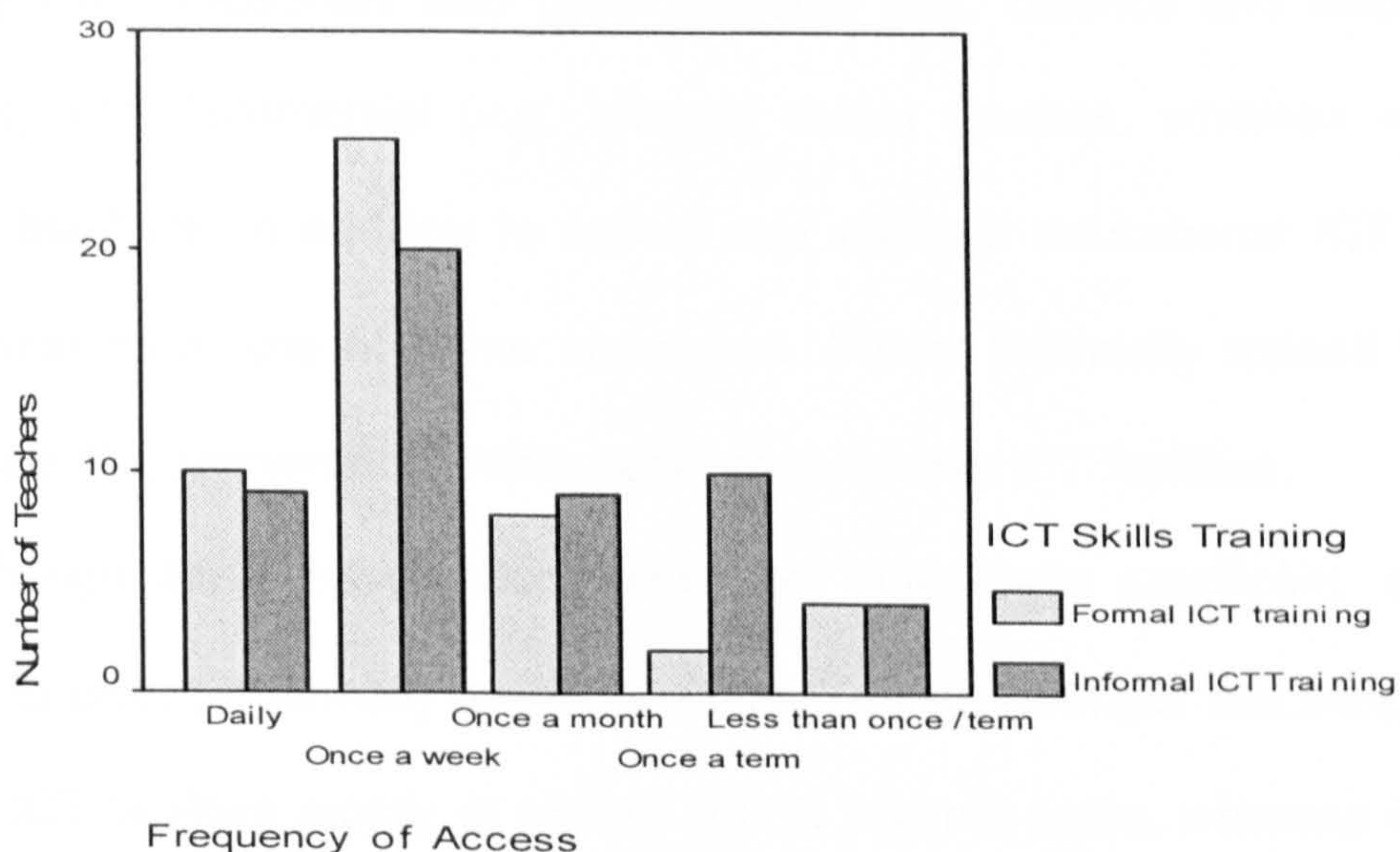
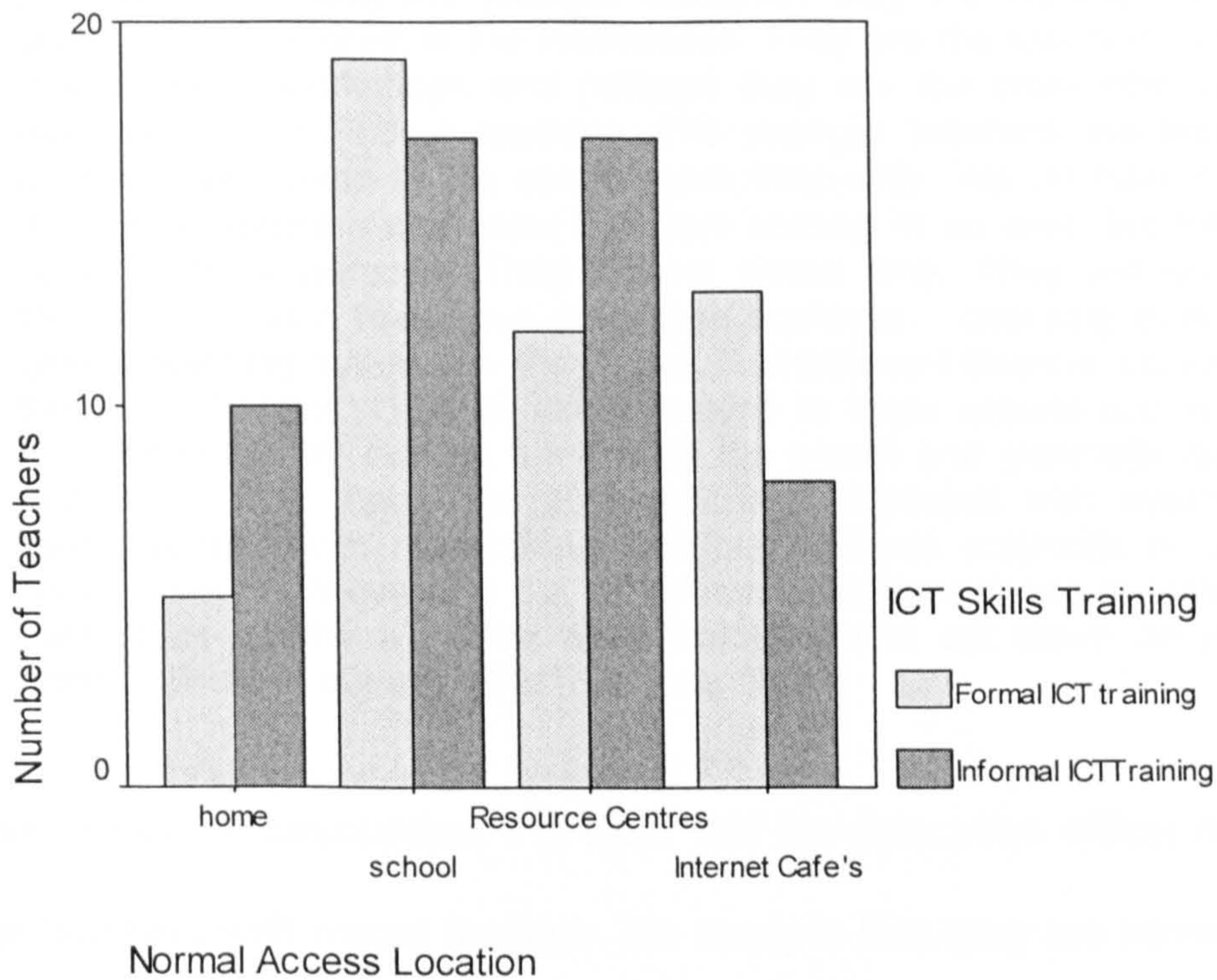


Figure 4.5: ICT skills training method compared to frequency of access

It appears as if, teachers who were formally trained in the use of ICT generally accessed ICT facilities more frequently than other teachers.

Figure 4.6 below shows that for both formally trained and informally trained teachers, access was mainly achieved at school.

Figure 4.6: ICT skills training compared to access location



However, additional differences in access location were also reported. More formally trained teachers also used Regional (e.g. Science and Mathematics Centres) and Commercial (e.g. Internet cafés) Centres, whereas informally trained teachers, in addition to school and regional educational ICT centres, also made more use of home computers. Fewer informally trained teachers made use of Commercial Centres services to access ICT facilities.

Although these observations were not statistically significant, a pattern seems to emerge: formally trained teachers (mostly younger teachers), tended to use ICT facilities mostly at school and at Internet cafés, whereas informally trained teachers (mostly older teachers – see figure 4.4) made more use of home computers and Regional Resource Centres to access ICT. However this observation is at variance with the views of some Regional Education Officers' observations. When describing the clientele at one Resource Centre, an Education Officer said,

However, some of these teachers spend mornings or afternoons preparing their lesson materials and we have had a few

consistently....mainly the younger teachers.. they are the ones who seem to show interest in the innovations. They are the teachers who mainly attend workshops and perhaps they are the ones who are more enthusiastic about teaching. The younger teachers are more energetic and come to the centre more frequently. We do have the Resource Teachers and older teachers coming in as well, but they come in for a purpose. They do not waste time. They are quite focused and once they have done their business – checking e-mail, getting teaching materials – they leave. Sometimes if there is a queue, they do not linger. Younger teachers tend to linger around and wait for colleagues, try out the Internet or the e-mail and generally laze around. In fact, there are more teachers interested with Internet searches than with researching with our textbook materials in our library here. I believe it is the computers that draw these teachers here. That is why we need more computers to cut down on the waiting time and queues. (MN15B; lines 58-81)

From the above description, it is clear that the Education officer regards the younger teachers with mixed feelings. He accepts that they are more energetic and embrace innovations, including the use of ICT perhaps because it is already part of the skills repertoire that they bring with them from college. They are the more consistent attendants and users of the Science and Mathematics Centres' ICT facilities. They are patient and are prepared to wait for colleagues. However, the younger teachers also tend to monopolise the use of these facilities to the extent that older, more focused teachers are unable to access the facilities and leave.

Ironically, it is the infectious optimism and enthusiasm of novice teachers (Steffy *et. al.*, 1999) as described above, that make it possible for teachers to embark on self-directed professional development activities.

Where as the younger teachers have graduated with ICT skills, and have been exposed to ICT's potential at college, older teachers face a different challenge, i.e. they have to learn the skills first before applying them. They find themselves on the bottom rung of the Level of Use in the Concerns Based Adoption Model (Horsely and Loucks-Horsely, 1998).

4.2.2 Challenges faced by teachers in accessing ICT facilities

Doyle and Ponder (1978) have argued that for teachers to develop an interest in an innovation, they must first be convinced of the usefulness of the innovation by carrying out a cost-benefit analysis. In this case, experienced teachers must be convinced that an innovation adds value to their existing practice. One teacher used this argument to explain why some head teachers resisted the introduction of ICT in their schools:

I remember the headmaster saying in a staff meeting that the school did not need computers since it had achieved high results and established a reputation without their use. There was no reason why teachers should learn to use computers since they did not need them in their teaching. (MN48M, lines 85 – 88)

The same teacher went on to claim that the major reason why centres were patronised by younger teachers was that they came to use the computers, rather than to learn how to use them:

So I tell you, most of the teachers who were trained before computers came into the schools are very uncomfortable in terms of the technology. On the other hand, younger teachers have adopted the technology from the period of their training and see ICT as a partnership in education. So now ICT centres enjoy large patronage from these teachers. Also younger teachers already possess ICT skills which they obtained from their colleges and they come here already knowing the basics of what they want to do. Hazvienzani nokuuya kuzodzidza (*It is not the same as coming to learn*) so mostly young teachers come searching for information on their subject. The most affected subjects in this region are mainly physics, chemistry, geography and literature. (MN48M, lines 93 – 100)

In the interview sample, as well as among the questionnaire respondents, some teachers mentioned that they had access to computers at home. For these lucky few, the distribution of ICT resources did not greatly affect them. However, the cost of access was still prohibitive especially for MAS22V and MN46S who had to pay for the dial up network connection as well.

Non formal skill acquisition is driven by personal interests and needs rather than by coercion. It appears there is a growing perception of ICT as an essential

skill among teachers. For example, when asked to comment on how he benefited from using ICT, MW17C replied:

I think I benefited greatly. I think ICT is a must for teachers to keep pace with modern trends and also to keep informed with the fast pace of knowledge production nowadays. Books quickly become out-dated and expensive to upgrade. The Internet provides us with a cheap way of upgrading ourselves and getting up-to-date information on topics. Also you find articles written by people from all over the world and in various fields. So it provides a rich variety of opinions and interpretations on the same topic. This is good and enriching. (lines 98 -105)

Doyle and Ponder (1978) have argued that teachers also make decisions based on the practicality of carrying out an action. They weigh the benefits against the cost in terms of time, money or convenience. The fact that a larger number of teachers in the sample had invested their time and resources into acquiring ICT skills through non-formal means shows that ICT is becoming an accepted part of the teachers' personal professional activity.

From listening to the teachers during the course of the interviews, one got the impression that teachers found accessing ICT resources a challenging and novel experience. When asked why they bothered to access and use ICT, teachers explained that computers are becoming a common feature in schools and the greater society. Pupils are becoming computer literate ahead of teachers and teachers feel threatened by this loss of authority and control over knowledge dissemination:

Students are being taught computer science, so they go to the Internet shops and they have access to some information, some of which is up to date, so the teacher might have a problem with that. He might not have information which is up to date, so there might be that problem with students, so they (teachers) need to be above the students they are teaching, for them to be able to earn the respect of the students. (MN47M, lines 16 – 20)

Thus teachers saw ICT as exerting some kind of personal pressure on the teacher. In a dynamic and increasingly technological world, teachers needed to move with the times to avoid becoming obsolete.

At the same time, the teachers recognised that they were constrained by resources and could not do much on their own, to develop and use ICT skills. Some of the teachers were similarly frustrated by the fact that there was no support forthcoming from their schools. Some blamed the lack of support on the absence of a ministry policy on the use of ICT in schools;

Computers have been introduced in the country's educational institutions without a clear cut policy on IT from the Ministry, or if it was there, it was not publicised. Headmasters were not trained to appreciate the benefits in terms of teacher professional development, but maybe as secretarial tools and maybe as another subject in the school curriculum (computer studies). So to them, they don't see computers as necessary or important for teachers' professional development except for those teachers teaching computer studies. (MN48M, lines 188-194).

However, other teachers saw the problem of lack of support as extending to all key stake holders in the education system, i.e. the ministry, the schools, the Internet services providers and the national telecommunications authority, Tel One.

In this country, I think we need to make ICT more accessible to teachers. A national ICT policy will help only if all the key stakeholders sign up to it. Tel One and Com One, as the major players in this scenario, can help a lot by enabling ISPs to charge lower tariffs for broadband Internet access so that more people benefit from faster access. I think ICT access for educational institutions should be subsidised. (M36M, lines 88 – 93)

A Chemistry teacher, whilst placing responsibility for professional development using ICT squarely on the shoulders of the teachers, had this observation to make:

ICT is being introduced in many aspects of our lives in Zimbabwe and I think it is in the interests of teachers to develop themselves in this regard. But again, teachers in this country are among the least paid in the labour force, so they cannot afford to make ends meet. Giving them that responsibility is like sounding the death-knell to professional development because they will not afford to pay for the things necessary for their development, like computer access and so forth. So I think the ministry, school and the community should also be stakeholders in the professional development of teachers by providing the necessary equipment and services" (MN54M, lines 4-11)

At the school level however, there is evidence that the key stakeholders (headmasters, parents-teachers associations and school boards) appreciated the need for teachers to use ICT for their own professional development. Teachers acknowledged this support. When one lady teacher was asked where she received the motivation to join an ICT skills training course, she replied:

The headmaster and the parents teachers association. They wanted all teachers to be computer literate and believe that this will enable us to help the girls more in their work. (M10M, line 22)

In grappling with the access constraints, teachers and students also joined forces to support each other. In one school, the Head of Department provided funds for one teacher to visit the Internet cafes and download teaching materials that they needed for their classes (M35B). Like wise, once students were convinced that teachers' activities were beneficial to them, they were even prepared to contribute towards the expenses of obtaining materials from the Internet (M18C; MN44S).

Still other teachers, in the absence of administrative support for ICT use in their schools, came up with ingenious ways of accessing ICT resources. They contributed some money for one teacher to use the Internet cafes to download materials that they required:

We do not have access to the Internet. We contribute money and once in a while go into town to the Internet café and download the materials or I can do it for them and pass it to them or I can ask them to come and collect the information. (MN43L lines 41-44)

The aspect of teachers voluntarily organising themselves and pooling their resources together in order to achieve a common purpose was very encouraging.

Teachers in private schools on the other hand were generally supported by the schools and shielded from both expense and access problems. In almost all the private schools represented in the sample, teachers were allowed and

encouraged to have unrestricted access either in their departments (H38W), library (H31A) or computer laboratories. In some schools, IT support staff was employed to assist teachers to access information on the Internet (ME30G, M08H).

4.2.3 Access Location

Teachers were also asked to indicate where they normally accessed ICT facilities. Table 4.7 below summarises their responses:

Table 4.7 locations where teachers normally access ICT facilities

Location	Frequency	Percentage %
Home	15	14.9
School	36	35.6
Resource Centres (Science and Mathematics Centre, BSP, WL)	29	28.7
Commercial Centres (ICs, public libraries)	21	20.8
Total	101	100

These results show that almost two-thirds of the teachers (64.3%) accessed ICT facilities within educational institutions (i.e. schools, resource centres). What is also interesting is the fact that about one fifth of the teachers were prepared to pay for access to ICT facilities.

An indicator to the way teachers use ICT facilities could also be the frequency with which they access these facilities. A comparison was made to see if there were any links between the access location, and the frequency with which teachers accessed ICT facilities. Figure 4.7 shows a bar chart of the comparison. Not surprisingly, the results below show that most of the teachers who accessed ICT facilities at educational institutions and at home, did so more frequently (at least once a week) than those teachers who had to pay for ICT facilities at commercial ICT centres such as Internet cafes.

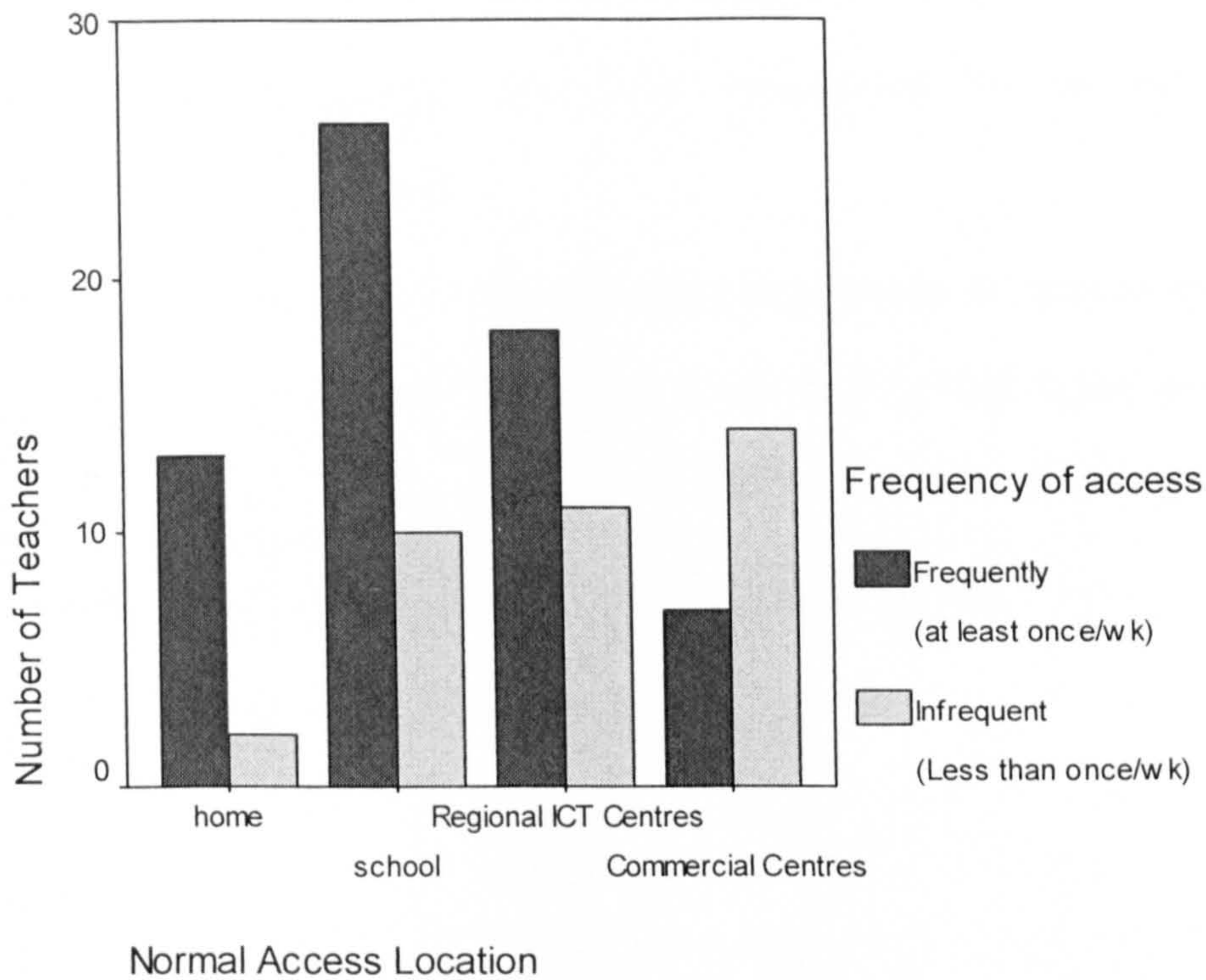


Figure 4.7: Frequency of accessing ICT compared to the location of ICT services ($\chi^2 = 12.905$; $df = 3$; $p = 0.005$)

An investigation was carried out to determine how the distance of the ICT facilities, from the workplace, affected the frequency of the teachers accessing ICT facilities. Table 4.8 below shows the results of the comparison.

Table 4.8: Comparison of distance from work place with frequency of use of ICT facilities

Distance of access location from workplace	Frequency of use		Total
	Frequently, at least once a week	Less than once a week	
0 – 2km	42	15	57
2.1 – 10 km	11	8	19
More than 10km	11	14	25
Total	64	37	101

($\chi^2 = 6.898$; $df = 2$; significance, $p < 0.05$;))

Significantly, the number of teachers who use ICT frequently (at least once a week) decreased with the increase in the distance of the facilities from the workplace. On the other hand, distance from the workplace had no bearing on the number of teachers using ICT facilities, for those teachers who used the

facilities less frequently (less than once a week); i.e. those teachers who used ICT facilities less frequently were less constrained by distance from the workplace in their access to ICT.

When comparisons were made between frequency of access and whether teachers experienced access problems, it was found that those teachers who reportedly accessed ICT facilities more frequently were those who reported having fewer problems of access. Figure 4.8 illustrates this point.

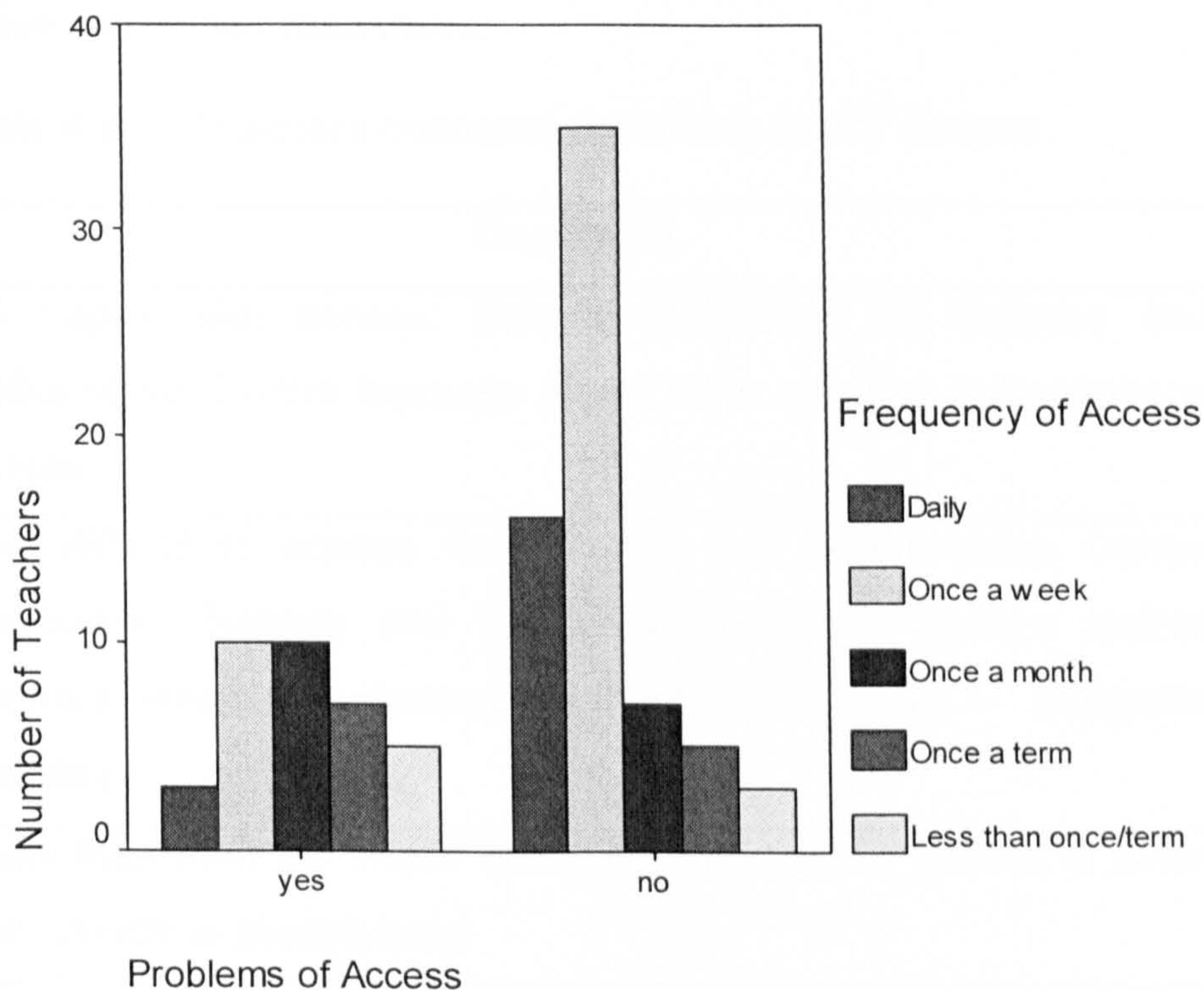


Figure 4.8: Access problems compared with frequency of access of ICT

Figure 4.7 (page 153) showed that frequent ICT access (daily and weekly access) mostly took place at school. Figure 4.8 shows that generally teachers who accessed ICT frequently tended to be those who reported experiencing less problems of access. As a corollary, the observation can be deduced to mean that teachers who accessed ICT at school, tended to have less problems in accessing ICT facilities. This seems to provide evidence that schools were supporting teachers in accessing ICT facilities. The interviews also supported this conclusion, as the next section illustrates.

4.2.4 Teachers' perceptions on ICT access

In twenty-two of the fifty-four interviews, teachers made 26 references to how they felt about their access of ICT facilities. Teachers were asked to comment about the overall accessibility of the ICT facilities that they used. Only six teachers expressed frustration about the overall access. Some of these teachers were concerned with the administration of the Science and Mathematics Centre and how this constrained their access. The table below summarises their responses:

Table 4.9 Teachers concerns pertaining to ICT access

Comment	Teacher
Not happy with access: School sanctioned by Science and Mathematics Centre because Head does not pay subscriptions on time	MAS 01M
Very difficult to access the Science and Mathematics Centre computers: Science and Mathematics Centre always locked because Resource teacher is involved in extra – curricular activities	MAS05V
Feels frustrated by World Links centre: cannot access it when free. Centre is always busy	M09M
Frustrated: had to negotiate for access during weekends	MW17C
De-motivated: Quality of materials obtained not up to expectations	M34S
Frustrated: Difficult to find websites with the right materials at the right level for students	MN46S

From the table above, four of the teachers concerns were directed at the administration of the ICT facilities. Note that all the comments related to resource centres. Ironically, the resource centres were set up to enable teachers to have easier access to ICT facilities. The cost of access was lower.

Apparently, access in schools, where granted, was not associated with problems of administration. Likewise, those teachers who accessed ICT through Internet cafes were not complaining, presumably because they were satisfied with the access even though they were paying for it.

In contrast, 13 teachers reported that they were satisfied with their access to ICT facilities. Of these, 8 teachers were simply happy with the access conditions. Three teachers felt that they had adequate access and one teacher simply thought it was worth the money she paid to access the facilities.

In summary, three factors were found to influence the access of ICT facilities by A-level science and mathematics teachers in Zimbabwe:

i) Access location

Analysis of the questionnaire survey has revealed that teachers accessed ICT facilities mainly at school and at the Resource Centres. A sizeable group of teachers also used Internet cafés while a small number of teachers had ICT facilities at home.

ii) ICT skills acquisition

The study revealed that the way teachers accessed ICT facilities was also related to how they had acquired ICT skills in the first place. 52% of the teachers had acquired ICT skills informally, by attending courses at Internet cafés and Resource Centres, and also by teaching themselves to use computers at school and at home. Among these teachers, most teachers from private schools had to learn how to use computers as a condition of employment and some had to register for the International Computer Driving Lessons (ICDL) in order to satisfy requirements for employment. Of the remaining 48% of teachers who acquired ICT skills formally, most of these skills were acquired during initial training at university or college. Most of

these teachers with formal training in ICT skills are relatively inexperienced and younger than teachers who acquired their skills informally because computer training programmes were only introduced recently into the college and university curricula. The large number of experienced teachers in the sample, who have used own resources to acquire ICT skills shows that ICT is increasingly becoming a part of science / mathematics teachers' professional practice.

iii) Access constraints

The demand for computer-use has also created constraints in accessing ICT. Resource centres are unable to cope with the increased number of users because their computer facilities are poorly maintained. Teachers are forced to visit Internet cafes where they pay for the service. Greater demand for ICT also results in long queues and shorter access time especially at Resource centres. One of the major problems teachers faced was the lack of administrative and structural support to enable them to use ICT facilities effectively. Some of the teachers attributed this constraint to an apparent lack of ministerial policy to guide schools on how to deal with ICT issues. Others however, saw this problem as arising from lack of concordance between the major stakeholders in the education system, i.e. the ministry, the school administration, the parents and industry, regarding the acquisition and use of ICT facilities in schools. Nevertheless, teachers did manage to get some support in five ways;

- a) Parents-Teachers Associations, the business community and heads of mainly private schools provided ICT infrastructure to enable teachers to access and use ICT effectively.

- b) Some schools engaged the services of IT managers and support staff to help teachers obtain stuff they needed from the Internet.
- c) Some headmasters and heads of department had small funds allocated for teachers to access and use ICT facilities at the Internet cafes, thus encouraging the teachers to use the ICT for their own professional development.
- d) Teachers assisted each other by pooling resources and funds to enable their representatives to access information they needed from the Internet cafes, download and bring it to school on diskette.
- e) There was also some evidence that some students contributed financially to enable teachers to access online subject information from Internet cafes and make copies for them.

4.3 For what purpose do teachers access ICT?

Teachers were asked to rate their experience in using specific ICT packages. They had to use a scale which ranged from extensive experience (1) to no experience what so ever (4). Thus a low mean in table 4.10 denotes more experience for the group, whilst a high mean denotes lower group experience. The scale ratings (1-4) were used to calculate the mean, standard deviation and co-efficient of variation.

Table 4.10: Summary of Teachers' rating of their experience in using ICT packages

Package	N	Extensive	Minimum	Mean	SD	CV
Word processing	101	86.1%	13.9%	1.71	0.70	0.41
Internet	101	71.3%	28.7%	1.97	0.85	0.43
e-conferencing	101	8.9%	91.1%	3.57	0.73	0.20
e-mail	101	82.2%	17.8%	1.82	0.84	0.46
Record keeping	101	51.5%	48.5%	2.57	1.11	0.43

Most teachers reported extensive experience in the use of word-processing, e-mail and Internet packages, but less experience in using record keeping and e-conferencing packages. By using the coefficient of variation, it can be shown that the teachers were more unanimous in their response to e-conferencing, and that they had more varied experiences pertaining to the use of the other four packages.

Internet and e-mail communication are both word-processing based packages. Evidently, the teachers also related the packages to word-processing and this is why their mean ratings are close to that of the word-processing package. Record keeping could have been interpreted by participants to involve the use of spreadsheets and databases, which would require other skills in addition to word-processing. As the rating was expressed as a scale ranging from 1(extensive experience) to 4 (no experience), it was possible to use measures of association to determine whether there were any relationships between the variables and to assess the strengths and directions of these relationships.

From table 4.11 below, it is clear that experience in using word-processing packages was significantly related to experience in using the other ICT packages.

Table 4.11: Teachers experience of using ICT packages (using Pearson's r)

Variables		N	r	r ²	2 – tail sig
Word processing	e-mail	101	0.644	0.41	p <0.05
	Internet	101	0.372	0.14	p <0.05
	e-conferencing	101	0.250	0.06	p <0.05
	record keeping	101	0.448	0.20	p <0.05

However, the strength of the association was most significant for e-mail, with a correlation co-efficient (r) of 0.6 which is regarded as moderate, and a proportion of variance (r²) of 41%, meaning that 41% of the variance observed

in the e-mail experience can be attributed to word-processing experience. Although there is a significant correlation between teachers' experience of word-processing and that of e-conferencing, the strength of the association is very weak, accounting for only 6% of the observed association. In fact, mean rating for e-conferencing (3.57) in table 4.10 shows that the majority of the teachers had very little experience with using that application.

4.3.1 Teachers' use of ICT for word-processing

Word processing provided teachers with a very convenient tool in their professional practice. 47 of the 55 interviewed teachers (85%) mentioned the use of word-processing during interviews. Some of the interviewed teachers indicated that their first experiences with ICT were guided by the need to find better methods for producing and storing their data. Teacher MAS02M for example, accessed ICT facilities at his school primarily to write termly reports and set examinations. Teacher MAS04V concurred with this view but added that using the ICT service at school:

... makes my work as senior master much easier because I can retrieve information that teachers, administration and parents want in a short time. (MAS04V, line 32-34)

Other teachers, notably from the private (independent) schools mentioned that they were now required by their heads, to present word-processed reports:

The other resources we access on our computers are word-processing software, excel, presentations, databases and the like. We are expected to have both electronic and hard copy records of our work. The school is planning to network all computers next year so that we can set exams, enter marks and even plan on line. This should make it easier to access student records for the administration (M08H, lines 30-34)

Even teachers from public schools could appreciate the benefits of word-processing documents, reducing the drudgery of repetitive actions. Instead of every year rewriting the schemes of work for certain topics, or re-setting test

items, teachers could store these documents electronically and retrieve and modify them as and when needed.

Previously we could only set hand written tests and give to the typist to type, but this was very laborious and so we ended up writing the questions on the board and having students copy. It took a lot of time and I always dreaded setting tests, but now I can have my test bank ready and just print it out whenever I want it. The students can get copies and there is no hassle. Likewise, lesson planning and preparation is made easier..... all I need to do is to take my diskette and upload the saved contents for the topic I want to teach. I can then print out the notes, worksheets and question assignments I want to use in class. This has made my work easier. (MW18C lines 13-21)

MW18C put the advantages of word-processing succinctly. He describes the advantages in terms of labour saving, time saving and convenience.

4.3.2 Teachers' use of ICT for e-mail communication

Two of the questionnaire items required teachers to demonstrate their perceptions on the usefulness of e-mail and the Internet by rating selected uses on a Likert scale of 1-6, with the 1 and 2 denoting high degrees of usefulness while 4 and 5 represented low degrees of usefulness. No 6 was a separate category for those teachers who did not know or did not understand the sub-category. In such questionnaire items the mid point of the scale is always difficult to interpret. Teachers could have chosen a 3 to indicate that they were non-committal about the usefulness of the particular ICT activity, or that they had not really decided how to rate it. The researcher called this choice a "borderline". Borderline cases are difficult to interpret. Tuckman (1994) suggests that they should be left out of computations and interpretation as they tend to cloud the issue. Cases with a borderline of more than 20% were therefore discarded as unreliable, because such a margin means that at least one fifth of the participants could not make a decision on the item, so the item might have been confusing. Fortunately, in this instance there were no borderline cases

and no items in the table were discarded. The results for the e-mail are given in table 4.12 and for the Internet, in table 4.13.

From table 4.12 below, teachers were quite emphatic about the usefulness of email in communicating with colleagues (83%) and communicating with friends (86%). In these two cases, only 1 teacher had no opinion about the usefulness of e-mail in this regard. In addition, the low mean values indicate that the majority of the teachers found these applications useful.

Table 4.12 Purpose of using e-mail facilities (N = 101)

Purpose	Very useful	Useful	Borderline	Least useful	Don't know	mean	sd
Communicating with colleagues	84	5	0	9	1	1.61	1.13
Communicate with friends	87	7	0	7	0	1.49	1.00
Seek assistance	62	18	0	17	4	2.48	1.44
Develop materials collaboratively	58	19	0	21	3	2.48	1.49
Compare teaching methods	44	22	0	31	4	2.91	1.49

This observation was also borne out through the interviews. When teachers were asked how they used ICT, 80% of the 55 teachers mentioned using e-mail, to communicate with friends and institutions:

Like I said, I have friends whom I communicated with regularly, one in the UK and another in the US. Email makes it easier to communicate with these guys more easily. ... It is convenient, fast and reliable. Letters take a long time and are very expensive especially for overseas destinations." (MAS02M line 77-79);

Use of private communications, may appear to be un-related to professional development of teachers, but nevertheless, it provides fertile grounds for the development of transferable skills that can then be used for professional development. Using ICT for personal interests provides a natural incentive for the exploration of ICT potential. Schwab (1978) and Kinach (2002) call this process *concept level understanding* or *instrumental understanding*.

This basic understanding leads to awareness of what can be achieved using ICT.

In the interviews, instrumental understanding was exemplified by the comment received from one of the teachers:

...through e-mail you can interact with other people from other areas, in a way that was not possible before – and you can get the latest information. I have a friend of mine who was saying there are some question papers you can access from the Internet, but I was yet to look at the page. (MN47M; lines 126-130)

MN47M was made aware of the possibilities of using the Internet, even though he had not yet had the chance to evaluate these possibilities. Thus personal contacts and interests can direct the teacher into professional development activities.

Personal use of ICT is therefore a necessary part of professional development, leading to a relational understanding (see table 2.1,p22) of the potential of ICT in professional development. Examples of this transformation of knowledge and interest from personal interest to professional application abound in science and mathematics. For example, during the second world war, a British father who had played with his children on the beach, making stones bounce on water went on to apply this concept of damped oscillations by masterminding the bombing and destruction of a strategic dam in the Ruhr industrial region of Germany by bouncing bombs on the water (cf. Morpugo, 1972). In terms of self-driven professional development, private interests are the harbingers of professional awareness.

Some of the teachers also claimed to use e-mail for more extensive professional purposes. One teacher claimed:

... I have been able to communicate with colleagues who were working on a physics materials module for SEITT. I also collaborated with colleagues doing a paper on networking (MAS04V; lines 72-74)

60% of the teachers also used e-mail to communicate with institutions such as examining boards and universities. In this case, e-mail as a medium of communication was chosen because of its speed and reliability, as well as the added advantage of being able to send applications by attachment.

Interviewed teachers frequently referred to their professional isolation. A lady teacher remarked:

...Of course I also want to be part of the global village. I feel isolated, but what can I do. I have two children and am divorced. I have to look after my family so cannot afford travelling to workshops and conferences. (ME25B)

Teachers also commented on how the use of ICT enabled them to work collaboratively with others, and how the potentials introduced through ICT collaboration were exploited for a variety of professional development activities. One teacher mentioned that she uses ICT to access world wide resources and also *“to share with others what I know about teaching biology”* (M11M). Thus the aspect of teacher networking seemed to be considered a major concern by the teachers.

4.3.3 Teachers' use of ICT for Internet connectivity

Table 4.13 provides a summary of the teachers' responses to the usefulness of using the Internet for specified activities. In table 4.13, only the item on entertainment had an unacceptably large borderline count (22.8%). The probable reason for this was that while teachers found the idea of online entertainment attractive, they seldom had time or resources to indulge in this activity and so were unsure how to rate it. All the other variables had values within the 20% threshold.

Teachers found *“using the Internet to get information”* very useful (74%). This item also had a more emphatic response, i.e. it had the lowest borderline

responses and the lowest standard deviation (low variation). It means teachers were more certain about how to interpret and relate to the item. The item also had the lowest mean value, indicating that most teachers rated it at the “very useful” end of the Likert scale.

Table 4.13 Purpose of using some aspects of the Internet (N = 101)

Purpose	Very useful	borderline	Least useful	Don't know	mean	sd
Online groups	58	12	26	5	2.50	1.65
Entertainment	60	23	17	1	2.25	1.42
Get Information	75	11	12	3	2.00	1.31
Develop teaching materials	66	13	19	3	2.21	1.47
Improve teaching	64	14	19	4	2.30	1.50

However, when the tables 4.12 and 4.13 are compared, the overall mean scores for Internet use is higher (representing less useful) than the overall mean scores for e-mail use. This implies that the teachers did not see Internet usage as useful as email. Again, this observation is borne out by the interviews. Fewer teachers indicated Internet use for the above purposes. Many cited access constraints (time, expenses) as the major limiting factors to their use of the Internet.

4.3.4. Methods of information retrieval used by teachers

In the face of access constraints described above, the interviewer was interested to know how the teachers approached ICT once they had obtained access. Questions of interest included whether there was any planning involved, did teachers prioritize their access of ICT and if so, what were the criteria?

In the course of the interviews, twenty three teachers made 31 references to their approach to using ICT. Teacher MAS03M was attending computer skills classes at the World Links Centre in Mucheke, Masvingo. When asked what he did when he finally had access to a computer, he could not remember which

Internet sites they visited ; *“we just open a window where you could search for information – you type in something and the computer gives you lots of topics on those words you typed”* (line 35). When pressed for more information, the teacher could not remember the website. Eight of the twenty – three teachers indicated exploratory browsing was their main method of interaction with ICT. In one instance, resource teachers had to go through several web sites before finding the addresses that they needed for their workshop preparations (MAS23K). Not surprisingly, teachers also complained that they could not get enough time to complete their searches.

However, it appears as if un-focused ICT interaction is not only unique to the training sessions at the World Links, even teachers who were computer literate themselves, continued to use this method of interaction. MAS04V is a physics teacher and senior master. He claimed to use ICT both for administrative and professional duties. However, when asked how he usually obtained his physics materials from the Internet, he responded *“I just checked by trial and error the physics sites that I came across in my searches until I found what I wanted”* (line 40). Used this way, Internet searches can be quite time consuming. If a teacher is using a premium ICT service, like the Internet café, this kind of approach does not leave one with enough time or resources to do other things hence teachers ended up prioritising access. As teachers MAS05V and M11M observed, *“the other sites we only access after doing something we need, like music, but the money left over will not be enough to access academic sites”* (MAS05V, line 45).

Some teachers did realise the importance of being focused when carrying out Internet searches. Teacher ME12M exemplifies the gradual refocusing process. He claims that initially he was using ICT out of curiosity and to while up

time “*but now, I see the utility of using ICT*” (ME12M, line 95). He further qualifies this explanation by stating;

At first I used to get any listed site on physics, but now I rely on ...high schools hub which contains materials that can be checked and rated by experts (ME12M, line 38)

For teachers who aspire to use ICT for their own professional development and who have to do this without institutional support from their schools or resource centres, the problem of focus and maximising search outputs can be quite daunting. One teacher who has been using the Internet for four years observed that teachers who are amateurs in ICT use tend;

...to be too general in their search part, when they click ‘search’, a lot of things come through and they spend a lot of time searching. I would have to say to them ‘be specific in your search plan’. I just try to make them be more specific so as to limit the articles that come up (MN16S, lines 71-74)

The SEITT programme has tried to reduce instances of random access by training resource teachers to build up a data bank of useful websites targeted at the teachers professional development needs. Teachers seemed to appreciate this improvement, as less time was wasted;

For the SEITT module we were given the site – *high school hub* by our trainers, at a materials development workshop in 2001. (M07H, line 24)

And;

I attended a computer literacy course at the UZ where some of the sites like *chemistry lab* were given to us as well (M09M, line 37)

The same model of training was used by the World Links programme at one of its centres:

We attended the workshop at the World Links centre at Marondera High, where some Internet skills were taught. We were shown how to use search engines to research for information on the Internet. We did some subject specific searches and came up with various web sites for each subject. (ME14N, lines 56-9)

Schools have also adopted the same approach. Some schools employ IT managers who assist teachers to get the materials that they need as quickly as possible (e.g. M08H). Others have prepared lists of recommended websites (H28G) which act as a starting point for teachers wishing to look for curriculum materials in their subjects. The provision of lists of favoured websites helps to cut the times when teachers are sourcing for information (H32A). Six of the twenty three teachers reported that they are provided with or have developed a list of favourite websites pertaining to their subject.

In summary, teachers used ICT for the following reasons:

i) Word-processing

Both public and private school teachers considered the use of ICT for word-processing to be very important to their work. Interviewed teachers cited the advantages of using computers as word-processors as including the convenient storage and easy retrieval of teaching materials and documents.

ii) e-mail

Most ICT users at Resource Centres and Internet cafés were reportedly accessing these facilities in order to make use of their e-mail services. Teachers highlighted the importance of e-mail communication as being faster and more efficient than ordinary mail. Teachers also revealed that they used e-mail to communicate with colleagues.

iii) Internet

Teachers also revealed that they used the Internet to access information resources. However, some interview respondents cited constraints such as time, and slow, poor quality connections as hindering their use of the Internet. However, by investigating how teachers actually obtained materials that they wanted from the internet, it was possible to reveal that

some of these problems were partly due to the teachers' poor web-searching skills.

4.4 Conclusion

The study revealed that 40% of the teachers who responded to the questionnaires had used ICT in the last 12 months. In describing the ICT environment as far as the Science / Mathematics teachers were concerned, the following observations were made.

- a) 80% of the teachers who responded to the questionnaire were working in schools that had ICT facilities but only 46% of these teachers had used ICT in the last twelve months. ICT use was found to be dependent on the type of school where teachers worked, the subject they taught and other factors that constrained access, such as the school administration policy and connectivity. Teachers had access to ICT facilities at school, at Resource Centres and at the Internet cafes. Private schools mostly had ICT facilities that are networked and teachers were expected to access these as part of their work. Public schools mainly had limited ICT facilities which were restricted to the library and school administration. These were more difficult for the teachers to access. Some teachers could not access ICT facilities at their schools and had to use Internet café's and Resource Centres.
- b) Teachers found ICT most useful for word-processing (86%), e-mail (82%) and the Internet (71%). Word processing was used for administrative work and lesson preparation. Teachers used e-mail to communicate with friends (93%) and colleagues (89%). E-mail was

also useful when teachers were seeking assistance or carrying out collaborative work.

- c) Teachers found the Internet useful for obtaining information (86%) on teaching materials and on ideas on improving their teaching.
- d) Teachers have different approaches to the use of ICT. The most common of these appears to be exploratory browsing. This approach is popular among teachers who are just beginning to learn how to use ICT and the Internet. This approach was also used by fairly experienced ICT users. The major disadvantage with this approach is that it is time wasteful and teachers do not manage to complete their tasks – especially if they are at the Internet cafes where they have to pay for access, or at the resource centres, where their access time is limited. Other time saving approaches used included the listing of favourite sites by individual teachers, and in private schools, the provision of recommended lists of websites by the schools. The major disadvantage noted for the latter option (private schools) is that sometimes the quality of the content was found to be below expectations.
- e) Generally, more than half of the teachers rated ICT facilities access “satisfactory”. This means that teachers were able to access ICT facilities and they were satisfied with the services on offer. However, a few teachers expressed concerns pertaining to the administration of ICT resources especially at the resource centres, and the quality of materials obtained from the Internet using these resources.

Among the various concerns raised by teachers, access to ICT facilities appears to be the most important issue (see Appendix 3.8), with issues of

access having been referred to more than 200 times during the 54 interviews held. ICT access accounted to about half of all references made in connection to the theme of the management of ICT environment. It was also apparent that if the impact of ICT on teachers' professional development was to be enhanced, the access issues raised by the teachers would have to be addressed seriously.

However, it is also enlightening to note that in spite of the access constraints described in this chapter, a good number of teachers nevertheless aspired to use ICT for their self-directed professional development, i.e. being prepared to invest money, time and resources in this activity. The struggle for empowerment among the Zimbabwean A-level science and mathematics teachers, as described in this chapter is reminiscent of the Zimbabwean liberation struggle, to break away from tradition, conservatism and prejudice and move towards freedom to practice as effective teachers. It embodies the struggle for enlightenment as described by Sawyer (2001) in the opening caption of this chapter.

Chapter 5: How do teachers perceive the use of ICT as affecting their professional development?

For teachers to be truly effective, they must first see themselves as learners (Miller and O'Shea, 1992 p. 201).

5.0 Introduction

In the literature review chapter (see section 2.1), professional development was defined as a process whereby teachers gained knowledge and experience and used these two aspects to integrate and adapt themselves into the teaching and learning context. In a professional development process, teachers behave as adult learners (Cross, 1981; Knowles, 1984). In this chapter, evidence is presented on how advanced-level science and mathematics teachers in Zimbabwe perceived the role played by ICT in the development of their professional learning. To address the second research question, data will be drawn mainly from the interviews. Section 5.1 re-caps and expands the findings from the last chapter on the reasons why teachers chose to use ICT for their professional development. Section 5.2 combines the discussion of the evidence of the remaining two sub-research questions. It discusses three aspects of professional development that the research has been found to be supported by the use of ICT and how each of these aspects enhances teachers' perceptions of their own professional development. Section 5.3 provides a summary and conclusion of the discussion.

5.1 Why do teachers use ICT for their professional development?

In chapter 4, evidence was presented showing that computers were becoming a common sight in A-level establishments in Zimbabwe, with roughly 80% of the A-level teachers in the questionnaire sample reportedly coming from

schools which had ICT facilities. This implies that, as an educational resource, ICT is gaining wide acceptance within the education system.

However, this study also revealed that ICT use (demand) by A-level science and mathematics teachers lags far behind the supply in educational establishment, with more than half the teachers from schools which had ICT facilities having reportedly not used ICT within the last twelve months (see section 4.1.2.1). The evidence discussed in chapter 4 also suggests that the way ICT is accessed and used by science and mathematics teachers is complex.

5.1.1 Reasons for ICT use from questionnaire responses

Questionnaire respondents who had reported to having used ICT in the last twelve months were asked in item 22, to write down how they used ICT and what benefits they derived from its use. The range of responses given by the teachers establishes the following common issues, as highlighted in table 5.1.

Table 5.1: Popular uses of ICT among A-level science / mathematics teachers

Popular uses of ICT from item 22	No of Teachers
No relevant comment	26
Do not use ICT for professional purposes	22
General professional usage / unspecified	20
Subject related notes supplements	23
Materials / module development	2
Organisation of teaching and learning	8
Total	101

From the above table, it is clear that the majority of ICT users among the questionnaire respondents used ICT in a variety of ways which were linked to their professional development. 26 of the 101 teachers did not respond to the open ended questionnaire item and 22 teachers mentioned that their use of ICT was unrelated to their work. This means that slightly more than half of the teachers who used ICT also used it for professional development purposes.

Twenty of the teachers did not directly refer to how they used ICT for their professional development, but instead commented on the benefits they and their students derived from the use of ICT. Typical comments given by teachers in this respect included statements such as *"Using ICT made my teaching style richer"* (K0101M), or *"I found the information on the Internet more simplified and detailed compared to the textbook materials"* (K0903M).

The remaining teachers (33/101) were quite specific about their usage of ICT and its benefits to their professional life. By far, most teachers saw ICT's utility in subject related activities and these were mostly concerned with securing resources for teaching and learning. The topics covered ranged from HIV / AIDS information in Biology:

I used google to find arguments presented by President Thabo Mbeki to back up his refusal to link the HIV vector with the AIDS disease, and his alternative explanation. (K1204M)

To Molecular shapes and models in Chemistry:

I intend to use information on shapes of molecules that I obtained from the Internet during this residential period. (A08F)

To a study of the El-Nino phenomenon which plunged southern Africa into serious droughts in the years 1992, 1998 and 2000:

I have used this information, especially on El Nino and tropical cyclones, especially cyclone Eline. The students used this information to produce excellent projects and assignments. (A21M)

...the teaching of matrices in Mathematics:

I had to teach pupils on the determinant of a 3x3 matrix. -Could not get any information from the school library. -Long list of choices from Internet search - chose the one that is clear to understand and relevant to the syllabus. - printed the materials for students. Pupils found the work very easy to deal with. (B15F)

...and Radioactivity in Physics:

Yes. I downloaded notes on radioactivity and print them on transparency. Used on OHP and it saves time. More time spent on class discussion. (C07M)

The main reasons provided for searching for these materials resources using ICT were that the required information was more up to date and not easily found in textbooks (E38M, E31M, K2102M), the illustrations contain original ideas and approaches, as well as providing a wider range of activities than textbook materials (K0104F, K1301M) and in some cases, the materials were simplified for the level of the students (K0903M).

Use of ICT in subject related professional development falls outside the scope of this present discussion however, and will be examined in more detail in the next chapter.

Of particular interest to this discussion was the fact that teachers associated their use of ICT with specific benefits to themselves and their students. The benefits cited by the teachers all pointed to their professional development and well-being. Benefits included an improvement to the teaching style of the teacher (K0101M), providing additional ideas for activities (K0104F), aiding student understanding (K0703F) and supporting the development of interest and relevance of the subject (K1301M, A21M, E38M). All these cited benefits led to the teacher perceiving themselves as becoming more effective professional and classroom practitioners.

5.1.2 Reasons for ICT use from the Interview Analysis Framework

The interview data shows that the perceived benefits of using ICT could be placed under nine themes using an analysis framework key described in chapter 3 (see appendix 3.8). The main themes isolated from the interview data were found to be: i) professional identity, ii) career development, iii) management of the ICT environment, iv) theoretical and content knowledge, v) practical knowledge and professional skills, vi) pedagogical content knowledge, vii) professional networking, viii) benefits to pupils and ix) benefits to self

(teachers). However, theme 3, relating to the management of the ICT environment, is mainly concerned with issues of structural support and is therefore not directly relevant to the teachers' professional development. Some aspects of this theme were discussed in the previous chapter while considering issues pertaining to access of teachers to ICT facilities. Appendix 3.8 describes these themes in detail.

These themes raised by teachers were used by them to explain how and why they used ICT for their professional development. The fact that teachers' responses to the interviews presented such wide-ranging and complex issues, shows that teachers' use of ICT for their professional development was a considered and rational decision making process, arrived at along the lines of Doyle and Ponder's *practicality ethic* (Doyle and Ponder, 1978) which was briefly described in chapter 2. Indeed, closer inspection of the themes raised in the interviews, shows that eight of these themes are related to the three conditions that an innovation must satisfy, for successful implementation. These are provided in table 5.2 below:

Practicality Ethic	Interview Analysis Framework Themes
Value Congruence	i) Professional Identity (efficacy, self-esteem, personal theory of teaching) ii) Career development
Instrumentality	iii) Theoretical and content knowledge iv) Practical knowledge and skills v) PCK
Cost-benefit analysis	vi) Teacher benefits vii) Student benefits viii) Networking

Table 5.2 Comparison of the analysis framework with the Practicality Ethic (Doyle and Ponder, 1978)

From table 5.2, it can be deduced that ICT provided teachers with a means to determining and satisfying their personal aspirations towards enhancing and

re-defining their professionalism. Teachers also recognised the utility of ICT as a pedagogical resource in providing support for practical knowledge, subject content knowledge and access to skills and training. ICT also provided opportunities for the adaptation and contextualisation of pedagogical content for use in the classroom. Finally, Interviewed teachers were able to identify the benefits, to themselves and their students, of using ICT. These benefits made it worthwhile for them to invest their time and financial resources to pursue the use of ICT in their self-directed professional development.

In this chapter, emphasis is given to the discussion on issues pertaining to value congruence and cost-benefit analysis, as these issues directly deal with the personal growth of the teacher, and issues that the second research question seeks to address. Understanding personal professional growth (henceforth called personal growth) is based on viewing the teacher as an adult learner and decision-maker, developing within the profession (Cross, 1981 and Knowles, 1984). Miller and O'Shea (1992) also see the teacher's status as an adult learner in professional development as a pre-requisite to teacher efficacy as a practitioner.

Issues pertaining to the instrumentality of ICT are discussed in the chapter 6. Throughout this discussion, and for purposes of analysis, ICT is viewed as an innovation because it is being used by teachers to improve upon their practice.

5.1.3 Reasons for the use of ICT from Factor Analysis

Responses to questionnaire items 18 and 19 provide perceptual variables of what applications of ICT teachers find most useful. An attempt was made to organise these perceptions into factors that could be used to explain how teachers made decisions in their use of e-mail and the Internet.

Factor analysis was used to extract the principal components that would explain the greatest portion of the variation observed in the teachers' responses regarding the use of e-mail and Internet applications of ICT to their professional development. As a method of confirming underlying psychological issues, factor analysis is widely used (Diamantopoulos and Schlegelmilch, 2000). The use of factor analysis in this case is justifiable because the sample of users was relatively large, (i.e greater than one third of all the teachers in the sample). The Kaiser's measure of sampling adequacy (KMO) was calculated to be 82.1%, Tabachnick and Fidell (2001) argue that KMO values which are greater than 60% are acceptable. Thus the sampling measure obtained through the questionnaire results was quite good. Using the method of principal components extraction, 2 factors, with eigenvalues larger than 1, were extracted as shown in table 5.3 below. These two factors explained 70.7% of the data set variation between them.

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	4.392	54.9	54.9
2	1.263	15.8	70.7
3	0.731	9.1	79.8
4	0.716	8.9	88.7
5	0.385	4.8	93.5
6	0.259	3.3	96.8
7	0.188	2.4	99.2
8	0.006	0.8	100.0

Table 5.3: Extraction Method: Principal Component Analysis (PCA).

The scree plot also visually confirmed the existence of two factors with eigenvalues greater than one (see figure 5.1 below).

The extracted factors were further rotated using varimax, to maximise the loading of each variable, on only one of the factors and thus more clearly delineate the association. Note that the first two factorial components contributed two thirds of the observed variation. Although the third component

contributed about one tenth of the observed variation, its eigenvalue is less than one and therefore it was discarded as an independent factor. Using this method, a high reliability α , of 87.33% was reached. A complete reliability analysis is given in Appendix 5.1

Figure 5.1: Scree Plot showing Extraction of two factors by PCA method

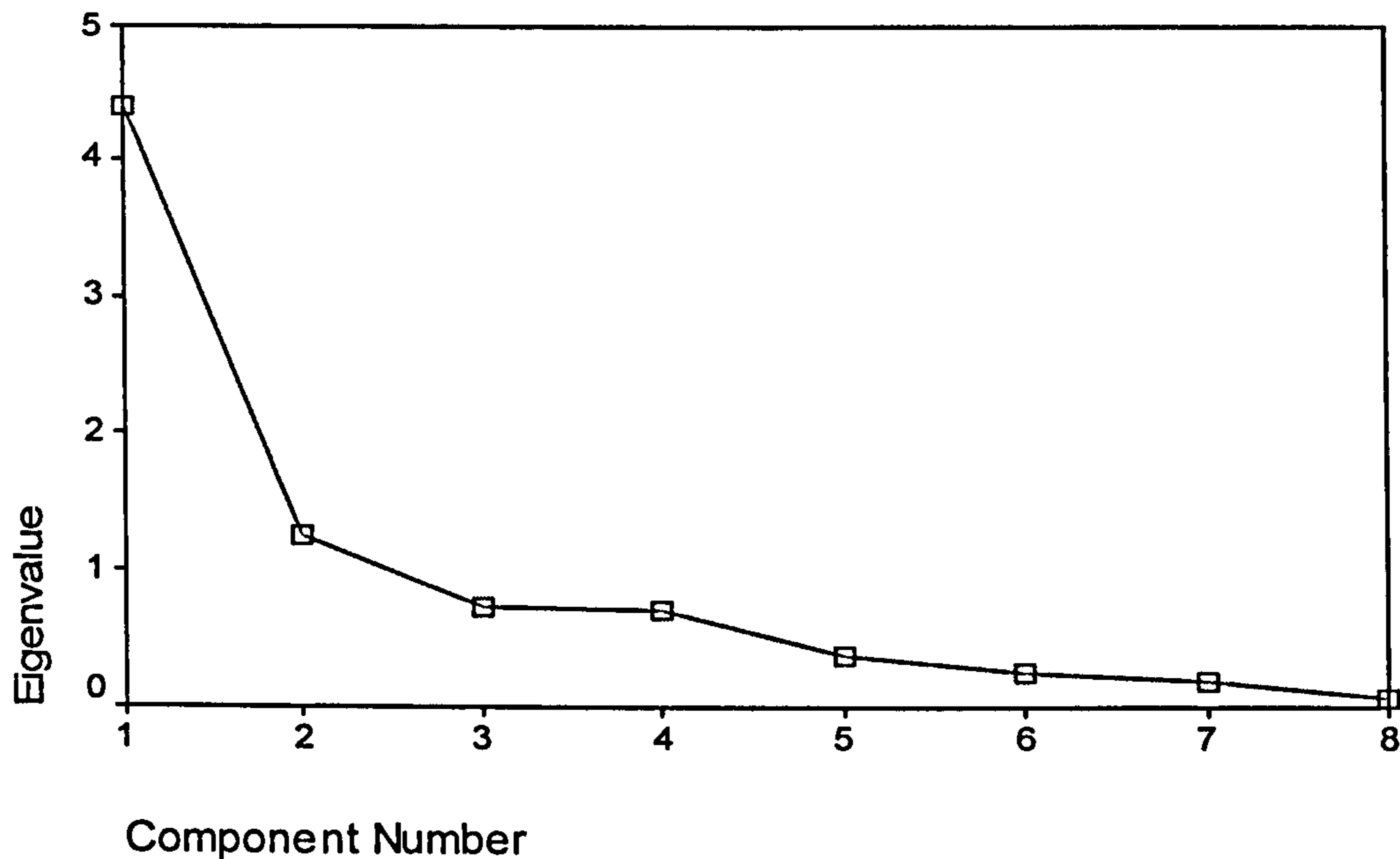


Table 5.4 shows how the questionnaire items cluster around the derived factors and the strengths of the association between the items and the factors. A high loading indicates a greater association. Since the variables were rotated to maximize a loading on only one of the factors, each factor can be thought of as a grouping name for the items associated with it. From the table 5.4 it can be seen that variables loading highly on factor 1 have to do with teachers' classroom practice, whilst those loading highly on factor 2 have to do with teachers' professional networking.

Variable	Factor loadings	
	Factor 1 (ICT as teaching resource)	Factor 2 (ICT as networking resource)
Using e-mail to communicate with colleagues		0.731
Using e-mail to seek for assistance		0.690
Using e-mail for professional collaboration		0.727
Using the Internet for online discussion groups		0.548
Using Internet to gain information	0.868	
Using the e-mail to compare teaching approaches		0.749
Using the Internet to develop teaching materials	0.935	
Using the Internet to improve your teaching	0.931	

Table 5.4 Extracted factors and their associations

Whilst factor 1 fits easily with the instrumentality concept discussed in section 5.1.2, in that teachers see and use ICT as a resource to assist them in their work, factor 2 is much more complex. It deals with the concept of the teacher as a professional who develops through social interaction. Pundits of adult learning (Gleick, 1988; Sawyer, 2001; Knowles, 1984 and Little, 1990) emphasise the contextual and social nature of adult learning. In this respect, teacher networking is seen as a crucial component in the process of professional learning. For example, teachers who participate in or aspire towards collaboration with others are behaving as adult learners. In addition, Little (1990) contends that teacher collaboration provides benefits and professional identity to the teacher in relation to their colleagues. Little goes on to conclude:

Teacher collaboration has been found to offset drawbacks of teacher isolation by *building on the value* teachers hold for themselves, their students and their teaching. The process of teacher collaboration supports teachers in *gaining reflection* needed for exploring and problematising taken for granted aspects of practice, and constitutes a challenge to the intellectual and collegial passivity. (Little, 1990; p. 8 – *my emphases*)

Little implies that collaboration provides for value congruence – by *building on the (professional) values* of the teachers, and providing opportunities for

reflection. Taken in this light then, the results of the factor analysis are consistent with the initial findings discussed earlier within this chapter and seem to confirm Doyle and Ponder's *Practicality Ethic* regarding the reasons why teachers chose to use ICT for their professional development.

However, it needs to be pointed out that the results of the factor analysis are dependent on the individual associations made by the teachers in response to the questionnaire items – i.e. the degrees to which they agreed or disagreed with the individual statements - and the correlations of these associations between the questionnaire items. Had the response pattern been different, this would have affected the correlations and hence the results of the factor analysis. The researcher had no control over the choices that the teachers made in considering these items therefore the decision making process from the point of view of the researcher, was completely random. A small change in the choices teachers made about the usefulness of ICT could well have affected the factor analysis results differently. The fact that the factor analysis results are consistent with the results obtained the interviews and the free-response questionnaire items shows that amidst the complexity of issues pertaining to the use of ICT by science and mathematics teachers, there is an underlying order.

Thus, using three different sources of data (i.e. questionnaire free responses, interview analysis framework and factor analysis), it was possible to converge the issues raised in each case to three major themes pertaining to science and mathematics teachers' use of ICT for their professional development. These themes have to do with teachers' professional values and aspirations (*value congruence*), teachers' classroom practice (*instrumentality*) and perceived professional benefits (*benefit analysis*).

5.1.4 The complex nature of self-directed professional development

The complexity of the professional development processes and the choices that teachers made pertaining to the usefulness of ICT in helping them to realise their developmental goals is analogous to the behaviour of a chaotic system. In fact, to study the order underlying complex behaviour issues such as teachers' professional development, more and more researchers are turning to complexity theory as a method of understanding and explaining human behaviour (Brennan, 1997; Capra, 1996; You, 1993 and Hunt, 1998)

Modelled along the same lines as quantum non-linear dynamics theory developed by Ludwig Von Bertalanffy in the late 1940s, complexity (chaos) theory has been introduced as an alternative to the Cartesian analytic tradition which still governs most academic analysis from physics to the social sciences. Cartesian systems are dependent on the cause-effect linear solution. When applied to the social sciences, Cartesian tradition views human behaviour as having a definite cause and effect pattern. The stage theories of professional development discussed in chapter 2 all have a definite beginning and ending. Teachers progress from initial induction to expert master stage in Steffy's model for example. However, chaos theory predicts human behaviour as being subject to uncertainty. Small changes and decisions can result in very different outcomes even in the above example. A teacher might not necessarily develop from induction to expert. They might enter the teaching field already exhibiting expert teacher characteristics, or might never reach the expert stage. Chaos theory attributes the uncertainty to the initial conditions. By recognising that human behaviour is non-linear, chaos theory sets limits to the predictions and generalities that can be made about individual behaviour and therefore instead

focuses on the behaviour of holistic system structures. This is the analytical approach that will be used in the rest of this and the following chapters.

As mentioned before, the following sections will focus mainly on how ICT adds value and benefits to the teachers' personal growth. Pedagogical issues of ICT use will be covered in more detail in chapter 6.

According to chaos theory, complex behaviour is dependent on the initial conditions; i.e. understanding teachers' professional behaviour in using ICT depends upon understanding the initial conditions that teachers are operating under in this instance. One of the initial conditions that teachers bring to the professional development process could be their concerns about using ICT. Item 20 of the questionnaire relates to the Concerns Based Adoption Model (CBAM). This model deals with teachers concerns about an innovation. The eight response options on the item correspond to the four categories of concern in the model. Table 5.5 below summarises the teachers' responses for this item.

Table 5.5 Role of ICT in teachers' professional development

CBAM component	Role / concerns	Frequency
Awareness	1. Little use of ICT. / Do not see its use in professional development.	3
Self Orientation	2. Need more information on ICT use / making enquiries	13
	3. Preparing to use ICT for first time in professional development.	6
Task Orientation	4. Primary interest in mastering ICT skills	20
Impact on Practice	5. Reasonably comfortable in using ICT / considering maximising effects of ICT on professional development	44
	6. Varied use of ICT to maximise effects on students	11
	7. Using ICT for networking to achieve greater impact	1
	8. Evaluate ICT use to maximise effectiveness on teaching	3
Total (N)		101

From table 5.5, 58% (59/101) of the respondents indicated that they are concerned with improving the impact of ICT on their practice. 20% (20/101) were more concerned with basic mastery of skills while another 19% are still trying to re-orient themselves in relation to using ICT for their professional development. Three of the teachers who stated that they used ICT in the last year, however did indicate though they were aware of ICT, they did not think it was relevant to their professional development.

5.1.4.1 Trigger events for self-directed professional development

Using cross tabulation, it was possible to confirm that of the three teachers who had little knowledge of the use of ICT for professional development, one of the teachers accessed ICT at least once a week, the other once a month and the third teacher, less than once a term. Whilst it could be argued that the third teacher is an infrequent user of ICT anyway and would not have enough exposure to start exploring possible professional uses of ICT, the same argument cannot be made for the other two teachers who are reasonably frequent users. In this case, lack of awareness of the potential usefulness of ICT in professional development could have been due to the absence of suitable trigger events that could have provided initial stimulation of interest. Examples of such coincidental triggers could include a chance comment by colleagues, about how a particular aspect of ICT was being used as a resource for teaching, or a chance to use resources derived from ICT by other teachers. In the interview sample one teacher described how he was able to secure the current teaching post at a private school:

Last year, when I was applying to come here from Assisi (*in Zimbabwe*), I had to apply by e-mail... We had gone to Marondera for a workshop and someone mentioned that this school was recruiting. When I asked for details, I was told that the closing date was the following Friday. I knew that a letter would never reach here in time so I wrote an e-mail indicating my interest there and then. They sent me the

application forms by attachment and the following Monday I downloaded the forms, filled them in and drove here to deliver them by hand. The following week, I was interviewed and got the job. If I had relied on the postal service, maybe I would have had to wait for three months before being notified that regrettably my application letter arrived after the deadline. (ME39W, lines 60 -70: *my emphasis*)

In the above quotation, three characteristics of a trigger event are apparent:

- i) The trigger is initiated by a chance event – in this case, a casual comment by colleagues.
- ii) The chance event produces a bifurcation point which leads to decision making – in this case, whether or not to apply, and how to do so.
- iii) The decision chosen changes the course of action (behaviour). This is called “phase transition” and marks the beginning of the change process as (in this case) the teacher tries new ideas by making the application.

In this case a chance remark by colleagues, and the teacher’s awareness of the potential of using ICT as a communication tool, acted as trigger mechanisms which led to events that changed the course of the teacher’s career. In chaotic systems, trigger events are important as they lead to decision making or bifurcation, which in turn can have far reaching consequences to the direction taken by the system as a whole – the so-called Lorenz’s butterfly-effect (Feltovich *et. al.*, 1996; Gregory and Sayers, 1994).

Table 5.5 also shows that around 44% of the respondents are operating at stage 5 of the stages of concern component of CBAM. This means that they are still trying to find ways of maximising the effects of their use of ICT into tangible impact on their own professional development. Further comparisons of item 20 with demographic variables such as type of school, teaching subject, experience, initial training institution and method of ICT skills acquisition did not

yield any significant correlations, implying that concerns about the role played by ICT in teacher professional development may not be related to any of these demographic characteristics.

5.1.4.2 Using ICT to address the concerns of teachers

Item 21 was also adapted from the standardised stages of concern questionnaire and focused on the *level of use* component of the CBAM. This component has 6 levels ranging from non-use to renewal. The component can however be broadly categorised into users and non-users – with the first three levels being linked to non use. Table 5.6 summarises the teachers' level of use responses.

Table 5.6: Teachers' responses to the level of use component of CBAM

CBAM Level	Level of use category	Frequency
Non Users	1. Never used ICT for professional development	5
	2. Lacking confidence	16
	3. Preparation	25
Users	4. Increased confidence / application	28
	5. ICT seen as a tool / mechanical use	13
	6. Integration / use ICT to design curriculum materials	13
Total (N) =		100

From table 5.6, 46% of the respondents would fall into the *non-user* level of the CBAM. However the majority of these non-users are just preparing themselves to use ICT, and can identify problems that can be addressed using ICT. Like wise, more than half of the 54 *users* were learning to apply ICT to professional development issues. Only 5% of the teachers had never used ICT for professional development purposes. The majority of teachers responded to this item as ICT users at levels 3 or 4 of the level of use scale.

Comparison of level of ICT use with demographic variables such as *type of school, teaching subject, teaching experience, initial training institution, and*

method of ICT skills training revealed no significant relationships. Again, the teachers' level of use of ICT does not appear to be related to any contextual and environmental variables. Apparently, more subtle attractors (to use chaos theory jargon) are at work. This observation is important because it appears to contradict popularly held beliefs about teacher professional development and about teachers as decision-makers. Grummet (1988) and Bradbeer (1998) argue that the choices that teachers make in connection to their professional development and practice are to a large extent influenced by the context in which they operate. Sawyer, (2001) goes on to claim that the teachers' personal history in relation to their schooling, also contributes to the way they make decisions. Some teachers identify strongly with the traditions of their qualifying institutions or their teachers and make decisions they feel would be in line with what that tradition dictates. The fact that in this case, there appeared to be no correlation between teachers demographic characteristics and the role ICT played in their professional development and level at which they used ICT for their professional development further confirms the complexity of the professional development process, and the behaviour of teachers as adult learners. Gleick (1988) summarises this observation succinctly:

Adult learning must be understood as a dynamic process constantly changing and re-shaping. Human learners do not passively follow a pre-programmed package or react to external stimuli within the parameters of a dynamic view of knowledge, rather they follow unpredictable patterns which are discontinuous and complex. (p113)

One way to develop better understanding of the underlying attractors for the reported teacher behaviour would be to seek for repeating patterns of reported behaviour (or fractals) that can be observed at the micro level. The two factors derived from factor analysis provide a good starting point. The factors were used to group discrete behaviour elements in the form of high loading

questionnaire items. Within each factor, these behaviour elements behave as if they were a single variable, here called *use of ICT*.

The scores of each of the questionnaire respondents were recalculated for Factor 2. The scores ranged from a minimum of 5 and a maximum of 30 for factor 2 because it was a grouping of 5 variables. A score between 5 and 12 was an indication that the teacher considered the use of ICT as a networking resource generally useful. A score-line of between 13 and 18 indicated that the teacher considered some aspects of ICT as a networking resource not as useful as others and so there was inconclusive evidence of the teacher's opinions as to the general usefulness of ICT as a networking resource. A score-line of between 19 and 25 was taken to be an indicator that the teacher generally considered networking using ICT as not useful. Finally, a score-line between 26 and 30 indicated that the teacher either had not used ICT for this purpose or was not experienced enough in the use of ICT as a networking resource, to form a general opinion.

A *Chi-square* analysis was carried out to discover if there were any significant associations between Factor 2 (*ICT as networking resource*), *role of ICT*, *level of use* and a new item (*use of ICT*), created from teachers responses to the open ended item 22. Table 5.7 shows the outcomes of the *Chi-square* analysis.

Table 5.7: Comparison of ICT as a networking resource with CBAM

Variable 1	Variable 2	N	X ²	df	significance
Use of ICT	Networking resource	72	17.082	6	0.01
Use of ICT	Level of use	71	23.882	10	0.01
Use of ICT	Stages of Concern	72	13.298	6	0.04
Networking resource	Level of use	100	19.255	15	0.20
Networking resource	Stages of concern	101	43.901	9	0.03
Stages of concern	Level of use	100	55.280	15	0.05

The table shows that there was no relationship between teachers' *use of ICT as a networking resource* and *the level of use of ICT*. There was a strong association between what teachers said they used ICT for (in free-response item 22), and the derived factor2 of their perceptions on the usefulness of ICT as a networking resource. Figure 5.2 illustrates this relationship.

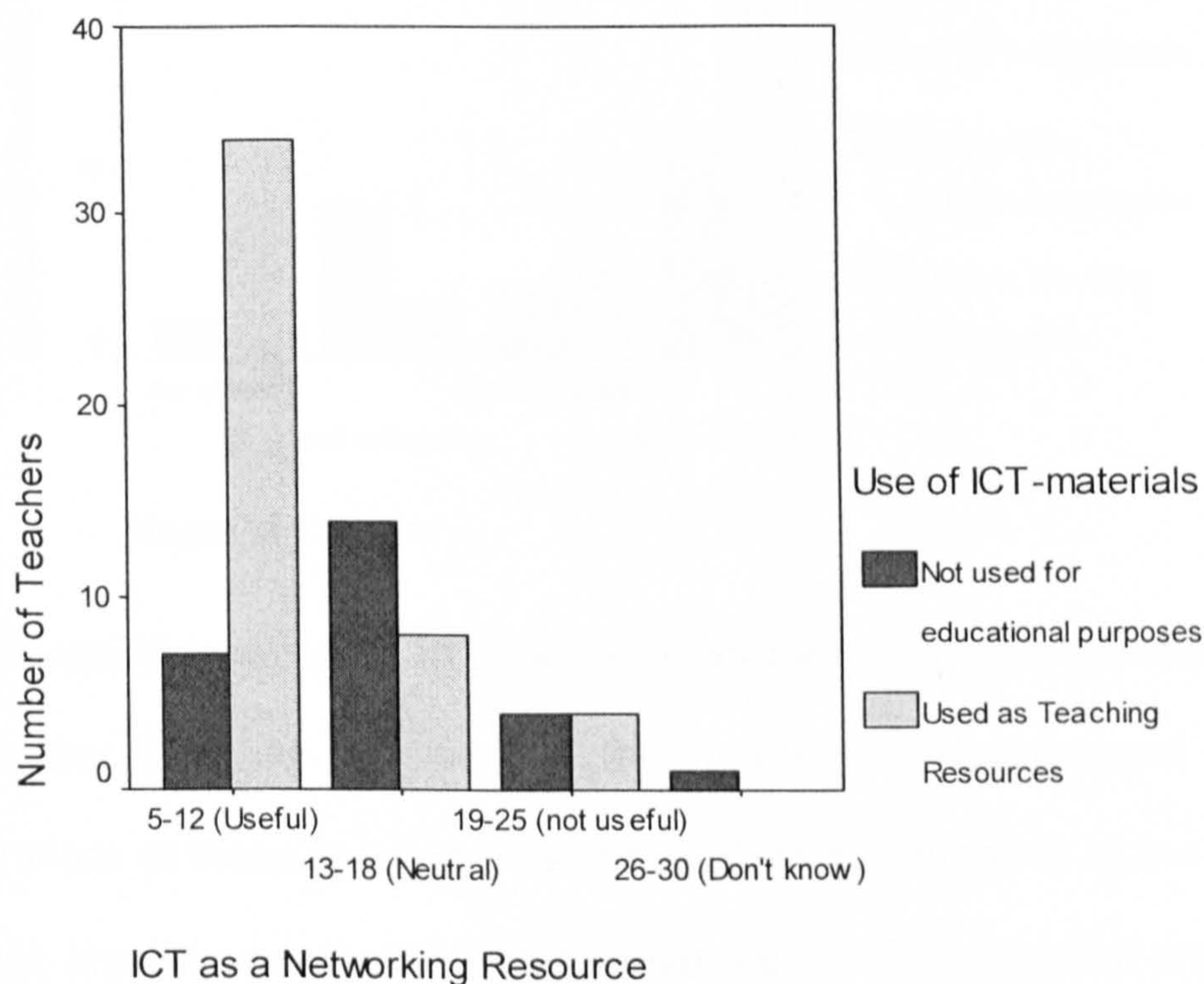
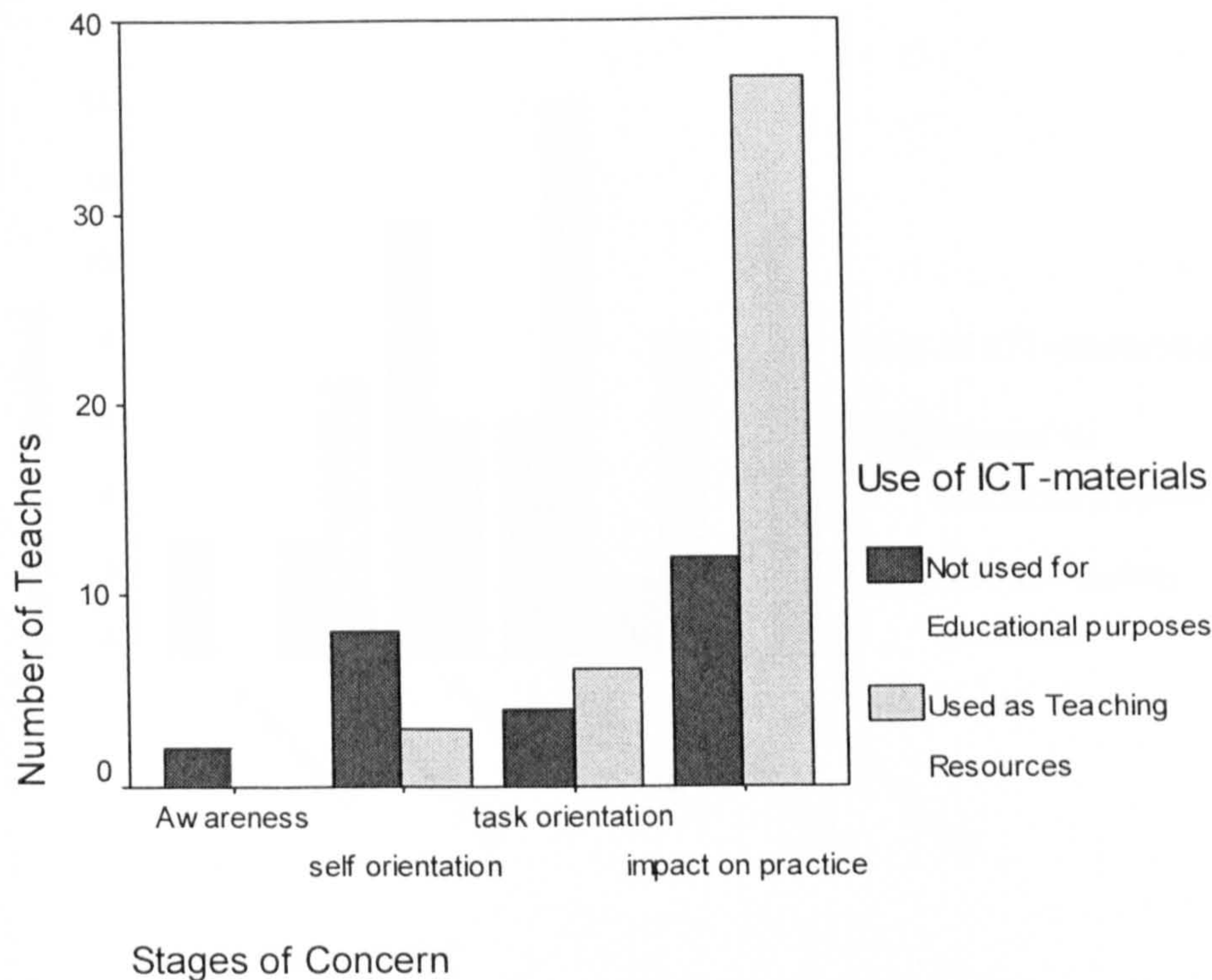


Figure 5.2: Comparison of ICT use with Networking Resource

From the graph one can see that teachers who used ICT as a source for teaching resources also found networking, using ICT to be quite useful.

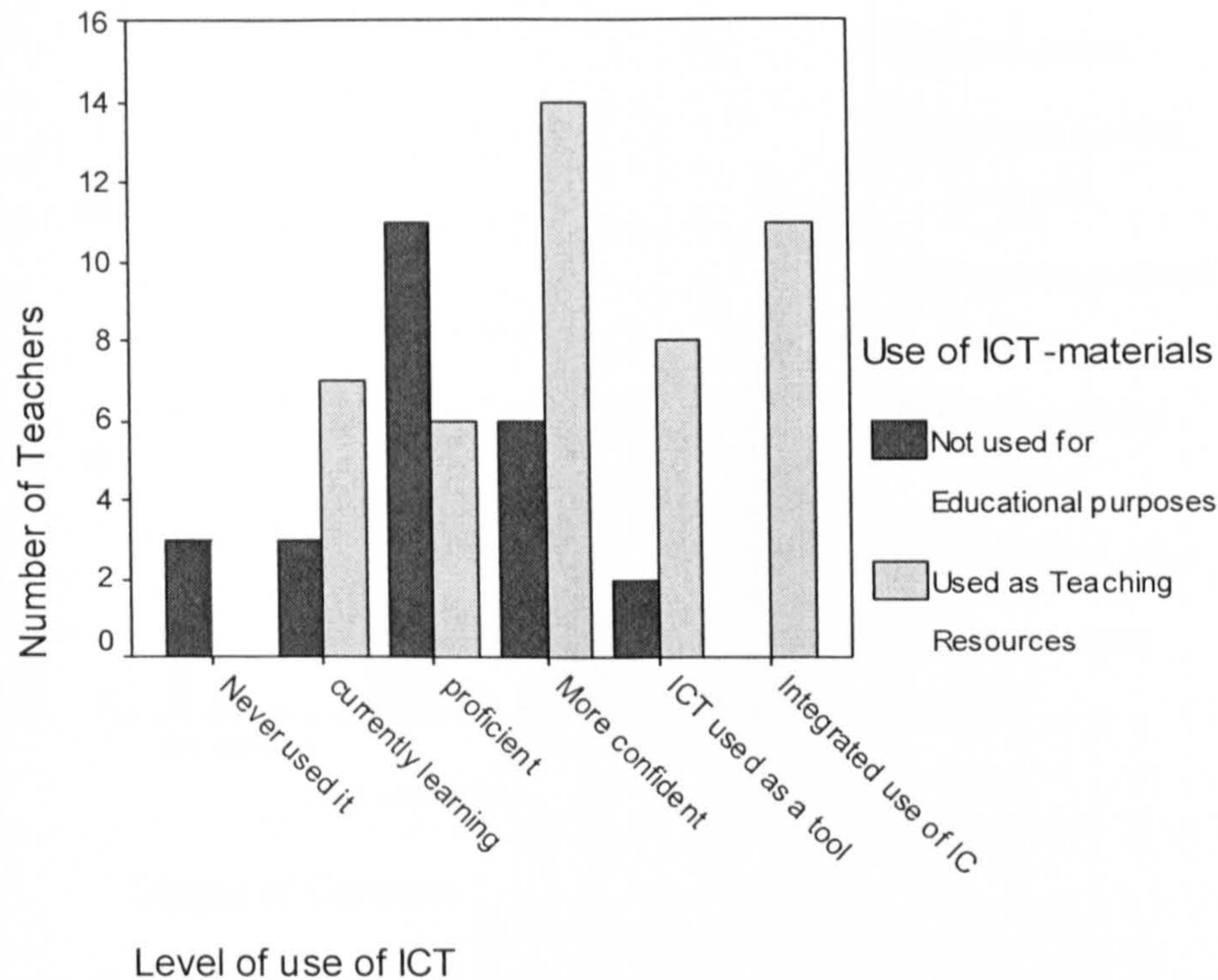
Table 5.7 also shows a strong association between teachers' ICT use and their *stages of concern* and the *level of use*. Teachers who indicated that they used ICT mainly as *teaching resources* also tended to see themselves as operating more at the *impact on practice* level. This is illustrated in figure 5.3.

Figure 5.3: Comparison of ICT use with the stage of concern

However, there appears to be an anomaly pertaining to those teachers who claimed that they did not use ICT for professional development purposes. Slightly more of these teachers saw themselves as operating at the advanced stage of impact on practice. This could be an indication of their overall confidence in using ICT, although in their view, these highly developed skills did not translate into actual educational use of ICT.

Figure 5.4 shows a graph of comparison for the *use of ICT* and the *level of use* of the teachers. The relationship illustrated in the graph was found to be statistically significant. From the graph, teachers who indicated themselves as using ICT as a teaching resource also tended to rank themselves at the higher levels of use on the *level of use* scale. Teachers who tended to use ICT to access teaching resources tended to be those teachers who were already confident ICT users in general. This implies some consistency in the way the respondents answered the questionnaire items.

Figure 5.4 Comparison of ICT use with level of use.



In addition, it is noted that teachers who indicated in the open ended item 22 that they did not use ICT for educational purposes, ranked themselves lower than those teachers who did.

Significant relationships were observed between the teachers' use of ICT pertaining to the CBAM stage of concern and to the *Level of ICT usage*. However even these results are not very reliable because of the high percentage of cells with a frequency count of less than 5. A tentative relationship however seems to suggest that teachers who were operating at higher stages of concern, such as *task orientation* and *impact on practice* also tended to be more confident in their use of ICT. Figure 5.5 illustrates this relationship.

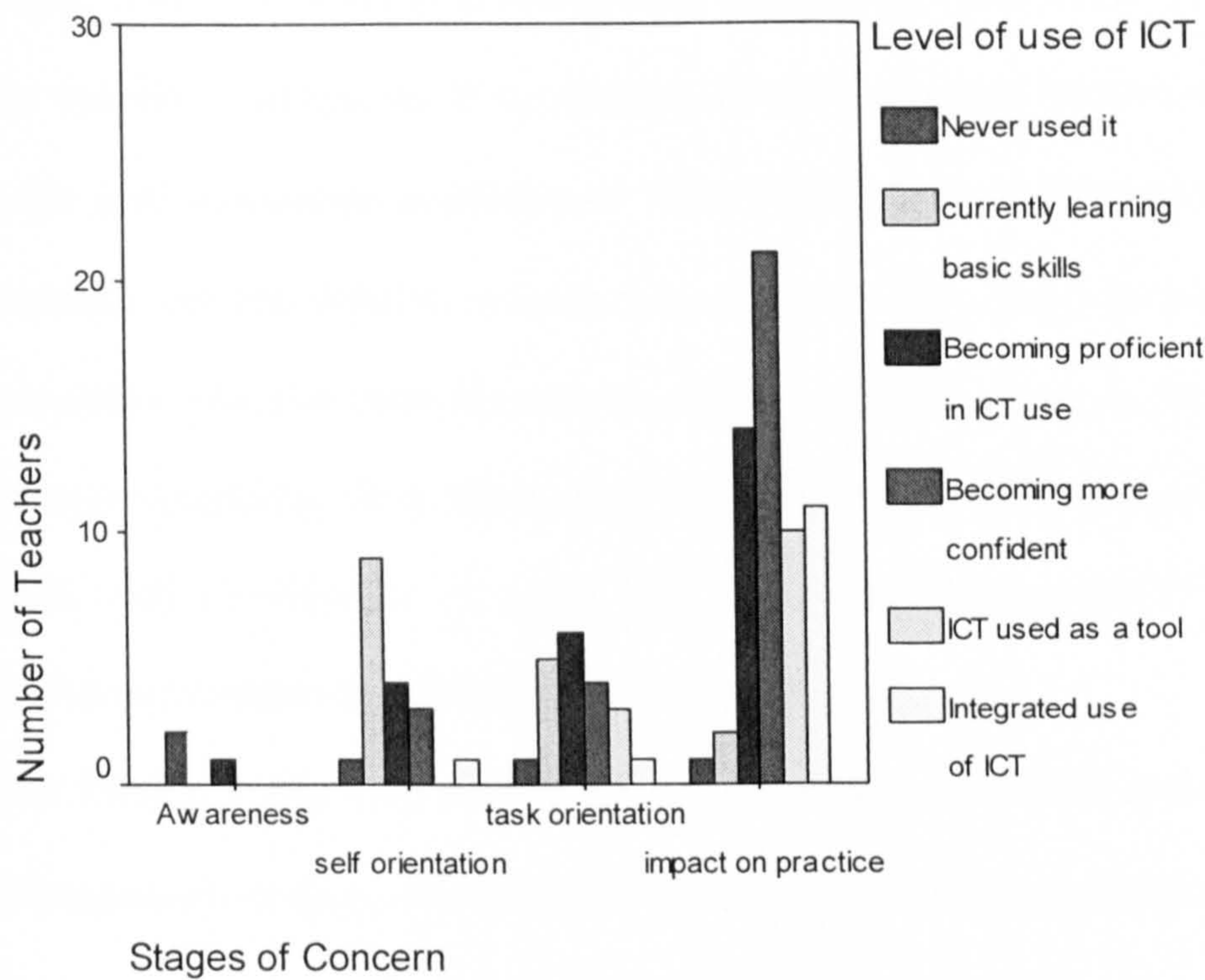


Figure 5.5 Teachers stage of concern versus the level of use of ICT

Thus higher levels of ICT use were associated with higher stages of concern. For example, teachers who reported becoming confident at using ICT for educational purposes, and those who used ICT as a tool, and those who claimed to have been able to integrate the use of ICT with their practice, tended to see themselves as being more concerned with the impact of ICT use on their practice. Whereas, those teachers who reported little experience or were involved in basic skills also tended to focus their concerns on awareness and orientation issues.

The CBAM analysis can be compared to other models of professional development, e.g. Sawyer (2001). Sawyer argued that teachers passed through phases of *survival*, *exploration* and *adaptation*. He argued that novice and inexperienced teachers went through a “survival” phase which is characterised by coping strategies. The second stage in Sawyer’s phases has to do with experimentation. The third and last phase of development according to Sawyer is adaptation and is characterised by competence in using multiple approaches

to teaching, reflection, critical thinking and integration. Self-orientation can be linked to teacher survival as it is concerned with learning basic skills to get started, i.e. self-orientation is utilitarian. Task-orientation can likewise be linked to exploration, as the teacher moves out of concerns about himself towards concerns about effectiveness. Impact on practice can be linked to being able to adapt to new situations. This observation implies that as the teachers gained in experience and confidence of using ICT, their concerns shifted from mere survival and exploration to adaptation (Sawyer, 2001).

When Factor 2 (*the use of ICT as a networking resource*) was compared with the *stages of concern*, it was found that teachers who were operating at the highest stage of concern (impact on practice) also found the use of ICT as a networking resource generally useful – a result that seems to confirm the conclusion reached by Sawyer, quoted above. This relationship is illustrated in figure 5.6

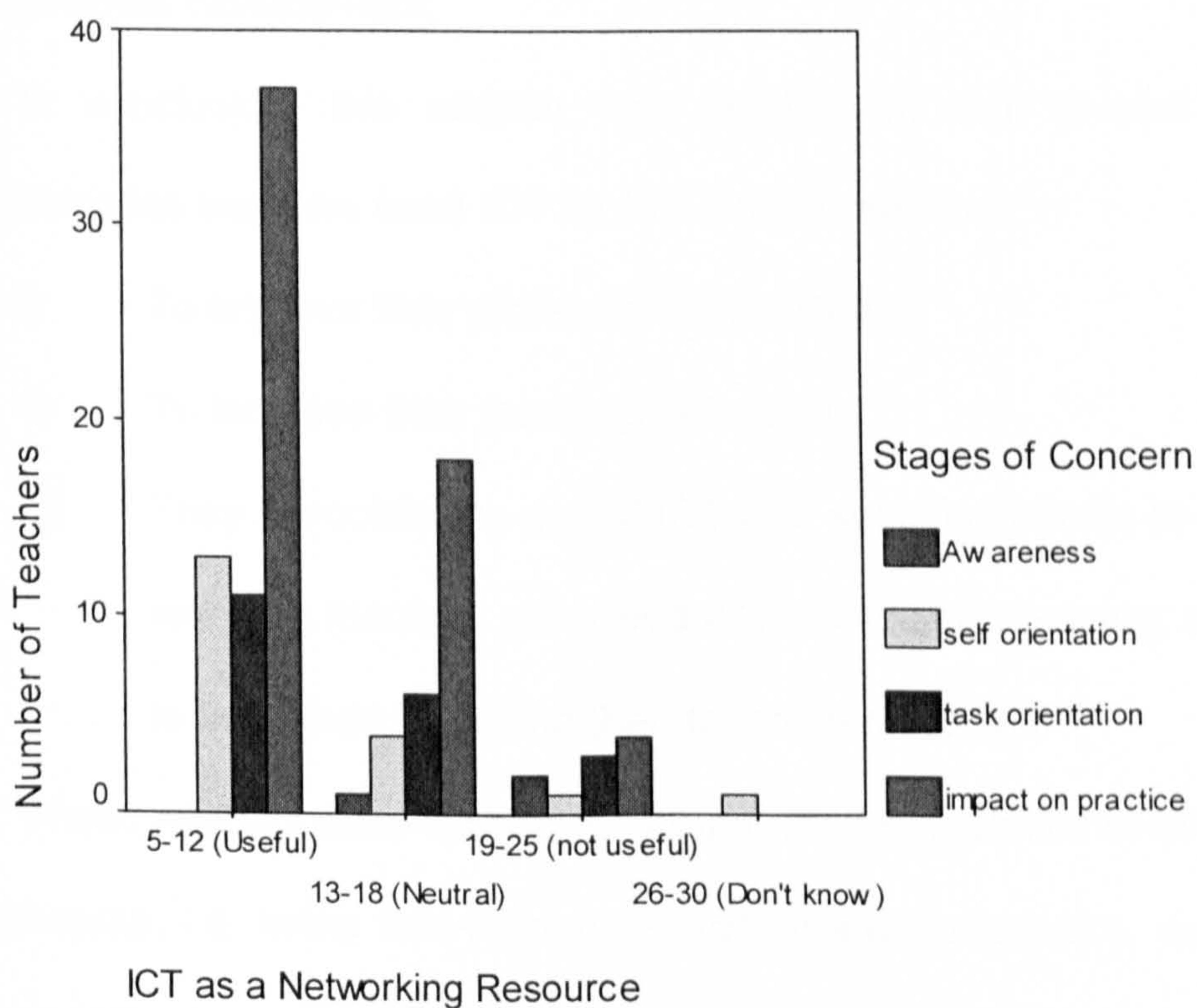


Figure 5.6 Comparison of Factor 2 with the stages of concern

The above discussion seems to suggest that one of the main reasons why teachers were using ICT for their professional development was to increase their networking with other professionals. Indeed there is a growing trend among researchers, to place professional collaboration at the centre of teacher professional development. Lieberman and Miller (1991) claim that our understanding and approaches to professional development has shifted from a “deficit” approach, in the late 70s and early 80s, which was characterised by short in-service courses aimed to “plug” gaps in content and pedagogy. Usually in this case external “experts” were invited to run these courses. Emphasis has now shifted to a collaborative approach, which recognises teachers as experts in their own fields and focuses on the sharing – rather than imposing of ideas. From this study, it appears that teachers voluntarily seek out collaborative activities with peers using ICT. One can therefore conclude that the potential for collaboration was one of the teachers’ major attractors to the use of ICT for their professional development.

In conclusion, this section has established that A-level science and mathematics teachers used ICT for three main reasons:

- i) To improve their professional knowledge
- ii) To increase their teaching skills and
- iii) They associate the use of ICT with specific benefits to their work. For example teachers perceived ICT to be labour saving, and convenient to use when preparing their teaching materials.

These reasons were arrived at through the triangulation of different analysis techniques, i.e. using free-responses from the questionnaire, using the results of an interview analysis framework and also using factor analysis. Teacher networking was identified as one strategy that teachers used to improve their

professional practice. Collaboration was also identified as an aspect of networking that teachers found to be very useful.

In the following sections, the exact nature of online professional collaboration, and the other aspects of teacher networking, together with their perceived benefits, will be explored in more detail using mainly interview data.

5.2 How does the use of ICT enhance teachers' professional development?

As indicated earlier, this section will address sub-research questions 2.2 (*what aspects of professional development enable teachers to be supported by ICT?*) and sub-research question 2.3 (*How does the use of ICT enhance teachers' perceptions of their own professional development in terms of professional values, personal aspirations and effectiveness?*) This change in the formatting of the report is due to the fact that chapters 5 and 6 rely mainly on the interview analysis framework, the discussion of which requires a thematic approach.

Lieberman (1994) has described the goal of professional development as that of building conditions conducive to teachers' continuing growth. This is achieved by providing for the teachers, opportunities for enquiry into their own practice. In self directed professional development, teachers have to learn to identify these opportunities as no external agents of change are involved. Section 5.1 has alluded to two main aspects of teacher professional development which appear to have drawn teachers towards the use of ICT. These have been identified as *personal-growth* and *professional networking*.

The first aspect has to do with the personal-growth benefits to be derived from using ICT. These benefits in turn can be sub-divided into improvements in *professional identity (theme 1)*, *career development (theme 2)* and *benefits to*

teachers and students (themes 8 and 9). Personal-growth within the profession leads to more confidence and self-esteem. Career development and progression leads to job satisfaction. If teachers could derive other benefits directly, (through recognition) or indirectly, (through improved pass rates – leading eventually to recognition), this would in turn impact on their personal-growth.

The second aspect of teacher professional development has to do with the mechanism by which these benefits can be realised. The previous section has also suggested that the teachers behaved like adult learners and strove for professional growth by directing their professional learning through collaborative activities. Thus the main mechanism for professional development through the use of ICT was identified as *professional networking (theme 7)* through e-mail. In this section, these two aspects are investigated in more detail.

In this section, interview data will be used to discuss themes 1, 2 and 7 in the analysis framework (see appendix 3.8). Themes 8 and 9 will be discussed together with themes 4, 5 and 6, dealing with the teachers' classroom practice, in chapter 6.

5.2.1 The use of ICT in promoting the professional identity of the teacher.

Shedd (1986) and Sawyer (2001) have highlighted the centrality of professional identity to the teacher's development. Shedd described teaching as an intensely active profession which placed enormous responsibilities and challenges on the teacher. A positive professional identity resulted in more confidence to accept challenges and responsibilities. In this study, it was possible to determine that the perceptions of Zimbabwean A-level science and mathematics teachers on the impact of ICT on their professional identity were three-fold (cf. Appendix 3.8):

- a) ICT had an impact on their professional “well-being” i.e. “feel good” emotions about themselves, having a positive image of themselves due to a high self esteem, high self-respect and confidence in their work,
- b) It also had an impact on their professional status among their peers and the community i.e. having a high standing among their peers and students and
- c) It had an impact on their epistemology i.e. what it means to be a teacher, their understanding of role of the teacher etc.

5.2.1.1 Impact of ICT on teachers’ professional well-being

Responding to a question on how the use of materials downloaded from the Internet had benefited her in her professional work, one female teacher said:

I also benefited by concretizing abstract concepts and my students benefit as they understand what I am talking about. So in the classroom, I am more confident and can answer their questions.
(MAS24M, line 46)

For this female teacher, gaining self-confidence through being able to make her pupils understand abstract concepts was very important to her. Being a female mathematics A-level teacher in a school which was dominated by male teachers, she might have felt intimidated and insecure, for later on in the interview she declared that her main reason to resort to using the Internet as a resource, was *“being a woman, I want to show the men that I can teach as well as they can”* (MAS24M, line 65).

The need to fight gender inspired professional inferiority feelings and lack of confidence was evidenced in other interviews as well. In-fact analysis of the interviews shows that of the 18 references made in respect to this aspect of well-being, twelve references were made by eight female teachers while six

male teachers referred to this issue only once during the interview. The presence of multiple references by a single teacher seems to emphasise the importance of the particular idea to the teachers, especially where the references recurred during different sections of the interview. For example teacher MAS34S referred to the aspect of professional well-being six times during her interview (lines 131, 133, 152, 165, 167, 169). She actually summed up the feeling that seemed to pervade the tone of her colleagues' interviews when she said:

I was given the syllabus and was told that I was teaching lower 6th and carrying it up to upper 6th. The students were quite sceptical because *I was young and being a woman* I guess they did not think that I could meet the challenge. I think that is what inspired me to use the ICT packages in the first place – the need to prove that I was capable. It made me more confident to realise the support that I could get. The library staff and the administration were also very supportive and tried to get me more packages that I requested. (lines 125-133 , own emphasis)

The fight for recognition and acceptance, regardless of gender, was thus one important attractor to the female teachers in the interview group. Grummet (1988) and Bradbeer (1998) both subscribe to the view that the context in which a teacher is operating can influence the choices that the teacher makes in relation to her practice. In this case, being young, female and operating in a prejudicial context drew MAS34S to explore the use of ICT to increase her resources. Note also that this choice she made was also accompanied by a sense of identity and achievement, i.e. an increase in self confidence. Thus, the social context in which a teacher is operating was found in this case to have a complex relationship with a teacher's sense of identity and also led to decisions about their practice - a finding that has been noted elsewhere by Zeichner and Liston (1996).

However, gender inequality were not the only reasons why teachers felt the need to boost their feelings of well-being, and ultimately, their identity as professionals. Some teachers derived intrinsic satisfaction from exerting their best efforts to help their students succeed. For these teachers, engagement with ICT to provide a rich, varied environment for learning was in itself, a worthy attractor. When asked why he had turned to the use of ICT in his practice, MN49E gave this response:

I get lots of new ideas on almost every topic I teach so my approach is going to be different from year to year. This makes me confident because I can approach the same teaching materials from different angles owing to the views that I get from reading different views of Biology teachers on the net. (MN49E, lines 50-54)

For this teacher, being a good teacher was associated with flexibility in delivery and being flexible helped to intrinsically increase the teacher's self confidence in his ability to teach. MN54M, a female teacher, forwarded the case for intrinsic motivation much more strongly when she said in response to a similar question:

I derive satisfaction that I am doing my best to provide my classes with a varied experience. This is my second year, and already my class which I had last year, did much better than the other classes during the mid-year examinations. I feel proud to be giving them my best effort. (MN54M lines 46-49)

Being able to provide a varied learning environment for students was perceived to be linked with success. However, what was striking about this teacher's reason for using ICT was the need to feel that she was doing her best. Thus, ICT enabled teachers to draw confidence and pride in the fact that they were able to vary their content and teaching methods. Another reason linked to the "variety" theory was that ICT resources were perceived as supplementary to textbooks, which made them almost as important as the set texts that teachers had access to. Being able to access such resources gave H28G a sense of well-being:

I am now more confident. I don't have to rely on textbooks only. My confidence is actually increased. (H28G, line 76)

Lesko (1986) argued that teachers become intrinsically engaged in their professional development when they can make decisions about their practice which are not based on contextual pressures. Thus teacher engagement can also result in bifurcation leading to the use of ICT in their professional development.

5.2.1.2 Impact of ICT on teachers' professional status

The development of professional identity may be linked to the teacher's professional status i.e. earning the professional respect, trust and esteem of fellow teachers, students and the society at large. Ten teachers claimed that the use of ICT actually helped them to develop their professional status. One physics teacher (ME12M, line 100) mentioned his ICT experience in the last year had enabled him to provide a variety of learning activities for his students and as a result, they now trusted him and were no longer bored by his lessons. Another teacher, commenting on how she used ideas from an online discussion group in her teaching stated:

Sometimes we (the discussion group) talk about new developments in content for example.... then I use some tit bits of the information in my teaching – just to show students the frontiers of research in the topic we will be discussing. I found that I really motivate students and they like it. It also boosts their confidence in me because I show that I am well informed about the topic I am teaching (MW17C, lines 72-84)

Both these teachers have taught physics at A-level for more than 4 years. In both cases, being able to go the extra mile, in providing learning activities or providing extra information conjures the image of a dedicated teacher who is passionate about his / her subject and in turn students respond positively to such teachers. Thus they are esteemed in the eyes of their students. Some of the teachers identified ICT as having assisted them to earn the respect and

esteem of their peers and thus contributing to the development of their professional identity. Responding to a question on how she has benefited from using ICT as a professional, one teacher said;

“I am now more confident. I feel I can be heard and respected by my colleagues.... Even now, at the workshops, I can contribute with confidence and my colleagues are beginning to sit up and notice....”
(M34S, lines 165-169)

A female geography teacher was discussing a workshop that she facilitated, in which she used ICT-based materials with her peers. She claimed:

“I had made some notes and transparencies from the remote sensing tutorial on the NASA website. People (other teachers) loved it and kept asking me how I managed to get such up to date materials.....I could see the respect in their eyes and I think now more teachers will be using Internet resources. They definitely see me as an empowered and knowledgeable teacher. So I have got some professional recognition and a means to assert myself among my colleagues through ICT”
(M35B, lines 125-131)

In this claim the teacher also indicated something interesting; that she needed a tool with which she could assert herself and make other teachers recognise and accept her. ICT provided her with that opportunity.

Although some of the teachers interviewed perceived ICT as playing an important role in the development of a positive professional status, a negative perception of the current professional status of the teacher tended to reduce teachers' inclination to use ICT for their own professional development. One teacher had indicated that she used ICT quite a lot for a variety of activities not related to her professional practice. When asked why she did not use the opportunities she had in accessing ICT for her professional practice, she responded:

If you mean teaching materials...I do not think it is fair on me to use my own money to do that. I cannot afford it. The information I get will benefit the school and the pupils, so they should support me on that. The school system in this country does not respect teachers and I do not see why I should invest in it. If they are serious about promoting our professional development, they should make the Internet freely accessible to all educational institutions... (lines 57-63)...for me, looking for subject content on the Internet is at the moment not my

priority ... I would only search for information if I thought it was to my benefit as a person, not as a professional because I am not recognised as a professional (MN50Ma, lines 77-81)

In this case, it appears that a negative perception of the professional status of teachers also influenced negatively, the desire to use ICT to promote professional growth, by dampening the motivation.

Although this teacher recognised the potential of ICT as a professional development tool, other contextual factors acted to influence her decision-making, leading to her rejection of this avenue. The comments by teachers M34S, M35B and MN50Ma above demonstrate the complexity and chaotic nature of the process of professional development. The same context, (females teaching in male dominated fields, having requisite access and skills to use ICT) led to completely different decisions and outcomes. This is a behavioural illustration of the chaos concept of *bifurcation*. Also note the dependence of the final outcome on the initial conditions: MN50Ma displayed frustration with the education system (...*does not respect teachers* ...) she then decided that it was not worth investing into (cf Doyle and Ponder, 1978: practicality ethic: cost-benefit analysis). The final outcome, her reluctance to use ICT for professional development purposes, was a result of the initial prevailing context (the work environment). This is again an example of the *butterfly-effect*.

5.2.1.3 Impact of ICT on the teachers' definition of their role

Hotchkins (1999) has identified one area critical to teacher decision - making to be *teacher efficacy*. Teachers strive to be seen to be effective and will constantly make decisions based on their need to be in control of their practice. In developing their professional identity teachers struggle to identify their role and practice. In the interviews, this struggle was evident and emerged as conflict between control and facilitation. Statements describing teachers'

views on teaching ranged from the need to retain control of the teaching / learning situation (M35B, line 82) to directing / facilitating the learning process (M36M, line 51). The need for control or power over information access for the students (herewith called *gate-keeping*), encouraged some teachers to use ICT extensively to obtain varied learning resources. As one female teacher put it when commenting about her perceived role as an information gate-keeper, and the support she received from accessing information on the Internet:

....Those are just theories (about teachers acting as facilitators). As far as your subject depth and coverage is concerned, the teacher is the expert. You have to know your stuff.If you believe in this facilitation nonsense, you'll never be a good teacher, you will never command the respect of your students and other teachers. Students respect a teacher who has data at the fingertips. They will respect you even more when you can answer their impromptu testing questions – you know, those questions that seem to come out casually and during break time.... (M35B, lines 90-99)

From this comment one can clearly see the association between control and professional identity. The teacher obviously believed that to be a good teacher, to be respected by students and colleagues, she had to be a “*know it all*” and this need encouraged her to make the decision to use ICT as her knowledge resource. An important attribution made by the teacher was that teacher efficacy is judged through the external; i.e. “*You are good if other teachers and your students think so*”. In other words, the teacher saw her efficacy as reflected through the responses of her colleagues and students. This attribution was repeated so many times by interviewees, that the researcher has code-named it the “mirror effect”. It appears as if most teachers in the interview sample used peer appraisal (though in an informal sense), as a benchmark to their professional status. Sparks and Bruder (1987), Hargreaves (1993) and Gaugers (1996) have described similar observations. They and other researchers have concluded that the need for recognition, acceptance and social status are central attributes of professional development and provide a

means by which teachers receive feedback and multiple perspectives on their practice. Gaugers noticed that the “significant other” played a very important role on female teachers’ perceptions of themselves, their leadership abilities and their aspirations. This might explain why even in the questionnaire findings, collaboration was identified as such a strong attractor.

Other teachers felt empowered by the use of ICT:

Using ICT packages also forces me to plan ahead as I must try out the materials before allowing the students access. This planning ahead helps in so many other ways as well. After some time you get used to it and you pay attention to details in what you are doing and this makes you a more organised person overall. From a teaching point of view, I am more in control of the learning process because I can decide specific learning activities for the students and this is good.....(ME37W, line 91-96)

Thus ICT is seen as empowering, not just in terms of knowledge, but also in terms providing a site of power. The teacher feels he is more in control and can therefore make decisions on what students can learn, without fear. In terms of professional development, the teacher has been uplifted from a position where he was worried with survival (just coping – prescriptive) to a stage when he can adapt to the teaching / learning situation and take control (Sawyer, 2001). Used in this manner, ICT builds the kind of conditions that provide opportunities for inquiry and reflective practice (Lieberman, 1994).

For yet another teacher, use of ICT resulted in a process of transition between control and facilitation:

The students have also become more critical and independent in their thinking. At first I didn’t like this because I felt as having less control, but now I feel liberated as they take responsibility for their own learning. I can now focus my energies on meeting their individual needs. My role is turning more and more towards being diagnostic – identifying and dealing with weaknesses and problems, rather than dishing out information. (ME38W, line 39-44)

This role re-alignment has arisen because the teacher now has access to more resources than before (line 21). She can now afford to use some of the ICT resources “...as challenges to stimulate pupil thinking” (line 20).

The above examples illustrate that just as teachers are influenced by the similar contexts in different ways, they also make the same decisions for different reasons. For example, both M35B and ME38W above, are drawn to use ICT for apparently conflicting reasons (control versus facilitation) which gives credence to the assertion made by the protagonists of applying chaos systems analysis to human behaviour i.e. Gleick (1988), You, (1993), Hunt 1998 and Reddan (2000), who claim that human behaviour is not pre-programmed, but follows unpredictable patterns that are discontinuous and complex. However, in both situations described above, the common attractor is the need to build a positive professional identity.

In summary, the quest for an enhanced professional identity has emerged as one of the major attractors to teachers using ICT for self-directed professional development. This aspect was found to be built up of three discrete behaviour patterns, or fractals: the need for professional well-being, the need for an enhanced professional status and the need to re-define the role of the teacher. The study also showed that these fractals are affected by the initial context in which the teacher is operating and, depending on that initial context, can lead to different behavioural and attitudinal modes. Figure 5.7 illustrates the relationship between the fractals and their attractor.

In figure 5.7 below, teachers felt a basic need to be accepted by and accorded recognition by their peers and students. To earn this respect and recognition they were driven to excellence in their professional practice. ICT provided a medium by which they demonstrated this excellence through for

example accessing up to date information (cf. M35B above). The appreciation and esteem they received as a result helped to enhance their professional identity. Thus teachers reported that the use of ICT enhanced their self esteem and self confidence.

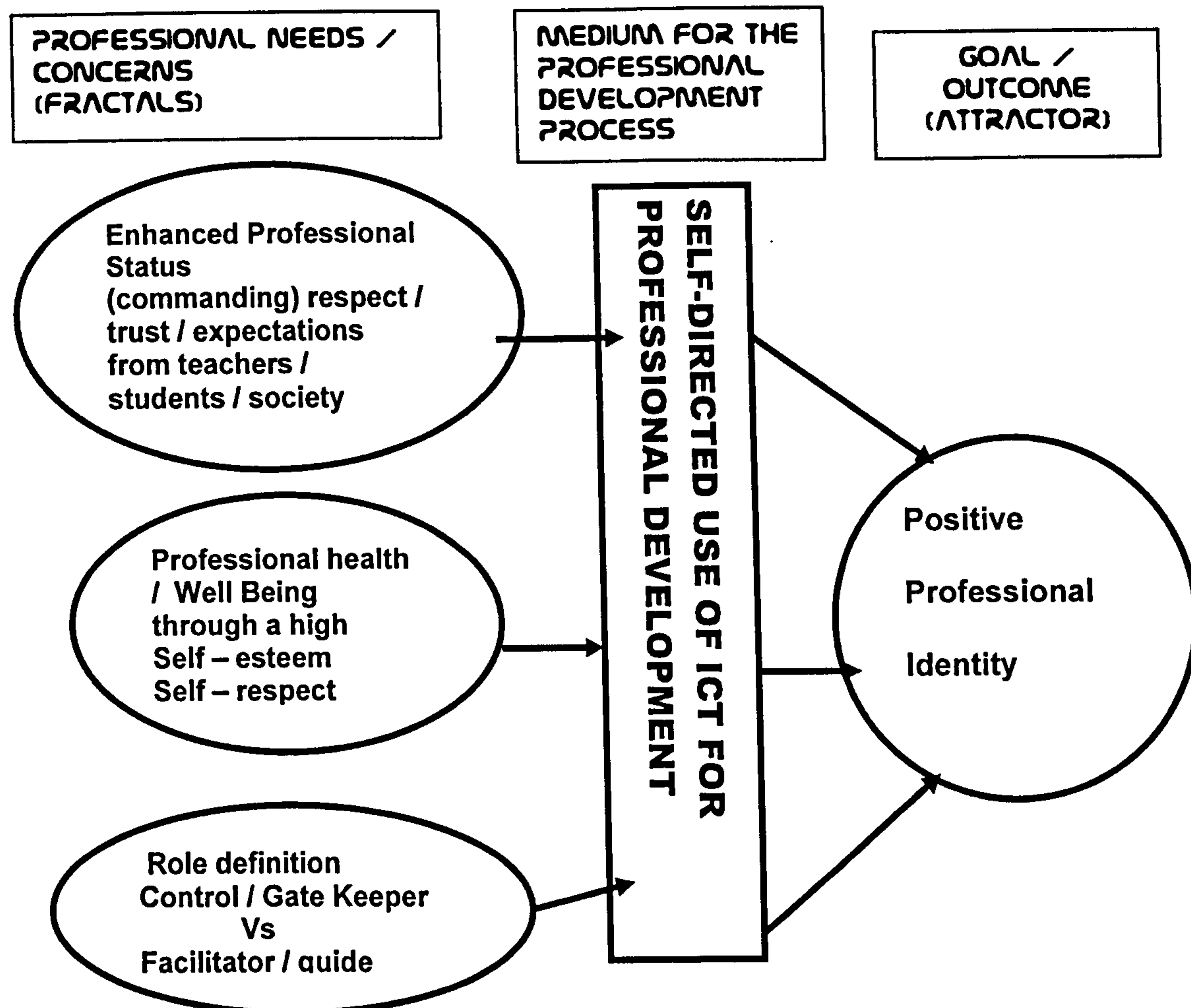


Figure 5.7 Impact of ICT on the professional identity of science / mathematics teachers

Teachers' appreciation of the nature of teaching also shaped their use of ICT. "Gate-keeper" teachers tended to see themselves as a conduit for information flow, and used ICT mainly to provide information and additional resources to their students. Use of ICT appeared to accentuate these teachers' perceptions of themselves as gate-keepers as they strove to keep a step ahead of their students.

As one teacher's (ME38W) perception of her role, evolved from "control" to "facilitator", her use of Internet materials also changed from merely providing

notes, to challenging students to find information. The change in the teacher's perception of her role appears to have been triggered by her increased access to ICT resources and her confidence in their uses. Note that a sense of control was linked to positive feelings of well-being (self-confidence, self-esteem and empowerment). Lack of control caused anxiety.

It is also pertinent to note that the role of *control* as used by the teachers, appeared to be linked to the teachers' level of use of ICT. Teachers who were confident in their use of ICT did not feel threatened by students acquiring skills to obtain information independently, but actually encouraged them to do so by giving them project work. When asked to comment on how she perceived the role of the teacher in the information age, MN54M, a frequent user of ICT, made the following comments:

The rate at which information is being processed is quite high. Teachers need to keep in touch with new developments in their subjects as well as in general events around the world. Our students are growing up in an information processing age and they would have more access to knowledge than we do, if we keep to our archaic textbooks. Teachers are supposed to be guides to their students. In the information age, it will be impossible for us to know everything, so how can we guide them?
 - By striving to keep ourselves up to date with developments in our subject area. To me computers are tools just like chalk and books. I use the Internet quite a lot to get background reading information on topics that I am teaching. That way, I am able to challenge my students to process information by giving them projects and tasks because I believe learning how to process information is now more important than just acquiring it. (MN54M, lines 19 – 28)

In the above comment, the teacher stressed three important points; a) the need for diversity in information acquisition and processing, b) the recognition that because of information deluge, it is impossible for teachers to control information flow to their students, hence the need to re-define their role to that of guides (facilitators) and placing more emphasis on information processing, and lastly, c) the need for the teacher to keep up to date. These points echo the feelings of some researchers, namely Heppell (1993) and Beardon (1994) who

advocated a paradigm shift from knowledge acquisition to information processing arguing that the exponential increase in knowledge made it impossible for teachers and students to know all about their subject areas.

However, Teachers who were themselves grappling with ICT use, tended to feel unease and threatened by the fact that students might have access to information that they did not have, as illustrated by the following comments made by MN44S:

The student was also computer literate so I felt challenged. She had access to information that I did not have and I thought, if she can do this I think I need to present something at higher level and so need to acquire more skills so as to say just look at the subject through the Internet rather than relying solely on books. (MN44S, lines 96-100)

Russell and Bradley (1997) identified teachers' computer anxiety as arising partly from a perceived threat of computers as opening up information floodgates and thus making the role of the teacher obsolete. However, Sawyer (2001) argues that this same fear of loss of control, could urge teachers to change their beliefs and values and adapt to the information age, redefining their role in the process. In this case, the fear of losing control helped the teacher to make a conscious decision to learn ICT skills so as to increase information sources for his subject.

Thus control of information appears to be associated with a dearth of information resources. The more resources available, the less need for control and the more need for more adaptive approaches.

5.2.2 The use of ICT in promoting the career development of the teacher

The second attractor for professional development that evolved out of the study as being supported by the use of ICT was the teachers' career development. Gregory and Sayers (1994) highlight the importance of career development within the overall professional development of an individual.

Career development provides professional benefits to teachers in the form of promotion, financial rewards, increased responsibility, recognition and status (Bertani and Tafaél, 1992). Thus, career development provides a link between personal professional development and institutional professional development. It signifies the symbiotic interaction that exists between the individual teacher and the institution or profession (the work context).

According to chaos theory, (Pryor and Bright, 2003) any open system will function as a self-generating and self-regulating order. This tendency of the system to regenerate and regulate itself is manifested as an underlying pattern in its operation, sometimes also called the system's fractal pattern (Patton and MacMahon, 1997). The individual teacher's career development operates like a complex open system (Patton and MacMahon, 1999) as it exhibits adaptive, regenerative and pattern forming properties. Vondracek and Schulenberg (1986) claim there is a reciprocal influence between an individual and the context which results in stability. This reciprocity has been verified and validated by many researchers from different backgrounds – from proponents of social judgement and social learning theory (Bandura, 1962; 1975), to cognitive dissonance advocates (Shapiro, 1979; Wagschal, 1982) and attribution theorists like Ashkanasy (1987). Career development signifies the individual's continual efforts to adapt and adjust to the challenges and needs of the context. It is a distinct sub-set of professional development (Miller and O'Shea, 1992).

During interviews teachers made repeated references to the idea of using ICT to support their careers. In 25 of the 54 interviews, teachers acknowledged that acquiring ICT skills was the first essential step towards meeting their career development needs. Analysis of the interview transcripts and notes revealed that "career development" (with regard to use of ICT) references could be

grouped into three major issues henceforth called *fractals*: a) those referring to current ICT training or *induction*, b) those referring to ICT use so as to effect *career change* or promotion - from the viewpoint of the teachers and c) those referring to ICT use to meet the need to improve current career paths through further study (*lateral development*).

5.2.2.1 ICT training and induction for career development purposes

Since a person's career development takes place within a context, career development is essentially a complex process of adaptation and adjustment. The individual has to adapt by learning from the environment; i.e. redefining their role within this constantly changing context and in the process, reframing their professional identity to suit their new perceived status. Pryor and Bright (2003) call these recursive adaptation efforts "*purposive*" as they are aimed at maintaining the balance of symbiosis (stability) between the individual and the system. Thus the teacher's career development is always operating on a knife edge i.e. balancing personal interests with institutional and professional challenges. The introduction of computers into the school system in Zimbabwe has resulted in changes in the context in which the teachers are operating. The teachers in turn have to contend with the emergence of ICT and incorporate its use in their practice. Computerisation of schools has resulted in additional pressures and concerns being added to the teacher professional development needs portfolio. MN47M, acknowledging the importance of ICT literacy for teachers, had this to say:

...Those teachers who trained long back didn't have knowledge about ICT, so they need probably to be updated and probably be taught so they appreciate the importance of ICT and computers because I believe they (computers) are now part of our educational system (lines 7-9)

Thus acquiring ICT skills is a way of ensuring the symbiotic balance between the context and the teacher.

According to complexity (chaos) theory, systems are sensitive to the initial conditions. Thus the computerisation of the school system changes both administrative and pedagogical patterns in the educational practice of teachers and this has the effect of altering the way the school business is run. The system has to adjust and adapt to these changes in a process similar to homeostasis. The self-adjustment of the system introduces change. Peterson *et al.* (1996) argue that change is always imminent in an open self-regulating system because of the system's sensitivity to alterations in the initial conditions. Such a system is said to be operating at the edge of chaos (Morowitz, 2002).

5.2.2.1.1 ICT skills acquisition as a career development process

In response to the introduction of ICT in global society and business, ICT skills are fast becoming transferable skills. Beardon (1994) and Bracewell *et al.* (1998) both contend that global computerisation has led to computing skills being upgraded to basic entry level skills for many professional jobs. This has been the case even in Zimbabwe, where more and more schools have been computerising (see section 4.2).

The impact of such pressures on teachers is demonstrated by the fact that in the questionnaire, at least 52% of the teachers who used computers in the last twelve months had acquired their skills through informal means (see section 4.2.1). Sowell (2000) claims that decisions teachers take in their professional development are tempered by the values of the stakeholders in the education process. This view is also supported by Bereiter (1999) who argued in the School-net report, that teachers' professional development could be viewed both as personal and organisational and that self-managed teachers tended to

direct their professional growth in ways that interface with their school development. Bolin (1987) goes further to claim:

Teachers must be able to negotiate the interests of all those who have an investment in educational practice (page 102)

Thus in making decisions to acquire ICT skills, teachers were responding to the pressures and needs imposed by the educational system and adjusting to it, in order to better serve their career prospects.

Interview analysis shows that teachers could be grouped according to the way they acquired their ICT skills:

- a) those who had no formal training, and were learning by experience and self training. Seven teachers fall into this category. Of these, three teachers were male and four were female. All but one of the teachers had teaching experience of between four and ten years, and so were in their "*mid-career*". These teachers decided to acquire ICT skills because:

Teaching in this country does not pay very well, so teachers try to make it easier for themselves by choosing schools that will offer attractive packages both in cash and kind. Private schools offer good packages, but they are very few so competition is intense hence some teachers resort to using electronic applications. ICT skills are in great demand in these schools and are considered the 'in' thing. ...Schools are choosy about the credentials of teachers who make private applications. (MN48M, lines 71-77)

- b) those who were attending some form of (informal) ICT training at school, resource centre or Internet café. Nine interviewees who referred to this type of ICT training had acquired their ICT skills at resource centres (e.g. MN47M), colleges (e.g. MAS06V) and schools (e.g. MAS03M). Seven of these teachers were male and again, all but one of them had taught between four and ten years.

This is not surprising since, as pointed out in chapter 4, teacher access to computers has become possible in the late 90s and universities and colleges have only introduced ICT skills training courses at the turn of the century.

Teachers with more than ten years experience most likely saw themselves at the twilight end of their career development and so had little impetus to develop. Two older teachers made reference to this point during interviews:

I do not think I have been able to reach my potential in using ICT. I know I have the capacity for obsession with the Internet, but I also have to balance this with practical considerations – money expenses – but more because of time. At my age I cannot be sitting at a computer all day. (MAS22V line 88-93)

...I think it is important to keep on learning new skills but realistically, one's capacity to do that decreases somewhat as everyone gets older. It is also clear to me that newly qualified teachers ...whether they ...whether they got the potential to learn these skills, will remain unrealised ... and I am talking from my own experience ... unless they are willing to invest time into it.... (MAS53V lines 27-33)

Two issues come out of the concerns raised by these teachers; firstly, the need to balance interests. The teachers recognise that informal ICT skills acquisition is time consuming and the older teachers invariably have other academic responsibilities (MAS22V was a senior master and head of department at his school). Secondly, the teachers recognise that aging takes the fun out of learning new skills. Since these teachers have other interests and responsibilities, their career paths are no longer centred exclusively on growing within the organisation, and therefore, acquisition of ICT skills is not as important to them as it is for younger teachers. For instance H45Q stated that she was more concerned about raising money to feed her family. She complained that she had to worry about bread and butter issues and did not have time to explore the use of ICT. Her fixation with 'bread and butter issues' is what social judgement theorists (Sherif *et al.*, 1965) term *ego-involvement*. When a person is faced with a decision that involves an ego-involvement issue,

the person has a very small latitude of acceptance, and a very large latitude of rejection, and will in most cases decide in favour of protecting their ego-interests. In the above case, family life is obviously very important to H45Q so family interests take precedence over any other interests including ICT in this case. In other words, her personal development attractors (ultimate concerns or driving force) lead her to choose fractal behaviour patterns that do not include the use of ICT to reach her career goals.

In most private schools, formal ICT training was sponsored by the school. Experienced teachers in their prime years were more likely to benefit from school sponsored training because they were more likely to hold positions of administrative and special responsibility within the school. One senior master noted:

They (Computers) make my work as senior master much easier because I can retrieve information that teachers, administration and parents want in a short time. (MAS04V, lines 32-34)

Similar sentiments were expressed by M10M and ME42M, both of whom have teaching experience between 4 and 10 years. Also these same teachers felt the greatest challenge to acquire skills because they were at the height of their careers, with everything to look forward to, and a lot of ambition. For example, M10M felt that the acquisition of ICT skills prepared her for modern life and enabled her to meet any future challenges to her teaching career (lines 38, 43-44). By comparison, the younger teachers (e.g. H30G) frequently focused on survival issues both in the classroom and in their profession. Older teachers (with more than ten years experience) like MAS53V are looking towards retirement. These observations further illustrate the fact that teachers at different career stages of development (whether experiential or motivational – see section 2.2.2.1) have different professional development attractors and can

therefore exhibit different fractal patterns. This is to be expected because chaos theory recognises the multi-variate nature of factors that can influence an individual's decision making process (Storgatz, 2003; Patton and MacMahon, 1999). Given such complex variables to choose from, individuals will tend to make choices that relate more closely to their personal professional development attractors (or driving force).

Interviews provided evidence that for most of those teachers who had to teach themselves how to use computers, career considerations were the major attractors. For some of these teachers, acquiring ICT skills was considered a necessary condition for employment. For example, one teacher from Marondera reported that ICT skills training formed part of the induction they had to undergo;

When you join the school at first, you are required to go through a standard induction course ... if you are not computer literate, you are also required to enrol for an ICDL (International computer driver's licence) course with Speciss College in Harare. Now even our recruitment policy requires a person applying for teaching here to have an ICDL certificate because we saw that it saves us time. (ME37W, lines 11-16)

Indeed, one would not be able to get a job at some private colleges, unless you were computer literate "*so, computer training is an essential skill you will have to learn*" (H28G line 16). Thus for these teachers, acquiring ICT skills became, in itself, a professional development activity aimed at satisfying a career development need.

5.2.2.1.2 Effect of method of ICT skills acquisition on ICT use

ICT skills acquisition was also compared to the teachers' use of ICT as a networking resource, the teachers' stages of concern, level of use and the teachers' use of ICT-based materials, to find out whether any trends in ICT use could be differentiated between formally and informally trained teachers. The results were inconclusive. However, interesting minor differences were

observed with regard to the level of use of ICT and the use of ICT-based materials as shown in Table 5.8.

Level of Use		Formal ICT Training	Informal ICT Training
Never used ICT for professional Development	Non Users	3	2
Currently learning to use ICT for Professional Development		5	11
Reasonably proficient in using ICT for my professional development		12	13
Becoming confident in using ICT for my professional development	Users	14	14
Using ICT as a tool in my professional development		5	8
I have integrated the use of ICT in my professional development		10	4
Total (101)		49	52

Table 5.8: Level of ICT use in professional development ($\chi^2 = 4.953$, $df = 5$, significance = 0.422)

Table 5.8 shows that half of the teachers who had informal ICT skills training, considered themselves as users of ICT on the level of use scale, compared to three-fifths of the teachers who had formal ICT training. This means that more formally trained teachers tended to regard themselves as meeting the criteria for “users” on the level of use scale, than did those teachers who had informal ICT skills training. This result is consistent with the earlier observation that informally trained teachers were having to overcome hurdles in acquiring ICT skills, such as, finding time (ME27M), money (ME25B) for training courses and so forth, and so spend more time mastering the skills than actually using ICT for professional development. Teachers with formal ICT skills training on the other hand have had ample opportunity to acquire ICT skills during initial teacher training, and have had time to adapt and make ICT use as part of their professional and career development’s fractal behaviour pattern. The introduction of ICT skills into the career development portfolio of the “informally

trained” teachers might generate resistance towards ICT use and uncertainty, which could also account for their reduced confidence on the level of use scale (Pryor and Bright, 2003).

The major implication of the analysis of data presented in this section is that informal ICT training might not be an effective way for teachers to meet their career development requirements pertaining to the use of ICT. The authorities and teacher educators should consider ICT skills as transferable skills which are as basic as literacy and numeracy (Preston, 1999). As the education system continues to undergo transformation, new needs are added and these have to be met by the teachers. This means that teachers’ personal knowledge and skills have to be continually updated. The researcher contends that the process of ICT skills building is an important part of teachers’ professional development as it contributes towards their readiness to use ICT for professional development. This is an area where overt support by the employer is recommended. Sawyer (2001) argues that for teachers to be able to adapt and use an innovation, they must have acquired skills and experience to enable them to advance beyond the “survival” and experimental stages. Formal ICT training especially during the professionally formative years of initial teacher training renders the teachers ready to accept and tackle future challenges in information technology and positions them well to meet any new career development challenges that might arise – i.e. they are ready to accept the challenges posed by trigger events as they arise. The old adage, *“Opportunity favours the prepared mind”* cannot be over emphasised in this case

5.2.2.1.3 Institutional incentives for ICT skills acquisition

There was also evidence that teachers received active support and encouragement from the school where they were practicing, to acquire ICT skills. Support was often in the form of free ICT skills training at school (MAS03M) and the development of an ICT policy that regulated teachers' access and use of ICT facilities at the school (MAS08H). Private schools frequently provided induction courses for new members of staff, and these courses included formal ICT skills training (H28G). Encouragement for teachers to acquire ICT skills was often disguised by providing a system of incentives. For example, in one school, teachers are expected to use computers in their day to day planning and practice; *"..most of our documents here, reports, schemes, data sheets are word processed"* (ME37W, line 18). Teachers had no choice, but to acquire ICT skills if they wanted to operate well in such an environment. In such cases, school policy provided opportunities for trigger events to occur. In another interview, a Chemistry teacher who could not access the ICT facilities at his school because he had not been formally trained in ICT complained:

The headmaster insists on formal training first before one can use the computers. He also stays with the keys to the computer lab so it is difficult to access the lab (M09M, lines 7-8)

The headmaster in the school mentioned above did not provide any training support for the teachers either financially or in any other ways. Thus access to the computer lab became a reward for teachers who had formal ICT skills.

The pattern of interactions between the school system and the individual teachers in the examples cited above epitomises the concept of metamorphosis as applied to chaotic systems. Sullivan (1994) argues that in a complex system, individual career development needs are overridden by systemic self-organising

forces. In the cases above, the system is adapting to the introduction of ICT to meet systemic needs (administrative , etc.) and in turn forces the teachers, who are components of the system, to adjust and accommodate ICT in their skills repertoire, thus in the process changing attitudes and building new shared understanding about the needs of the system.

The researcher subscribes to the view held by Davis (2003), that the system is transformed with each decision and action taken and each response that teachers make as they adapt to changes in the complex dynamic systems that intrude in their fractal patterns. As more and more teachers embrace the shared understanding and change their values and practices to suit the new order, the system is slowly transformed over time and the change becomes widespread. However, systemic transformation is not a smooth process. There is always a certain tension associated with change. Pryor and Bright (2003) argue that individuals tend to resist change because it disrupts the established fractal pattern of their lives and exposes the limitations of their control. Thus in this transformation it is inevitable that some teachers will resist the urge to use ICT for their professional development, unless coerced by incentives, such as those described above.

5.2.2.1.4 Effect of institutional policy on the use of ICT by teachers

In Zimbabwe, where the majority of teachers have been trained prior to the introduction of computers in the teacher education curricula, the burden of formal training passes on the employer (Heppell, 1993). Although the interview data chronicles evidence that this challenge was recognised and taken up by some employers, notably in the private sector, there was glaring lack of support from Government run institutions. Teachers from private schools constantly talked of a school “policy” pertaining to ICT (H28G, H32A, ME37W). The

policies ranged from actively assisting teachers to acquire ICT skills (H32A), to demanding that ICT skills become part of the repertoire that new teachers recruited into the school brought along with them (ME37W, H29G). In making these recruitment policies, the private schools ensure that teachers who join the teaching staff already possess the required career fractal patterns. This reduces the dissipative forces that result from the discord in career interactions and expectations between the teachers and the system (Bloch, 2003) and helps to reinforce the symbiotic relationship between the individual and the system. This symbiosis strengthens the system's desired fractal pattern and thence, the desired direction of development through a shared understanding of the system's development goals.

On the other hand, no such "policies" either overt or covert were reported by teachers from Government schools. Public schools usually take their cue from government, when deciding policy matters. There was evidence that teachers were not aware of the existence of any policy guidelines pertaining to the use of ICT, from the Ministry of Education, Sport and Culture, or any other government arm. Teachers frequently complained that their efforts at acquiring ICT skills were frequently frustrated by conservatism of the authorities:

I was in a school where I met a lot of opposition especially relating to the use of ICT. I remember the headmaster saying in a staff meeting that the school did not need computers since it had achieved high results and established a reputation without their use. There was no reason why teachers should learn to use computers since they did not need them in their teaching. (MN48M, lines 85 – 88)

The reported views of the head belie an underlying concern which is at the root of change theory. The micro-politics of the school have a profound effect on change within the school system. Unsupportive or ignorant school leadership can act as an impediment to change. The above observation by the head serves to demonstrate change's chaotic dependence on prevailing hegemony.

Davis (2003) argues that hegemony is the main obstruction to teacher engagement. Innovations that rise from the grass roots are often thwarted and frustrated by those in authority. Ball (1987) extends the argument by claiming that innovation and change are rarely neutral and tend to enhance the position of certain groups of stakeholders over others. Those in authority (in this case, the headmaster) could have felt threatened by the introduction of computers – perhaps because he / she did not have requisite skills to handle them and sought to escape the responsibility by rationalising that computers were not essential for teaching. Such a rationalisation, coming from an authority figure, has the effect of discouraging the other teachers from pursuing the said action (using computers). This fragility of self-driven change processes was further illustrated in another region, by two lady teachers who gave a group interview. They felt that the lack of support from the school authorities was hampering their attempts to acquire and use ICT skills.

Sometimes also in some schools in Zimbabwe you will find kuti maticha anoda kuita ma computer literacy courses kuti vakwanise kushandisa ma computers. (*Teachers want to attend courses to enable them to use computers*) But again, the school does not help you to do this. You use your own money to pay for the course. Saka muchizoono kuti most teachers will simply not bother and would rather just continue teaching in the old ways giving students shallow information. Vanongoti, well if the school cannot supply the resources, hameno zvavo. I will just do the best I can with the limited resources – and the standard of education decreases as a result.

MB: Ndizvozvo chaizvo, unongoita course yako yeuteacher maybe pa University of Zimbabwe watora Bachelor of Science wopedza. Graduation woita but hauna kumboita that computer course and you are not at all computer literate. (*Its true. You undergo teacher training – maybe at the University of Zimbabwe, and you graduate but without the computer skills*) You see a computer here, you cannot even touch it. It is a strange animal because hauzive how to operate it. Saka kuti uende kuCentre unodzidziswa kuti one – one is difficult, which is why we were saying professional development should be continuous, but teachers must be supported in order to develop properly. No one can be called an expert because there is always something new that you have to learn. (MAS52V, lines 236 -250 – *Italics are researcher's translation*)

Analysis of the comments by the two ladies reveals four important issues that capture their feelings towards professional development and ICT. These are:

- i) Teachers feel frustrated because their efforts are not being recognised or rewarded.
- ii) This frustration led to a feeling of helplessness – lack of the will-power to change.
- iii) Teachers need support in order to develop and;
- iv) Failure to effectively use ICT was attributed to lack of support or indifference of the authorities.

By attributing their failure to utilize ICT to external causes, the teachers were renouncing their responsibility over their own career development. Attribution theory (Fritz-Heider, 1958; and Miller, 1989) argues that by assigning the cause of their failure to outside forces over which they have no control, the teachers remove the motivation to try to change and justify the status quo. If the fractal behaviour patterns of the headmaster quoted above and the two teachers (MAS52V) are taken together, we have a situation where the two fractal patterns resonate. In chaos theory terms, the resulting amplified impact of such behaviour is reduced use of ICT by teachers.

The teachers' emotional outbursts also give an indication of the stress that teachers are subjected to as a result of their inability to influence change. Sarros and Sarros (1991), Thomas (2001) and Kyriacou (2001) concur that teaching is one the highest stressed professions. This is more so, if the teachers' efforts at coping with the stress are frustrated as described by the teachers above. Such teachers exhibit the symptoms of teacher burnout – a concept first introduced in 1974 by Freudenberger (1977) and further developed by Maslach and Leiter (1999) and Dorman, (2003a). Maslach developed a

model that later came to be known as the Maslach Burnout Inventory (MBI) which categorises burnout into three loosely coupled dimensions of emotional exhaustion, depersonalisation and negative personal accomplishment. All three categories are prevalent in the above teachers' statements, suggesting that the teachers were trying to justify reasons for the feelings of burnout that they were experiencing. Indeed, the first interviewee refers to the notion of depersonalisation when she implies that teachers simply stop caring about giving their students good quality information as a result of frustration.

Davis (2003) argued that for teachers to be engaged in transformative processes, they need support and encouragement from the school authorities. MN48M on the other hand argues that the guidelines for the support should come from the Ministry as the responsible authority of the public schools. A ministry policy would provide the necessary guidelines for heads to approach issues of ICT even when they themselves have not been trained in its use. A supportive policy would have the effect of placing the power of ICT development and use back in the hands of the teachers – a situation similar to that already obtaining in the private schools.

Calloids *et al.* (1996) highlights the importance of policy in determining the content and form of professional development at the school level. School policy ensures that all stakeholders share the same vision and this helps teachers in prioritising their career development activities. Career development has been described as providing the link between individual and institutional interests (Gregory and Sayers, 1994). Thus, in the final analysis, education authority and planners need to decide whether the interests of the system are best served by an ICT policy which would provide career guidance for individuals wanting to develop through the system.

5.2.2.2 Use of ICT for career change

ICT was also seen as assisting teachers towards a career change. Steffy *et al.* (2000) identifies “career exit” as an important stage in a teacher’s career. Since an individual’s career is tied to the context in which they operate, career exit refers to a change of career path and is distinct from “*retirement*” when teachers have reached the end of their productive years and simply want to rest. Understanding how and why teachers decide to exit from the profession is an important challenge for career development researchers (Kyriacou, 2001). Whilst these researchers have proffered reasons why teachers decide to leave the profession, such discussion is not directly relevant to this study except in instances where the interviewed teachers made such references with respect to their use of ICT. In this study teachers repeatedly mentioned that they used ICT, especially the Internet and e-mail, to search and apply for jobs. Expressions such as “*ICT enables me to seek greener pastures*” (MAS20N, line 26) and “*I use ICT to search for new teaching vacancies ...*” (MAS01M, line 26) were common. In all, 32 references were made by the 17 teachers who were concerned about this aspect of career development.

Further analysis showed that these teachers could be divided into two groups:

- a) One group was made up of those teachers who simply wanted to change their current teaching circumstances, and were looking to move from mainly public schools to private schools within the country, or to other schools outside the country (MAS01M, MN16S).
- b) A second group expressed interest in seeking other jobs not related to teaching (MAS20N, ME12M).

5.2.2.2.1 The use of ICT to initiate lateral career transfer

The use of ICT in career changes of the first type is described by MN48M who is a Physics Resource Teacher at one of the resource centres in Bulawayo. When asked to comment on the attendance and use of ICT by teachers at the centre, he said:

Teachers come here (at the centre) because the facilities here are still working and are available to them. They are simply taking advantage of the available resources. We get all the ranges of teachers. They come here to look for online advertisements – we have a very large turnover of teachers in this region, experienced teachers moving They do not only move from one local school to another, from a rural school to an urban school, but mostly also from public schools to private schools – and these advertise over the Internet - so some of the more experienced teachers come here to look for advertisements as well. (lines 58-69)

Thus MN48M identified ‘searching for online adverts’ as one of the major occupations of teachers who came to the centre. Reading adverts might not appear as a logical professional development activity at first sight, but if such activity is viewed as the teacher’s attempt to cope with burnout and stress in their present occupation, one can see that lateral transfers from one school to another provides teachers with a chance to start again. For this reason, both Steffy (1989) and Sarros and Sarros (1991) identified career exit as an important part of a teacher’s career development. Dinham (1993) and Howard and Johnson (2004) suggest that career transfer might be an effective coping strategy for teachers experiencing emotional exhaustion. The new environment presents a new fractal behaviour pattern that the teachers may well find easy to integrate with their own behaviour. In most cases, lateral transfer, if achieved, provides palliative remedies to stress (Kyriacou, 2001; Goddard and O’Brien, 2003), such as improved quality of life due to better pay, enhanced family life because of more relaxed working conditions etc. Thus, according to MN48M,

ICT played an important role in assisting teachers to cope with stress and burnout effects.

For several teachers, ICT presented access to hitherto elusive career opportunities to teach in other countries. Due to the worsening socio-economic situation in Zimbabwe, there has been a steady migration of teachers from the country to neighbouring states, to take up teaching posts in South Africa, Namibia and Botswana (The Independent, 2000; VOA, 2003 and The Herald, 2005). The speed of information dissemination available only with ICT (Internet and e-mail) use made it the most ideal method for searching and applying for vacancies abroad, as MN48M noted. Interviewed teachers reported using the Internet to search for jobs - *"I also search for information I want like on teaching vacancies in Botswana, South Africa, New Zealand and Canada...."* (MAS01M, 25-28). For teachers like ME27M, the Internet provided an advertising medium that enabled them to reach across national boundaries. This aspect of ICT use becomes quite significant if contextual factors are considered. Since 2000, Zimbabwe was behaving like a closed community. Information flow was restricted, partly because of the negative economic environment which made it very expensive to access outside newspapers and magazines, and partly also due to the inhibiting socio-political environment which overtly restricted information flow within the country. Thus the Internet became the only major source of external information which was relatively unrestricted, accessible and affordable. Most interviewees extolled the benefits of ICT communication over the more traditional methods in terms of speed of communication. Some teachers even mentioned their anxiety that their *"snail mail"* might be intercepted (ME14N, MW17C) and were quite comforted in their perception of the relative security of e-mail communication.

5.2.2.2 The use of ICT to exit teaching profession

The sustained pressure from the dearth of teaching resources, the negative socio – economic and political environment and the low status accorded to teachers was starting to tell on some of the interviewees however, and they exhibited burnout effects and appeared to be seriously considering leaving the teaching field altogether. In this case ICT was used to facilitate exit from the profession. When asked to explain why she was using ICT to apply for jobs outside the teaching profession, one lady responded:

I am fed up of being treated like trash here. The salary of a teacher here is very low. I am actually earning less than an uneducated factory worker, yet I am a Chemistry graduate. I know that my skills are in great demand in other countries. I am using Google to search for better rewarding jobs in institutions in other countries because they advertise over the Internet. (ME42M, lines 40-43)

The first statement reveals that the teacher was frustrated and emotionally exhausted. The three statements that follow reveal her feelings of being unappreciated. MN50Ma gave vent to her frustrations when she was asked why she was not using ICT for educational purposes:

....I think professional development concerns come in when everything is okay in the system and you are thinking about your career development. The system recognises you and rewards your efforts and there are incentives for development – attractive incentives – not just aspiring to become a headmaster one day, and continue getting peanuts for all your troubles. When the situation is like that, then there is hope and people can aspire towards professional development. As it is now, we have just come out of a strike where we were told 'if you do not go back to work, we will employ O-level school leavers and we will sack you. We do not need you, you need us.' Where is the professionalism in that? Even the authorities do not regard teaching as a profession. Can they do the same to nurses? – No. So there. We cannot talk of professional development where there is no profession. We are too busy fighting for survival and sustenance to worry about that. That is why so many teachers are moonlighting nowadays. (MN50Ma, lines 65-77)

From the two quotations, the teachers were making the following points:

- i) That professional development was only possible in a supportive system;

- ii) That the current public school system was not supportive to teachers. It was insensitive to their needs;
- iii) That teachers were pre-occupied with survival issues. The fight for survival left them with no time for professional development activities.

The cumulative effects of frustration at the workplace and low social acceptance are associated with stress (Langford, 2001; Kyriacou, 2001). The stress acts like a trigger event, pushing the teacher to find ways of ameliorating the pressure. The researcher feels that ICT plays an important part in helping such teachers to lessen the stress. Practically, the chances of most of the Zimbabwean science teachers who were applying for jobs over the Internet, actually landing those jobs were slim, and the researcher suspects that the teachers were aware of it. However, the feeling that they were doing something about their stressful situations acted like a placebo and helped to reduce the stress. The situation is analogous to the poor man who buys lottery tickets week after week in the hope of one day landing the big price. The dream of winning keeps the person going – and coping! Thus again, ICT was seen as a coping mechanism. Needless to say though, some success stories were reported – a case in point is ME39W who was quoted earlier. However, such successes serve to reinforce and strengthen the resolve of the unsuccessful majority.

5.2.2.3 Use of ICT to improve current career path

Related to the issue of career exit, is the issue of further study. Some teachers claimed that they used ICT to look for study opportunities both within and outside the country. Ten teachers made nineteen references to this issue. The main *modus operandus* in this case was that a) teachers use the Internet to scour for universities and colleges and download information and application

forms (H28G), and b) they use e-mail to contact those institutions, and in some cases attach completed electronic forms (MAS14N).

Several reasons were given for preferring to use online applications rather than more traditional methods. ICT was perceived to be “.convenient, fast and reliable, letters take a long time and are very expensive especially if they are for overseas destinations” (MAS04V).

5.2.2.4 Summary of ICT use for career development needs

The survey has also demonstrated how the self-directed use of ICT by science / mathematics teachers in Zimbabwe highlights the complex nature of career development within the fold of a teacher’s professional development.

Career development was shown to be a complex interplay of forces between the individual and institution’s interests. Where these forces are in sync, they reinforce each other and symbiotic development results (Bertani and Tafael, 1992; see page 14). Where the forces are at odds with each other, they produce strained relationships and the individual teachers are frustrated. Teacher burnout is the ultimate result. Thus, the study helped to unveil some of the intricate fractal patterns of relationships in the career development process. Teachers used ICT in these relationships primarily as a method of coping with the challenges and job-related strains they experienced at the workplace.

This complex relationship is presented in figure 5.8 below.

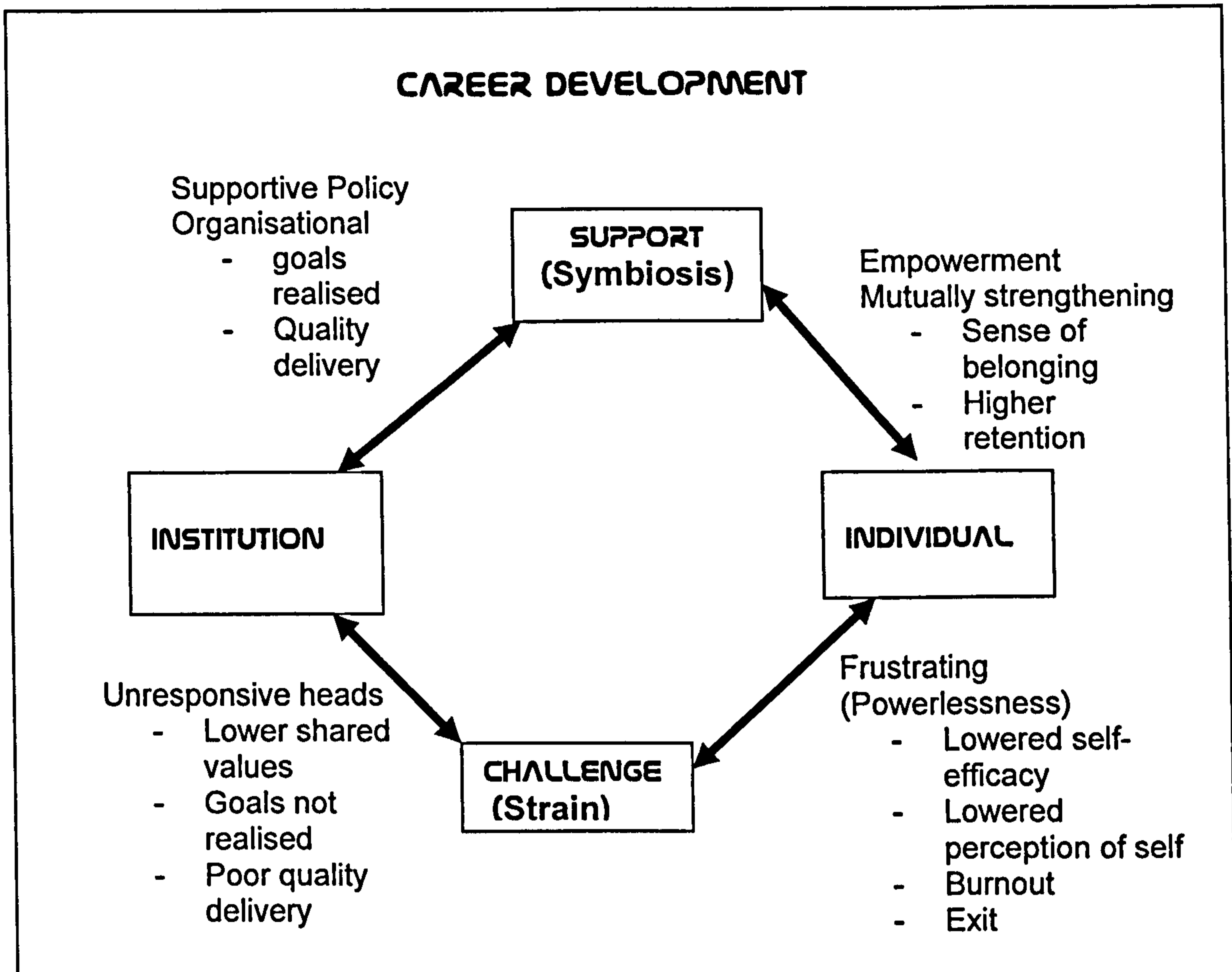


Figure 5.8: The complex nature of the career development process as revealed through the teachers use of ICT.

It can be argued that, on the whole, what the teachers reported about their use of ICT, and their relationships with their institutions in this case, was a pointer to a more generalised career development relationship. Where the school authorities rendered support, shared purpose and mutual benefit from the use of ICT were realised. For example, the schools could demand that teachers used software packages for processing reports, schemes and other administrative duties, and teachers also benefited from access to the immense resources provided by the Internet, thus there was a symbiotic, mutually strengthening relationship.

However, for some of the teachers, especially in public schools, there was no forthcoming support. Some of these teachers exhibited signs of frustration

and powerlessness (ME42M), implying that the lack of support touched on other facets of their careers, other than just ICT. Some of these teachers also exhibited job dis-affectation and other signs of burnout (MN50Ma). These were the teachers who tried to use ICT to help them exit from the profession.

Figure 5.9 summarises the way ICT was used by science and mathematics teachers in Zimbabwe, as a medium for their self-directed career development.

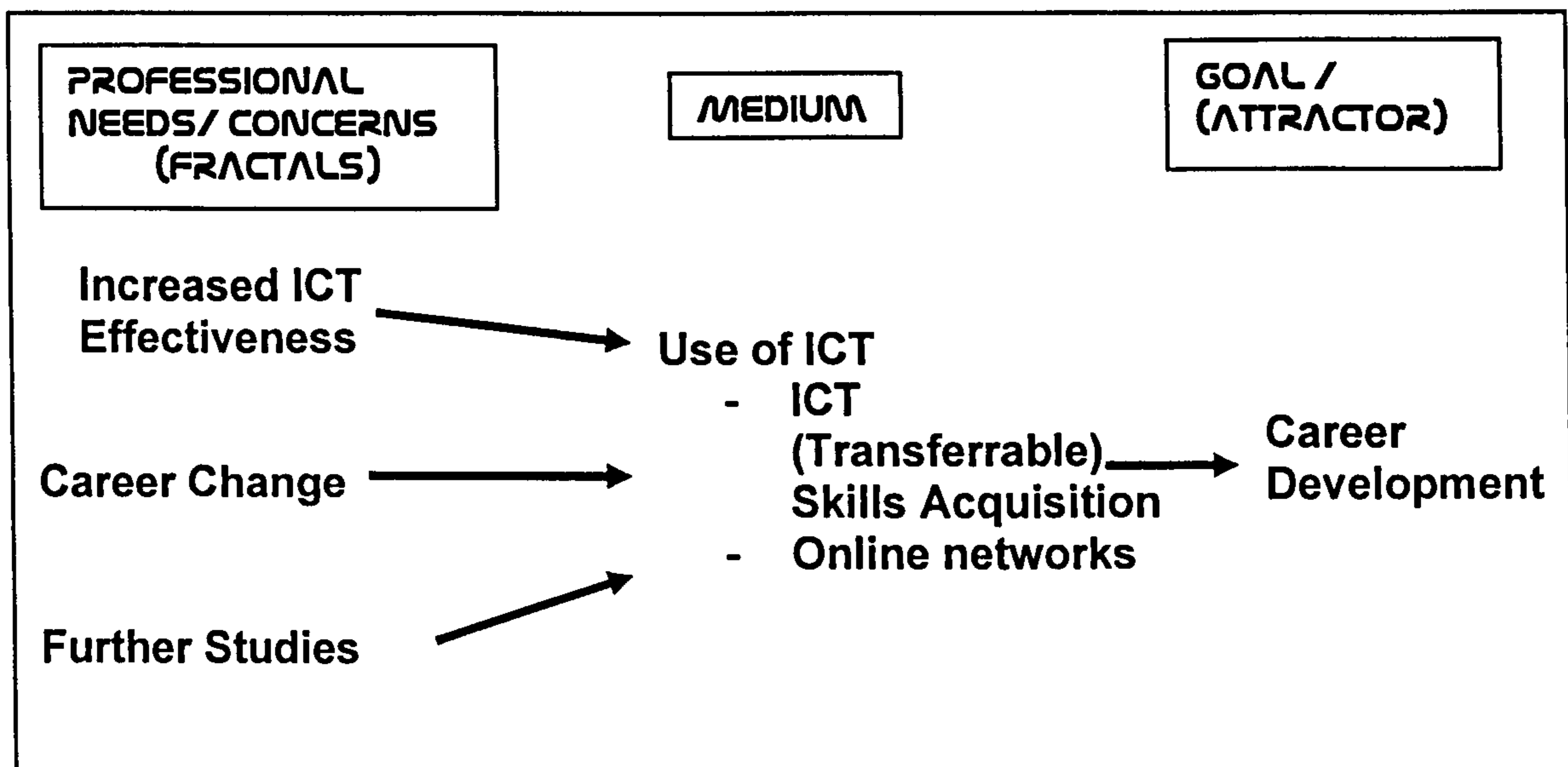


Figure 5.9: Use of ICT in the career development of science / mathematics teachers

The major concerns of interviewed teachers included professional and personal effectiveness, career concerns and self-improvement through further studies. Teachers used ICT as a medium to achieve these aspirations and this led to their career development. Thus, teachers strove to acquire ICT skills in order to enable them to become more effective in their work. This is why effectiveness was regarded as the fractal behaviour pattern.

It is suggested that teachers have a general ideal about their profession. A belief of what it is like to be a teacher and a professional. We constantly measure our professional experiences against this ideal. Professional satisfaction arises, when experience comes close to the ideal. However, when experience falls short of the ideal, tension is generated and we try to find ways

of reducing this professional tension. The further away from the ideal our experience is, the higher the tension we experience. The greater the number of 'tensors' (aspects of our experience that cause tension), we encounter, the greater the stress that we have to endure. An example of a tensor which would fall under the category 'effectiveness' would be 'lack of teaching resources'. This tensor forces teachers to perform their work in ways that they perceive as in-effective and far from ideal, thus they will try to find means of remedying that situation.

A teacher's professional ideal is influenced by several work-related 'stressors' (multiple tensors) that act to inhibit his / her effectiveness, hence teachers are constantly looking for ways to reduce stress. An example of a stressor in figure 5.9 is *in-effectiveness*, or *stagnation*. The researcher believes that it is this need to reduce stress that takes the form of the attractors in complexity theory and provides the drive or motivation for teachers to make decisions, learn or change. For the sample of Zimbabwean teachers who participated in the study, there is evidence that ICT provided a solution, especially pertaining to the teachers' career development concerns.

5.2.3 The use of ICT for enhancing professional networking

It has been suggested that teachers behaved like adult learners and strive for professional growth by directing their professional learning through collaborative activities. This suggestion is borne out by research evidence from several researchers, among them Lieberman (1994), who argued that teachers use self-directed collaboration to support their continuous enquiry into their classroom practice. Other researchers who have adopted a similar view to Lieberman's include Cross (1981), Lesko (1986), Smith (1988), Wallace and Lauden (1994), and Feltovich et.al. (1996). Clandinin and Connelly (1992)

extend this argument by claiming that teachers make choices in their classrooms that reflect their collaboration with peers on the curriculum outside the classroom. Through peer collaboration, teachers gain new insights into the curriculum and these insights are taken into consideration when designing new classroom experiences for their students.

Sections 5.2.1 and 5.2.2 have also sought to provide evidence that one of the main attractors in the professional development of science and mathematics teachers who participated in the study, is self-efficacy. Teachers sought to define themselves, both through internal processes (5.2.1) and also through their relationship with their institution (5.2.2). Thus so far, teacher development was defined as a parity of self-efficacy revolving around personal and social values. These results are also corroborated by findings from other areas of research in teacher development (see table 5.9). For example, Butler (1992) visualised a professional development model of teacher action as vascillating between a social context (public knowledge, theoretical and professional knowledge) and a personal context (personal experience, values and attitudes and culture). He then argued that teacher reflection is interaction between these two knowledge systems, resulting in the modification of behaviour or values or practice. Buchmann (1983) on the other hand, was investigating teacher thinking, and concluded with a model that characterised teacher thinking as oscillating between self and role orientation. She defines role orientation in terms of accountability to the system (colleagues, institution, society), whereas self orientation was envisaged as having to do with the teacher's actions, feelings and classroom reality. Dweck (1986) was studying adult learners and concluded that these could be distinguished on the basis of competence and image orientation. Those who learned mainly to gain competence had a

completely different fractal behaviour pattern (hard work, like challenges, like to prove themselves) to those who learned to improve their image / social standing. The latter considered it more important to be *perceived* to be smart. The public image was most important. Self-esteem was measured by social-esteem. However, Dweck found that both orientations could produce very high achievers. Thus it appears that self-efficacy has both personal and social aspects. These views are summarised in table 5.9 below:

Researcher	Model	Explanation
Buchmann, (1983)	Teacher Thinking Self-role orientation	Self-orientation – accountability to self: role orientation – accountability to society
Dweck, (1986)	Adult learning Competency vs image	Competency – individual Image – institutional
Butler, (1992)	Teacher action Social context vs personal context	Reflection: Interaction between social-personal knowledge

Table 5.9: Personal versus social perspectives in professional development

Knowles (1984) argues that for most adults, the social aspects of self-efficacy are dominant over the personal. This means that most adults are driven towards change and learning more by social considerations. This is why teacher collaboration is a very important strategy for learning and change among adults. The present study revealed that science and mathematics teachers in Zimbabwe used ICT to help them define themselves among their peers through professional collaborative activities. Interview analysis revealed four different behaviour patterns pertaining to the teachers self directed use of ICT: Using ICT to communicate with peers; using ICT to compare and share resources, experiences and skills; Using ICT to support, encourage, mentor and tutor each other and using ICT to jointly develop ideas and carry out collaborative studies. These aspects of ICT use are discussed below.

5.2.3.1 Use of ICT to communicate with peers

As reported in chapter 4, teachers mainly used ICT to communicate with friends and colleagues. In the questionnaire sample, 86% of the teachers who had used ICT in the last twelve months perceived e-mail communication with friends to be useful. Likewise, 83% also thought that using e-mail to communicate with colleagues was quite useful. Teachers cited several reasons for communicating with colleagues using e-mail. Since e-mail and Internet are both based on real-time communication, they provide teachers with obvious benefits for collaboration. One teacher said:

... I have been able to communicate with colleagues who were working on a physics materials module for SEITT. I also collaborated with colleagues doing a paper on networking (MAS04V, lines 72 - 74)

Teachers also used ICT to communicate with institutions such as examining boards, universities. In this case, e-mail as a media of communication was chosen because of its speed and reliability, as well as the added advantage of being able to send documents by attachment:

Before A-levels were localised, I used email to communicate directly with UCLES (*University of Cambridge Local Examinations Syndicate*) to get information on exam practicals and this helped me in planning practical work. (MAS04V lines 82-83)

The use of e-mail to communicate with persons and institutions is also referred to as e-networking. From the two quotations above, it can be inferred that MAS04V viewed ICT communication as a practical way of collaborating with geographically distributed colleagues and institutions. Used in this way, ICT has the potential of satisfying all three tenets of the practicality ethic (Doyle and Ponder, 1978) i.e. it is easy to use, satisfies the demands of the teacher's context (it is the only feasible way for them to communicate with peers) and it is cheaper to use than alternative methods (as in the above example, it was easier

for the teacher to obtain examination materials through e-mail attachments – it would have been costlier both in time and money, to use the unreliable postal system).

The table 5.10 summarises the collaborative ways by which teachers made use of ICT.

Collaborative Activity	Details	Reasons
Subject materials development	Biology (MN49E) Chemistry (MAS06V), Geography (MW17C), Mathematics (H32A) and Physics (MN50Ma) Modules	- Fast, efficient and reliable communications - Use of attachments and comments
Discussion groups	Setting regional exams (M09H) Sharing Ideas (H32A)	- Access to global village - part of a community of professionals
Institutional communications	Examination Boards (M09H) Universities (ME12M), (MN16S)	- Exam Practical Materials and reports - Online content - Study proposals
Sporting and Extra Curricular	College sports (M08H)	Convenient and fast
Distance and e-learning	Mentoring and Tutoring M10M	- Use of attachments and comments

Table 5.10 Ways by which ICT is used for collaborative communication

5.2.3.2 Use of e-mail in collaborative professional development activities

Teachers identified the use of e-mail as being particularly potent in facilitating their collaboration in materials development. For example, MN16S, a chemistry teacher described how ICT made collaboration possible:

I am a reviewer of the chemistry module and we exchange the papers through e-mail where I edit the attachments by making corrections and additions in different colours then I send the papers back to my colleagues. (line 154-155)

Using e-mail as a means for collaborative activity especially relating to the development and authoring of materials is a widely accepted routine in e-

networking. The School-net survey report (CSCE, 1999) showed that in Canada, there was increasing inter – school collaboration among teachers, even though these activities were encouraged through a formalised professional development programme. Other online based projects e.g. Reiner, (1995), the Open University (Kyriakidou *et. al*, 1999) and Mirandanet (Preston, 1999) also tried to encourage teachers to use e-mail resources for collaboration across regions and internationally. Some of these initiatives have become so successful that it has become difficult to imagine how previous generations managed collaboration without the aid of ICT and e-mail (Kyriakidou, 1999; Preston, 2001). It was therefore quite interesting to note that even Zimbabwean teachers operating independently, opted to use this method in carrying out their collaborative activities.

The weakness of the Zimbabwean dollar against major currencies, and the depressed state of the economy, meant that it would be too expensive for Zimbabwean teachers to subscribe to professional organisations outside the country. However, the Internet hosts several professional organisations and teachers were able to join these online. For some of these organisations, as H32A and MAS53V noted, membership was free. Teachers chose to participate in these organisations as part of discussion or special interest groups. Participation enabled teachers to feel that they were contributing to the global development of their subject (MAS05V). MAS53V justified online collaboration thus:

...I think e-mail has enabled me to keep in contact with other colleagues all over the world, who have ideas that I can use in my subject. It gives me a feeling of belonging in a community which is quite important to me professionally. I feel quite isolated here. There are a few people who I can talk to about what I'm trying to do largely because people think I am an expert and even when I ask questions they wait for me to provide the answers. ICT has enabled me to access learning

communities and to receive support and it is the feeling of support that is important to me. (lines 157-166)

MAS53V is what Steffy (2000) calls an *expert master*. He is quite experienced and respected in his community and according to his statement above, this provides drawbacks to his professional development. He feels isolated even though there are other mathematics teachers around him, because he feels they have nothing to offer him. Indeed he went on to describe how each time, in a workshop or grouping, the teachers expect him to take the lead, and take out their pens as soon as he stands out to speak. At the same time, MAS53V appears to be experiencing what Palmer (1998) calls "*functional deification*", i.e. he is expected to take on the ultimate responsibility - have the last say in every discussion - while the other teachers are content to follow his lead. Although thus far he had been able to provide support and act the role of Resource Teacher and mentor to his peers, his statements above show that he was beginning to feel the strain and he recognised that he also needed renewal. It is also clear from the statements that he was unable to obtain the support he needed locally and so the use of ICT provided him with a useful outlet.

MAS53V was not alone in experiencing isolation. MAS01M commented that he was not happy with the state of his development as a teacher because:

...I would like to meet with other teachers and share with them..... It is always good to find out how others are doing things. There are three mathematics teachers at this school but I am the only one teaching A-level since this school was upgraded recently. (lines 21-23)

Again, in this statement, the feeling of professional loneliness is quite evident. Lieberman (1994) identified teacher isolation as one of the main causes of stagnation. He then suggested that one of the major goals of professional development should be to provide the kind of conditions that enable teachers to grow continuously through reflective inquiry into their own

practice, by self-directed collaboration activities. He further argues that this type of collaboration (where teachers freely and voluntarily share experiences with their peers) is based on teachers recognizing each other as experts in their fields. It focuses on their co-operation and supports and allows them to develop their content within context (Lieberman and Miller, 1991). This is the kind of collaboration that MAS53V craved for, and was only able to achieve through ICT.

Other teachers also commented on how the use of ICT enabled them to work collaboratively with others, and how the potentials introduced through ICT collaboration were exploited for a variety of professional development activities. One teacher mentioned that she uses ICT to access world wide resources and also *“to share with others what I know about teaching biology”* (M11M). M09H explained further:

I still communicate with my colleagues in SEITT although our module has now been completed. We still maintain e-mail contact and discuss about our teaching content, and some work related announcements for example, we are planning to co-ordinate the setting of chemistry Lower 6th examinations, but we have no money to come together so we keep discussing..... I think I have picked up a few things from these discussions for example, during module writing, a teacher may write to say that he favours a particular approach over another and this may lead to a discussion of both approaches. We may end up adopting or rejecting his approach for inclusion into the module.... (lines 72-75, 80-82)

Normally, one would expect the type of collaboration discussed by M09H to be possible only in workshop or conference situations where teachers have a chance to have face to face discussions. The complex challenges faced by teachers in Zimbabwe would preclude the viability of workshops as fertile spawning grounds for such collaborative activities, hence the emergence of ICT communication as an alternative. The adoption of ICT communication by the teachers was a purposive action that was necessitated by the need to minimise

the constraints of the environment on professional development. Vondracek and Schulenberg (1986) identified such purposive events aimed at producing change and stability as characteristic of complex systems.

5.2.3.3 Use of ICT for institutional communication

Apart from e-mail collaboration, the study also revealed evidence that mathematics and science teachers engaged in on-line collaboration, using web-based resources. During interviews, several of the teachers explained that they were members of professional organisations and carried out their membership responsibilities online. Describing his experience, MW17C explained:

In some of the organisations where I am a member, we have been divided into panels based on interest groups. We communicate and discuss ideas and even share papers using discussion forums for our group on the organisation web page.... Sometimes we discuss about methods and demonstrations that are used to teach certain topics. ...through these discussions we get a rich variety of opinions and interpretations on a topic. This is very enriching. (lines 72-74, 82, 104-105)

The search for a variety of ideas for teaching has thus been identified as an important desirable benefit of collaboration. This is in keeping with similar observations made by other researchers. Fisher *et. al.* (2000) and Agostinho *et al.* (1997) both concluded that the search for 'second opinions' was an important aspect in teacher decision making. In terms of complexity theory, collaboration is a self regulatory mechanism by which the system can ensure the expansion of desired change processes and the dissipation of undesirable traits. For example, through collaboration, desirable practices are adopted gradually by the teachers who are in constant engagement with them and these practices spread. ICT use itself, as described in this study, provides a useful example. On the other hand, as more and more people turn to the use of ICT in

communication, one will expect that the use of snail mail will become less and less important. Thus the system evolves over time.

Section 5.2.3 provided evidence that the teachers' use of ICT was driven by a third attractor: the need to collaborate with peers – the search for the 'second opinion'. The fractal behaviour patterns associated with this attractor were identified as: the use of ICT for communication with friends, colleagues and institutions and the use of web-based discussion groups.

Interviewed teachers also identified another important use of ICT communication. Some of the teachers used e-mail, to communicate with sister institutions and other academic organisations. MN16S, ME26N, M08H and M10M indicated that they had used e-mail to submit their proposals for higher degree studies to the University of South Africa. As a result they were in constant communication with their allotted supervisors, as they worked on their proposals. M08H also indicated that he used ICT to forge sporting links with other private schools in and around Harare. Thus ICT communication covered a wide variety of the teachers' professional development needs.

5.3 Summary and Conclusion

Through ICT, Zimbabwean science and mathematics teachers have managed to overcome the constraints that were extant within the education system. They strove to achieve a high efficacy in the delivery of their work despite the scarcity of resources available to them. ICT has enabled some teachers to engage with the professional development process and make decisions that affected the way they perceived themselves, were perceived by others and also how they related to the profession. Throughout this research, most of the teacher-participants have portrayed themselves as learners, not just of the content of professional development, but of the process as well. The

study revealed how some teachers struggled to acquire the requisite ICT skills. Once acquired, ICT proved to be a versatile tool with which most of these teachers could satisfy most of their perceived developmental needs. In the words of Miller and O'Shea (1992) the teachers embraced themselves as learners in order to become effective in their professional development.

Chapter 6: How do teachers perceive the use of ICT as affecting their classroom practice?

Effective teachers recognise no best way to teach in any given situation and seek innovative solutions to unanticipated problems (Shedd, 1986 p3).

6.0 Introduction

In Chapter 4, the analysis of the questionnaire survey revealed that teachers acquired ICT skills and used them for purposes of administration (word-processing), communication (e-mail and Internet) and application (teaching and learning resources). In Chapter 5, the teachers' use of ICT *vis a vis* aspects of their professional development were investigated in more detail, including affective factors (professional identity), skills (career development) and systemic attributes (collaboration).

In this chapter, the focus of the analysis and discussion is on pedagogical practice (i.e. the ways in which ICT was used by these teachers as a teaching resource). Data will be presented to address the sub-research questions 3.1 (*How do teachers claim to use ICT-based materials in the classroom?*); 3.2 (*How does the actual use of ICT-based materials correspond with the teachers' intentions?*) and sub-research question 3.3 (*How do teachers perceive the use of ICT-based materials in teaching as contributing towards their classroom practice?*). As in chapter 5, chapter 6 is organized thematically. Section 6.1 discusses the results of the analysis framework, focusing on the perception of teachers with regard to their use of ICT in enriching their theoretical and content knowledge (*theme 4*); practical knowledge and skills (*theme 5*) and their pedagogical content knowledge (*theme 6*).

Section 6.2 discusses the benefits that teachers perceive as gaining from using ICT for their professional development (*theme 9*). Bearing in mind, the advice from various researchers, namely Collis (1994), Loucks-Horsley *et al.* (1998) and Sawyer (2001), that continuing professional development is about teachers learning to cope and make decisions concerning student learning, section 6.2 also looks at how teachers perceived their students as benefiting from their use of ICT (*theme 8*).

6.1 How do teachers claim to use ICT-derived materials in their classrooms?

In section 5.1.3 it was mentioned that factor analysis was used to search for patterns of association between the responses to items 18 and 19 of the questionnaire. It was also mentioned that two factors were isolated (see table 5.3), which were able to explain 71% of the variance observed, between them. The two factors were: *use of ICT for teacher networking*, and *use of ICT as a teaching resource*. The former factor was discussed in chapter 5. Chapter 5 also dealt with practicality aspects of *value congruence* and *cost-benefit analysis* (Doyle and Ponder, 1978) as applied to teachers' use of ICT for their professional development. In this chapter, the second factor (*Use of ICT as a teaching resource*) will be discussed in more detail. The use of ICT as a teaching resource is also linked to Doyle and Ponder's concept of the *instrumentality* as applied to teacher professional development.

The factor (*use of ICT as a teaching resource*) was found to contribute roughly 55% of the total variance observed with respect to the teachers' choices of responses to items 18 and 19. This computes to just over two-thirds (71%) of the variance covered by the two factors together. Reliability analysis for items 18 and 19 yielded an alpha constant of 87%, which has very high reliability

(Walsh, 1990). A complete treatment of the reliability analysis is given in (Appendix 5.1). A scale of *ICT-as-a-teaching-resource* was constructed by combining the individual scores of the three items in the factor1 so that they could be treated as one. Thus the scale ranged from a scalar minimum of 3 to a maximum of 18. A range of scores totalling between 3 and 7 were considered to have overall positive views about ICT use, whilst a score range totalling between 8-10 indicated that the teacher had mixed feelings about the use of aspects of ICT as Teaching Resources. Teachers whose total scores ranged between 11 and 15 did not find ICT useful as a teaching resource, whilst those who had an overall score above 15 were inexperienced in the use of ICT as a teaching resource or could not make judgements as to its usefulness.

Table 6.1 shows the frequencies of teachers' perceptions of the usefulness of ICT as a teaching resource.

Category	frequency	Percentage (%)
Considered useful	71	70.3
Neutral	10	9.9
Considered useless	18	17.8
Not enough experience	2	2.0
Total	101	100

Table 6.1 Teachers' perceptions of usefulness of ICT as a teaching resource.

The table shows that 70% of the teachers who had used ICT in the last twelve months considered it to be a useful teaching resource, compared to only 18% of the teachers who perceived otherwise. Ten teachers presented views that were so mixed that it was difficult to tell whether they had a general opinion on the usefulness of ICT as a teaching resource. Two teachers did not have enough experience of using ICT as a teaching resource, to be able to make an opinion. Factor analysis therefore confirmed that the majority of teachers generally considered ICT as a useful resource for teaching.

These findings were corroborated by those teachers who answered the free-response item 22, which asked them whether they had used ICT as a teaching resource. 65% of the 71 teachers who attempted this item indicated that they had used aspects of ICT as teaching and learning resources (see Appendix 5.2). 85% of these teachers also identified the development of ICT-based resources i.e. teaching / lesson notes, simulations, lesson plans, demonstrations and the preparation of supplementary notes as some of their most common uses of ICT. Item 22 was discussed in more detail in the last chapter (section 5.1).

Formalised professional development programmes in Canada (CSCE, 1999) have also reached similar conclusions pertaining to the way teachers perceive the usefulness of ICT. Surveys conducted in several states revealed that once teachers had acquired ICT, Internet and e-mail skills, they accessed ICT to learn and use individually driven skills to meet personal and professional targets. Invariably, these targets included aspects of teaching and learning.

Several researchers have presented arguments to justify why teachers would perceive computers as generally useful teaching resources. Collis (1994) argued that computers have graduated from being a mere subject in the curriculum, to becoming an essential tool of the curriculum. Through computers, teachers can engage in continuing learning, thus blurring the traditional distinction between teacher education and continuing professional development. Loucks-Horsley *et al.* (1998) elaborated on this idea by claiming that computers contribute to continuing professional development by enhancing teachers understanding of certain teaching and learning methodologies. In addition, the increased information resources available to teachers, and the increased potential for networking enable teachers to establish a 'community of thinkers'

who contribute and share in the analysis of their classroom practice (Risco, 1996).

Table 5.5 (*Role of ICT in teachers professional development*) in the previous chapter showed that almost 60% of the teachers who used ICT in the last 12 months were advanced enough in their use of ICT to be able to incorporate it into their practice. Similarly in table 5.6 (*Level of ICT use*), the survey shows that 54% of the teachers perceived themselves as users of ICT. On this scale, which was based on the concerns based adoption model (CBAM) levels of use, user competencies range from application of ICT (based on increased confidence of ICT use) to integration (as evidenced by the use of ICT in developing curriculum materials).

Factor analysis (table 5.3) had revealed that teachers' responses to items 18 and 19 could be grouped into two categories: *use of ICT as a networking resource*, and *use of ICT as a teaching resource*. The latter factor was compared with teachers' responses to items 20 and 21, to find out whether there was any relationship between the way teachers used ICT and the level at which they were using ICT. Table 6.2 shows the results of the comparison.

Variable 1	Variable 2	N	X ²	df	significance
Teaching Resource	Use of ICT	72	14.427	3	0.002
Teaching Resource	Level of use	100	16.374	3	0.001
Teaching Resource	Stages of concern	101	26.023	9	0.002

Table 6.2: Comparison of ICT as a teaching resource with other variables

Table 6.2 shows that a significant association was found between the use of ICT as a teaching resource and the teachers reported use of ICT. Figure 6.1 clarifies this relationship:

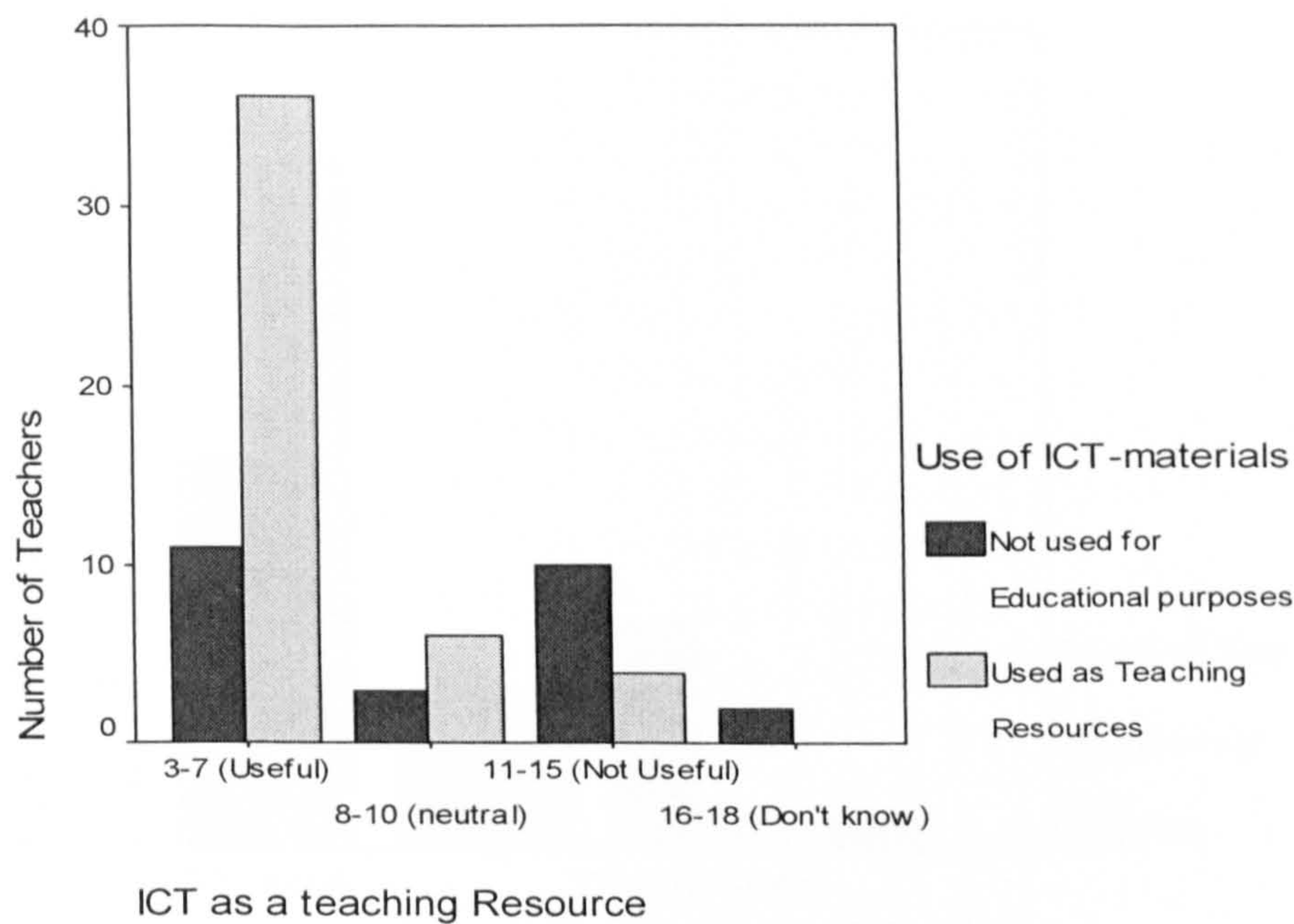
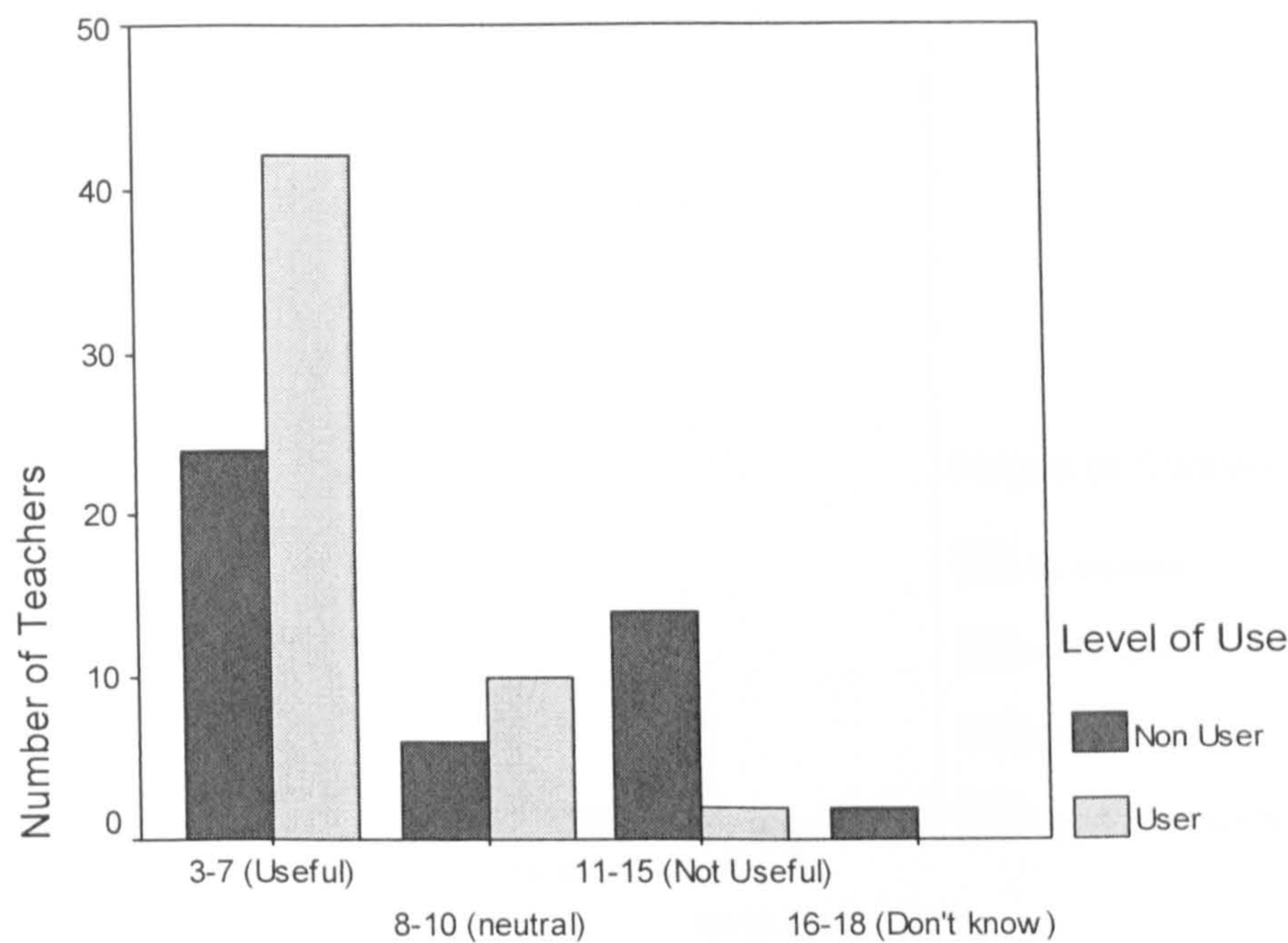


Figure 6.1: Variation of ICT as teaching resource with Use of IT based materials (n = 72)

From the Figure 6.1, it can be inferred that most of the teachers who reported that they used ICT-based teaching resources, in the open-ended item 22, had a generally positive view on the use of ICT as a teaching resource. This result is to be expected and confirms the consistency of the teachers' responses. From table 6.2, there was again, a significant relationship between the factor, (*use of ICT as a teaching resource*) and the teachers' level of use on the CBAM scale. This relationship is further illustrated in figure 6.2.



ICT as a teaching Resource

Figure 6.2: Variation of ICT as at Teaching resource with Level of Use (n = 100)

From figure 6.2, it can be shown that teachers who claimed to be operating at the higher end of the level of use scale (*more confident, use ICT as a tool, integrates ICT use*), also tended to score higher on the ICT as a teaching resource scale. However, it was also interesting to note that a large number of teachers who were classified as none users on the level of use scale, also considered ICT to be quite useful even though they had not advanced enough to be able to take advantage of its full potential.

This observation seems to suggest that the perceived usefulness of ICT is pre-emptive of teachers' subsequent activities: i.e. teachers perceived ICT to be useful and this encouraged them to want to learn more about its uses. This idea was explored in the context of professional development in the previous chapter.

Finally, the relationship between the teachers' stage of concern and their perception of ICT as a teaching resource was also found to be significant.

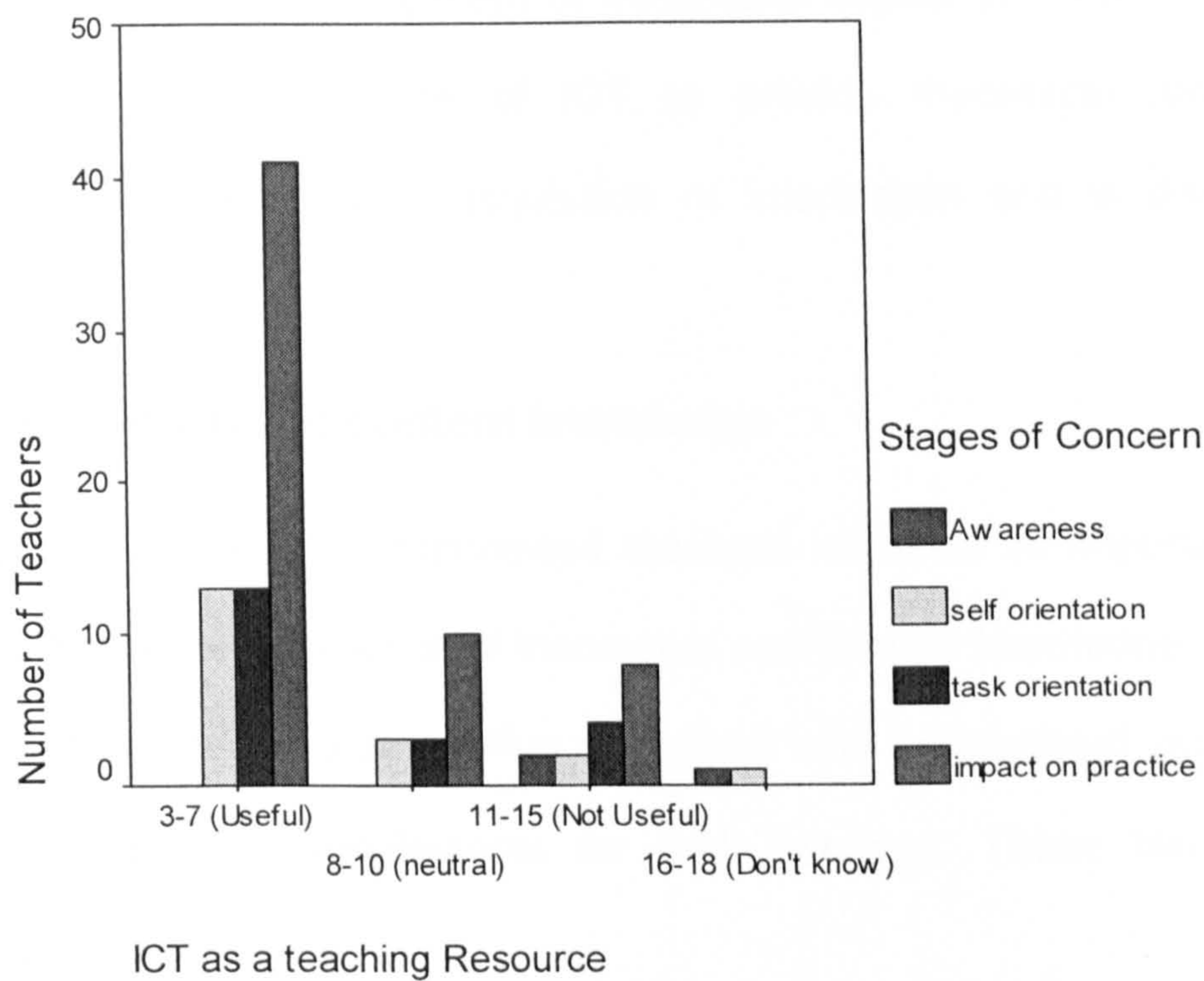


Figure 6.3: Variation of ICT as teaching resource with the stages of concern (n = 101)

From Figure 6.3 one can see that teachers operating at higher stages of concern with regard to ICT, also considered ICT to be useful.

All in all, the questionnaire survey revealed that the majority of science and mathematics teachers who participated perceived ICT as being a useful teaching resource. From factor analysis, the components of ICT use that seemed to lend themselves most easily to teachers use as resources included acquisition of information, development of teaching materials and improvement of practice.

The interview analysis framework revealed parallels in the way teachers used ICT as a teaching resource. For example, ICT was used as a resource to provide theoretical and content knowledge, as a resource for practical knowledge and skills and as a resource to enable teachers adapt, modify and develop materials for teaching and learning. This self-initiated use of ICT as a resource for innovation and knowledge management sets ICT apart as an

emerging tool in the development of intellectual capital (cf. Roffe, 2000) and expertise in Zimbabwe. Use of ICT to provide theoretical and content knowledge, is analogous to acquisition of information and is discussed in section 6.1.1.

6.1.1 Theoretical and content knowledge

One of the areas the interviewed teachers identified as important in their use of ICT was the acquisition of theoretical and content knowledge. Within this area, teachers identified acquisition of content both for personal use, and also to provide textbook supplements for their teaching. These two uses are discussed below.

6.1.1.1 New content for personal use

Several teachers identified specific topics in their subjects where they had actually resorted to the use of ICT (Internet) to gain information. The topics ranged from “bio - technology” (MW17C) and “genetics” (M08H) in biology, to “molecular structure” (MN44S), “enzyme inhibitors” (MAS06V) and “pesticides and enzymes” (MN46S) in chemistry; from “differential equations” (MAS01M) in mathematics to drawing sketch maps (MAS23K) in Geography and “radioactivity and modern physics” (H29G). For example, one teacher said;

.... I was researching into the historical origins of some constants like π and came across a web site quite by accident, which was talking about “the golden ratio” It was quite interesting and I was just working towards introducing *finnobachi* numbers so it was quite interesting to find that these numbers could also be linked to the so called golden ratio. Its applications in construction, art and the natural world, were also highlighted. I had not been aware of this and it was a learning moment for me. (ME40P, lines 25-31)

When asked why they used the Internet for this purpose, teachers suggested several reasons:

The problem is because of change of syllabus, there is no single book which adequately covers everything. Some go too far with some topics so that students will require more than 5 textbooks to cover the entire course. Mathematics books are quite expensive and even as teachers, we cannot afford to buy all those texts. So the Internet helps because we search for specific information and can make notes. (MAS22V, lines 56-62)

Another teacher (ME27M) mentioned that some of the teaching materials and notes that he was seeking over the Internet were not available in print form especially relating to the chemistry textbooks available in his school. Thus the search for subject based content by the teachers' can be seen as an attempt to plug gaps both in content and pedagogy. Sawyer (2001) noticed similar actions by teachers in Australia and concluded that teachers were motivated by decisions relating to concerns about student learning and engagement.

Ironically, Zimbabwean A-level teachers are University graduates and specialists in their subject content areas and as such one would expect them to be competent enough to handle A-level content in their subjects. Chapter 4, however, has established that some of these teachers teach a combination of subjects, and that ICT use among these teachers (who teach combinations) is significantly higher than for the other teachers (see section 4.1.1). When the teachers were asked to explain their need to search for subject content over the Internet, four main reasons were given. These were:

6.1.1.1.1 The use of ICT for enrichment of subject content knowledge

Teachers felt the need to keep updating their own content database. Interviewed teachers constantly referred to the need to broaden their understanding. Commenting on how ICT enabled them to achieve this, MAS20N explained:

...I did not have specific practical examples on the use of calculus until I came across a website example of the Nile flood plains. It deepened my own awareness and understanding and today calculus ceases to be just a mathematical concept to be learned. I

now understand its practical significance and I believe too, that if my students can grasp this, they will appreciate it better and will not see it as a difficult and abstract topic. (MAS20N, lines 53-58)

On the other hand, H31A felt that the use of Internet materials had helped him to be “academically involved in my work” (line 116). He went on to elaborate:

Materials I have obtained from the Internet have helped to broaden my understanding of the topics I teach (lines 117-118).

Perhaps M35B expressed the concept more succinctly when she said:

My understanding of my subject matter has deepened since I started using the Internet to get supplementary materials for teaching. I learnt a lot of new ideas that I did not know before, both *mucontent nemuma* teaching approaches (lines 119-122)

From these quotations one gets the message that the teachers prioritized the need for greater depth in understanding their subject content, to enable them to teach more effectively. Indeed other researchers and organisations (Sawyer, 2001; NSDC, 2001) also regard content enrichment as central to quality teaching. Under its content standards for academic staff development, the NSDC has identified continual subject content broadening as a benchmark for quality teaching.

Also linked to the concept of enrichment was the need to keep updating information. This aspect was presented in two main arguments. Teachers such as MAS23K and M14N argued that due to financial constraints, schools could not afford new up to date textbooks and frequently discovered that information presented in their textbooks was obsolete. For example, relating to Geography textbooks, MAS23K stated:

...In human geography, things change quickly and our old books become obsolete. Sometimes you talk about a town where actually things have changed already in that town. (lines 91-93)

In addition, recent scientific developments in environmental physics for example had resulted in a paradigm shift in the attribution of causes for natural disasters such as *El niño* and its effects on the 1992-1993 drought in southern

Africa. M36M, a female Geography teacher explained that such information will not be found in textbooks;

..For example, older textbooks report that Southern Africa is subject to relief rainfall patterns, and discusses the rainfall pattern as mainly dependent on the warm Mozambican currents. They cannot explain why in recent years, for example, droughts have been on the increase. The effect of the *El nino* phenomenon has only been put forward as an explanation recently. So you find that if you do not keep updating, you end up giving students outdated explanations. (Lines 25 – 30)

The other major reason given for updating information was the need to maintain contextual relevance of the subject to the pupils' lives. The example given by M36M provides a case in point. The 1992 and 1998 droughts were the worst in living memory, especially for Zimbabweans and topics relating to their causes would elicit natural interest in students. The pressure to keep abreast of current developments in knowledge was mainly manifest among Geography and Biology Teachers. For example, H45Q (line 38), observed that although HIV and AIDS were ravaging the country and had become matters of national interest, yet the traditional Biology textbooks used in A-level classes did not treat these subjects adequately. Indeed teachers resorted to using the Internet to supply the missing information. Other issues of current interest which were not covered sufficiently if at all, in A-level textbooks, included topics on *genetically modified organisms [GMOs']*, (MN47M) and *tropical cyclones* (M35B). All these topics have been placed on the national agenda and are now examination favourites for the recently localised *ZimSEC* A-level examinations.

In seeking to enrich their subject knowledge base through the use of ICT, teachers re-define ICT as a context for curriculum decision making (Sawyer, 2001). Such decisions relate to questions about how to support and deepen student learning engagement. The Internet presented the teachers with a

unique opportunity to meeting these needs, as the explanation given by M35B, a teacher in the eastern province of Manicaland, illustrates below;

I used Internet articles of the Rio Earth Summit to link environmental mismanagement to global warming and other concerns. I then presented the information on cyclones and typhoons, including the arguments that also link the prevalence of these to global warming. By the time the actual cyclone Eline hit Mozambique with disastrous effects and reached Zimbabwe, the debates we were discussing in class became suddenly very real for my students. They experienced the winds and the violence and the downpours. The effect on the students was very dramatic. After the disaster of cyclone Eline, you could tell that the students really appreciated the concerns raised in these topics. They began to see the relevance of what they were learning. (Lines 137-152)

From this explanation, one notes the crucial role played by ICT in preparing the students for real-time events. The combination of real-time information and the impact of current events provided conditions conducive to phase transition in chaotic terms. Ball, 1989; Ingvarson and Loughran, 1997 argue that such combination results in a cognitive shift towards better understanding and awareness.

6.1.1.1.2 The use of ICT to provide alternative ideas for teaching

The second reason offered by teachers concerned the need to provide a variety of learning opportunities for their students, through varied teaching methods and presentation techniques. Some teachers expressed this argument in terms of their search for methods of increasing meaningful student learning engagement (Bradbeer, 1998; Sawyer, 2001). One teacher described ICT's contribution to this search thus:

Well, it widens my horizon by providing more resources at my disposal. I think when you have more resources and more ways of doing something, you can select the best method for your students and so you become more responsive to their needs, and you become a better teacher, also you don't have to use the same method every year, and your teaching becomes interesting and challenging also to yourself. (M08H, line 49-54)

The above statement also demonstrates the teacher's genuine concern for his students as individuals and learners. He was concerned about meeting their learning needs. The decision to use or not to use ICT in this instance also appears to have been guided by the teacher's knowledge of his students and their individual needs. In addition, the teacher also observed that his actions were not purely philanthropic, but also driven by mutual gains as variety increased his enjoyment of his profession.

One of the biggest fears that a beginning teacher has to cope with is the feeling of being inadequate to deal with unexpected learning situations. Sawyer (2001) argues that the first few years of a teacher's professional life are characterised by survival concerns. At this stage, teachers religiously follow prescriptive teaching techniques from textbooks. In such a case, inadequate resources and equipment may result in anxiety and stress as teachers are concerned that they might not cope. Interviewed teachers saw the variety of resources provided by ICT as preparing them to meet and cope with unfamiliar situations:

Even now we do have the same problem, but the Internet has increased the amount of resources at my disposal and chances of me meeting a new situation I cannot deal with is now much less. (ME14N, lines 45-46)

Access to ICT resources also helped them to plan their lessons more thoroughly, thus reducing the chances of "unpleasant surprises" occurring as a result of poor planning:

I have more resources at my disposal, compared to teachers with no access. I can plan my lessons to provide a rich environment for learning. Using ICT packages also forces me to plan ahead as I must try out the materials before allowing the students access. This planning ahead helps in so many other ways as well. After some time you get used to it and you pay attention to details in what you are doing and this makes you a more organised person overall (ME37W, lines 89-93)

Kolb (1984) argues that exposure to the vast ICT resource base enable teachers to engage students in reflective learning, as teachers shift emphasis from abstraction and rote learning to constructivism. Teachers are presented with choices in the use of teaching approaches, and in the resources they can apply to ensure that their students learn. Thus the availability of ICT resources provide many bifurcation points along which teacher development can take place, as noted in the first statement of ME37W quoted above.

6.1.1.1.3 The use of ICT to provide supplementary teaching notes

Another use of ICT resources linked to the acquisition of new knowledge was the provision of supplementary teaching notes. Interviewees claimed that they also prepare teaching notes from the Internet. The notes are used for different pedagogical purposes, for example, teaching aids;

Yes, I have also downloaded some lesson notes on the use of CRO and the Hall effect in magnetism. Both these topics are not dealt with in detail in standard textbooks and I found the note quite enriching.....Mostly they were my own notes and I used them to enrich my teaching, what I provided to students was a re-organized frame of notes from all the different sources integrated and modified to their level. (ME14N, lines 92-94, 96-98)

as additional reading materials;

Well, as I have already said, I have not used the materials in class yet, but reading about them has given me some ideas about how differently I would approach the topic next time, so in that respect I think that I have benefited. (MW17C, lines 48-50)

I use the Internet quite a lot to get background reading information on topics that I am teaching. I look for teaching ideas, approaches, unusual experiments and demonstrations, which I can include in my teaching. Our textbooks do not always show how some mathematics concepts are arrived at. Sometimes I am more interested in the application side of mathematics and I have found American Colleges and Universities web sites to be very good at concretising mathematics. (MAS54M, lines 28-34)

and contextual practical examples / illustrations;

I made some notes on the illustrations and teaching methods suggested and I then used the notes to enrich my teaching of the subject. In Trigonometry, some of the examples were incorporated into worksheets and students could work in groups. Unfortunately, I

could not use any animation since we do not have computers at school. (MAS20N, 41-44)

The above quotes illustrate the fact that the interviewed teachers perceived ICT as a kind of pedagogical almanac. Bradbeer (1998) argues that the context in which teachers operate influences the teaching approaches that they choose. It was quite refreshing to find out how the teachers struggled to overcome the restraints and limitations of their educational resources in order to carry out their duties as best they could. Teachers used ICT as a means to change their classroom practice, towards an approach that they felt defined their professionalism. In all the quotations above, the concept of enrichment of practice comes out very strongly, implying that the teachers were aware of the restrictive environment in which they were operating. This observation confirms Grummet's contention (Grummet, 1988), that the context influences the choices that teachers make relating to practice and that these choices are linked to their sense of identity.

6.1.1.1.4 The use of ICT to provide means for fighting misconceptions

Constructivists (Driver and Oldham, 1986) emphasise the importance of identifying and correcting misconceptions and alternative conceptual frameworks, which can persist and interfere with learning. In Zimbabwe, since science is frequently presented from a Western perspective, culturally based alternative explanations to natural phenomena can exist in tandem with "scientific" explanations. Shumba (1996) investigated the interaction of indigenous African culture with science education and found that Zimbabwean science teachers were able to identify instances of culture-science interactions which inhibited adoption and spontaneous application of scientific knowledge to problem situations. The A-level teachers who participated in this study were

aware of the challenges posed by misconceptions and some of them reported to using the Internet to look for ways to identify and fight misconceptions:

...Using the approaches I obtained from web – based resources, I learnt how to identify and correct misconceptions. (ME12M, line 58)

However, some teachers also realised, through the use of ICT-based materials, that they had been holding onto erroneous beliefs. ICT helped them to evaluate their own knowledge base and plug in the knowledge gaps:

The A level chemistry module was meant to address problems that teachers face when they teach the topics. Some of the problems I was not even aware of myself, it was when I searched for materials on the Internet that I realized from their explanations that I also had misconceptions, so the use of the materials helped to broaden my understanding of the topic as well as showing me some errors that I had in my conceptions (M09M, lines 40-45).

As I said, I had some errors that I was not aware of. Using materials from the Internet, especially reading about different approaches to teaching a topic and other teachers' explanations helped me to identify my own knowledge gaps and I was able to pay more attention to the misconceptions when teaching my students although I did not actually use the same approach suggested in the Internet materials. (M09M, lines 47-51)

The use of varied approaches and experiences in teaching and learning promotes personal discovery both within the learners and the teachers, as demonstrated by M09M above. Knowles (1984) goes further to claim that varied instructional design strategies promote self-regulatory and reflective learning.

As mentioned before, A-level teachers in Zimbabwe are all University graduates. The fact that some of them could admit to having held misconceptions, is testimony to the tenacity of culturally held beliefs in the knowledge system. Using complexity theory (Pryor and Bright, 2003) it is suggested that the resistance of cultural values and beliefs, to make way for “scientific” knowledge, is inevitable as the new knowledge usually demands adoption of new fractal behaviour patterns. However in actively reflecting on and targeting identified misconceptions, teachers and students can become

engaged in the construction of knowledge and thus integrate the new knowledge into the existing fractal patterns without causing too much disruption of the knowledge base. The king pin of the success for such efforts, is the learner's ability to relate the content to the context in which they operate, hence the need for varied experiential learning (Boud and Pascoe, 1978; Kolb, 1984). The interviewed teachers' constant references to "varied, enriching" resources, seems to suggest that they too, were instinctively, searching for methods of helping their students experience the content they were teaching. The increasing primacy of ICT as a resource is best summarised by H31A quoted below:

You mean ... Oh, I just wanted to increase the base for my teaching. You know Geography is just like sciences – resource intensive. You just cannot teach it effectively through chalk and talk. You need to be able to help the students to visualise plate tectonics for example. You need maps and models and simulations. We cannot get these in this country and have to rely on textbook illustrations sometimes. So to increase the resources available, I had to look up some websites (H31A, lines 66-71).

From this testimony, it can be seen that ICT presented the teachers with an ideal resource base. The easy referencing and search systems employed by web browsers gives them an edge over other information retrieval systems, such as public libraries. The School-net project (King, 1999) in Canada has also described the transforming power of ICT. In his report, King addressed how teachers' perspectives of their profession, work and world views changed as a result of learning to use ICT for professional and personal purposes. King's views were further confirmed by Carter and Leeh (2001) who validated behaviour change attributed to teachers' use of ICT in England and Korea.

From the discussion above it can be surmised that the teachers who participated in exploiting the vast knowledge resources available in ICT, to provide a varied learning environment for their students were acting as agents

of change, and were themselves actively involved in self controlled and self-paced professional development based on their own personal discovery and insight.

6.1.1.2. Textbook supplements

Teachers identified the dearth of material resources such as books and equipment, in their schools, as the other contributing factor which led them to search for teaching materials over the Internet. 30 of the 54 interviewees, referred to this use of ICT. Analysis revealed that the supplementary materials were used in three different ways; a) as teacher notes, to assist in preparing lessons e.g. MAS52V; b) as notes for students' background reading (MN47M); and c) as notes for developing ideas / materials for teaching (ME38W).

6.1.1.2.1 Use of ICT resources to prepare teacher notes

Interviewed teachers indicated that they wanted to increase the amount of information around the topic that they were teaching so that their lessons could be more enjoyable for their students;

Yes I have. I downloaded some materials on waves and on cameras. I used these materials in my teaching on optics and it was quite good. I supplemented textbook notes with other ideas and students enjoyed the lesson. (ME12M, lines 32-34)

Other teachers used the materials to help them evaluate the teaching materials that were available to them and choose appropriate approaches for teaching;

You are kept up to date with information. You can also access some electronic textbooks and journals so you have a wider variety of teaching material resources which you can use. For example, in chemistry you can find some of the textbooks suitable for A-level. These will supplement the five limited textbooks that are recommended by the syllabus. You can then compare what they say about each particular topic you teach. (MAS52V, lines 204-209)

Yet other teachers saw a dual role for the materials; as extra reading materials for students, and also as illustrative materials for teaching abstract topics;

Yes, most of the Internet materials were suitable, as supplementary materials. In most cases the quality is higher than that expected at A-level, but it is also readable material so students can use it to widen their knowledge so that when they write their essays they demonstrate greater knowledge in depth. I collect the diagrams and sketches and graphical materials, print them onto transparencies and use them to illustrate points in my teaching. I have also downloaded images showing the movement of tectonic plates over time, thus showing the separation of the continents. Most of the material I have saved is graphical, with short explanatory notes – materials that is easy for me to adapt to my teaching. (H31A, lines 73-82)

It was also noted, in this case, H31A found the materials particularly handy because they could easily be adapted to different teaching approaches. It is interesting to note that the above uses described by teachers were also noted by Thompson (1997), (and confirmed by Bowskill *et al.* 2000), as being among the most common modes in which online resources were utilised by teachers in the United Kingdom.

6.1.1.2.2. Use of ICT resources to prepare students' additional reading materials

Due to the inadequate number of textbooks available in schools, teachers were aware that students were limited in their access to information for background or extended reading. Some teachers therefore undertook to prepare detailed notes for their students in order to provide them with enough information to enable them to learn effectively. For example, when asked why he was preparing notes for his students, ME26N replied;

Well, the notes were in addition to textbook materials, but those from the Internet, for example, pertaining to the gain in operational amplifiers in electronics, were much more detailed and practical. I was able to offer more than textbook materials to students and they loved it. Their participation increased. (ME26N, lines 39-42)

Whilst ME26N was mainly concerned with student participation, H31A was grappling with another more fundamental problem that is common to Geography teachers in Zimbabwe the ambivalence of their subject. He claimed that the status of the subject in his school deprived him of essential resources such as a laboratory and equipment, and yet they are expected to carry out scientific studies in physical geography for example;

The materials are of good quality. You have to understand that A-level Geography is a bit difficult because it combines aspects of scientific study and humanities whilst in schools, we do not carry out experiments or have laboratories. The Internet materials I obtained go slightly deeper than textbook stuff and draw upon current discoveries. The diagrams and sketches are very good quality too. (H31A, lines 83-87)

In such cases teachers do the best they can, by providing enough information to enable the students to proceed from a theoretical perspective. It is notable that these efforts by teachers were aimed at enhancing student participation (ME26N).

6.1.1.2.3 Use of ICT resources to develop materials and ideas for teaching

Despite the fact that the teachers were working in restrictive environments without adequate resources, their quest to make the process of learning more meaningful to their students drove them into becoming material developers. M33S was able to share this unique experience as evidenced by the following two quotations:

We were developing a mathematics module for mechanics and were shown some materials that had been downloaded from the Internet by the resource teacher. These materials were meant to supplement textbook materials and we were to use them in developing our units in the module. We found the materials to be very useful as illustrations and activity ideas. (M33S, lines 31 – 35)

However, the success of the above experience acted as a trigger event and opened him to further possibilities in the use of ICT and he was quick to take advantage of the situation...

I would try to look for more materials for teaching – like those illustrations (pointing at some printed diagrams on the display board), to provide variety of resources for my teaching activities. Our textbooks are old and they do not adequately cover the requirements – even for the core section – of the syllabus, so I need to supplement the textbook materials with other information. You do get some interesting Internet articles that can be used to illustrate a mathematical process. Just the other day I came across a scientific article on snow slides which related this phenomenon to the geometry of snow crystals. Mathematical concepts of fractals and iterations were mentioned. I can see the usefulness of such an article when teaching about number series, so I keep such things. Of-course, here we do not have snow, but we do have mud slides, which one can use instead, except that you have to think about mud crystals or other such particle geometry in order to describe the friction properties that make them possible. M33S, lines 69-79)

As can be deduced in the above argument, M33S was becoming a reflective practitioner. His description of the snow slide / mud slide phenomena indicates that he was becoming attuned to resource opportunities and at the same time recognised the limitations of the resources he could acquire. The two quotations from M33S demonstrate the chaotic process of transformation (Hunt, 1998). Davis, (2003) describes a successful transformation in teacher professional development as being guided by a response to perceived challenges to the current practice, understanding the nature of the problem (in this case, the dearth of resources), and awareness and review of sources of information and supportive strategies available (in this case, the teacher had been exposed to materials development with colleagues). M33S's argument above satisfies all the above conditions as shown in the brackets. In so doing, M33S demonstrates the triangulation of teacher professional knowledge, with classroom practice. The intersection of which was identified by van Driel (2001) as the key to understanding a teacher's pedagogical content knowledge, a topic which is discussed in section 6.1.3.

6.1.2 Practical Knowledge and skills

Another major theme which was identified from the responses of the interviewed teachers, as driving their professional use of ICT, was the perception that ICT helped them to develop practical knowledge and skills. Issues arising under this theme included the use of teaching resources in demonstrations, simulations and practical work; the organisation of teaching and assessment, which included syllabus interpretation, amassing and management of examination materials and teaching administration; and the development of ideas on teaching approaches and their effects on teachers.

These issues are discussed in more detail below:

6.1.2.1 Teaching resources

In the previous section, it was shown that one of the reasons why teachers access and use ICT was to acquire teaching resources. The section therefore focused on the type of resources that were obtained by teachers and why. In this section, the subject of teaching resources is re-visited but the emphasis is on what the teachers do with the unmodified material resources that they get from the Internet.

Teachers identified three ways by which unmodified ICT-based material resources were used. Teachers revealed that they accessed ICT to acquire guidelines for practical work and project work (MAS04V, H29G and MN16S). They also indicated that they used ICT-derived demonstration and presentation materials (M35B, MAS23K). Some of the materials were also used as diagnostic materials, to assist teachers in their work (M14N, MW18C) and within this category, marking schemes (ME14N) and lesson plans (H29G) were also downloaded from the Internet for certain topics.

6.1.2.2 Use of ICT to acquire guidelines and ideas for practical work.

Several teachers mentioned that they routinely use ICT to get ideas for designing practical activities with students. One such teacher was MN16S, a Chemistry major, who stated that he obtained information on:

Practicals on solubility products, background theory on acid based titrations I think those are some of the examples which came in my mind.(MN16S, lines 175-176)

Other teachers who made reference to similar uses for ICT in their subject areas included MAS04V (collisions- physics); M07H (reaction kinetics – chemistry) and MN46S (solubility product – chemistry). Teachers justified this use of ICT through their search for innovative ideas for teaching practical science. For example, MAS52V talked of searching for “unusual experiments – something not found in textbooks” (line 161). When asked to explain how they identified suitable materials from Internet sources, one of the teachers explained:

The Physics websites provide some materials resources that have been used by other teachers and found to be useful. You can try out the resources, demos and practicals for yourself (H29G, lines 26 -28)

Another teacher, referring to his students, elaborated;

Using ICT in combination with normal methods sharpens their investigative skills and also their critical judgement, especially if the ICT materials are presented as worksheets. Comparison helps them to appreciate the effect of context on an experiment. (ME37W lines 74-78)

Of particular interest to the interviewer, was how teachers addressed concerns about the reliability of the Internet resources that they accessed. These concerns were highlighted by the narrative of some teachers who had acknowledged that they had found some of the materials to be mediocre (M08H) and others had identified serious factual errors in the presented data. One example was given by ME12M who disclosed:

At first I used to get any Google listed physics sites, but I have since discovered that some of these writers are 'fake', so now I rely mostly on Royal Society of Physics web-sites, physics online and the High Schools Hub which contain materials that has been checked and rated by experts. (lines 36-39)

When pressed to explain why he thought some of the materials were fake, he elaborated:

I mean the materials they produce are sometimes not correct for example at one time I was researching for ways of teaching about pendulums. I came across this interesting website at a college in Canada, where a lecturer wrote about interrupted pendulums. I discovered that the formula that was given for the period was incorrect and inconsistent with dimensional analysis. (lines 41-45)

When presented with these problems, some of the teachers identified the problem as stemming from the fact that ICT materials are by and large unregulated. They have indicated that their solution has been to identify reliable, trustworthy sites where they obtained their materials from. H29G explained:

Yes – Internet materials are unregulated / but there are some reputable sites eg. ICSlearn / projectalevel and practicalphysics.org which are developed by serious physics teachers and practitioners with the purpose of developing a resource base for teaching physics. In addition, you are encouraged to use these sites materials critically and to evaluate them after use and write feedback to the site – so in a sense, there are sites which are verified by us the teachers, in a practical way. (H29G, lines 33-38)

Due to the vast resource database available from the Internet, and the open nature of its access, teachers were forced (through experience) to be selective in identifying the sources of their materials. In so doing teachers were exhibiting a reflective and evaluative engagement with the materials. Considering that the information access was carried out at the teacher's cost and convenience, they wanted to ensure that they obtained the greatest value for their money – hence the prioritisation and rating of reliable and trusted sites. For a teacher who is hard up on money and time, having a few reliable web sources, saves time and money especially considering that the computer hardware facilities used by these teachers had very slow connection speeds. Thus less time (and frustration)

was spent surfing / exploring the web and more time was spent 'on task'. This kind of behaviour fits in well with Doyle and Ponder (1978)'s arguments concerning the *cost – benefit analysis* as being central to the uptake of an innovation. It is also interesting to note in the above examples that all the teachers quoted above came from different regions of the country (as indicated by the first letters of their codes) yet they independently came up with similar solutions to the same problem (of determining the reliability of their materials sources). Such an observation is interesting because it seems to imply that the decisions taken by the teachers when faced with the constraints described above all converged around similar actions. From a chaos perspective, it appears as if professional development process develops through a path of least resistance, resulting in similar working solutions to common problems. These adjustments in the teachers' searching behaviour reinforce the self regulatory nature of the professional development process.

6.1.2.3 Use of ICT-based materials for demonstrations and presentations.

Apart from searching for ideas on practical work, teachers also sought for innovative ideas in teaching, using demonstrations, illustrations and presentations:

- I access many different sites according to particular need. Physics coursework bank for demonstrations and coursework support materials (H29G lines 22-23)

For one thing, I use computers extensively throughout my work. I use demonstrations and simulations in my teaching of Physical and Human Geography. (H31A lines 50-52)

Over the past three years we have downloaded several demonstrations from the geological survey and other websites. Some of them on remote sensing, I was able to get from the UNESCO website.(H31A lines 54-56)

However, some teachers also indicated that some of the information that they come by is not specifically targeted, but that it is information that is accumulated during the course of their other ICT-based activities.;

Yes, several times. I used human development data for example, to illustrate aspects of economic geography. However, I did not specifically go to the café with that in mind. I used the information only because I came across it and said – I think this might be useful. It is accidental, (M36M lines 43-46)

There was an article last year (2002) on Computerised Tomography scanning. I first heard about CT scans about 5 years ago when I was in Harare and my husband had to have his head scanned after a driving accident. So when I saw this article, I read it, and downloaded it and filed it away. In a CT scan sometimes doctors use radio-iodine and it so happened that I was teaching radioactivity this year and I remembered the article. I used the article to demonstrate the uses of radioactivity in the medical field. (MN50Ma line 90-95)

The fact that some of the information was accessed incidentally, on the fringes of other activities, implied a high level of professional vigilance and alertness. Such actions show that the teachers are highly tuned into and engaged with their professional practice. Wittrock (1986) and Tobin and Fraser, (1987) both list professional vigilance and teacher engagement as attributes of effective teachers. Brophy (1997) describes effective teachers as those capable of making decisions focusing on the effective use of curriculum and instructional materials. To be able to achieve this level of effectiveness, teachers would need to be able to employ both creativity and experience in their decision making. It appears as if it was this quest for efficacy in the classroom that motivated teachers to seek alternative ways of presenting materials to their students.

6.1.2.4 Use of ICT-based materials as diagnostic tools for assessment and evaluation.

One area which is of greatest importance to teachers, apart from the actual classroom practice, is the assessment and evaluation of students performance. Perhaps in Zimbabwe this is more so because the integrity and stature of a

teacher is largely dependent on the performance of his / her students in the national and international examinations. The Zimbabwean school curriculum is examination centred and this focus permeates all areas of teacher development including the appraisal system and promotion. Thus teachers linked students' performance in examinations to their own self-efficacy / effectiveness as teachers, as MAS21M explained:

Yes, I also teach private classes and in this way I discover what students really need in order to pass exams. The more my students pass, the more my reputation grows so I believe that focus on those areas that enable my students to pass leads to my professional development as I become a better teacher. (MAS21M line 40 – 44)

It was only natural therefore that teachers should consider using ICT to provide them with insights on tackling the problems of assessment and evaluation of students performance. Teachers used examination materials in different ways, i) as diagnostic tools;

They were quite useful. The school-net exam questions are presented together with a discussion of the main concepts, major pupil misconceptions and model answers presented in a point by point format. I found this to be useful because it helps me to diagnose difficulties that my students may have. (ME14N lines 33 – 37)

And ii) as revision test items;

During revision period, I copied some questions from my data bank and gave to students as revision exercises. I would then use a detailed marking scheme and mark their work highlighting common errors.(M34S, lines 67-69)

Used in this way, ICT-based test and examination items provided teachers with tools for determining and correcting misconceptions. The development of assessment procedures (marking schemes), ensures that the teachers adopt internationally accepted routines for helping students to demonstrate what they know, can do and understand (Keiler and Woolnough, 2002).

6.1.2.5 Organisation of teaching and assessment

Internet materials were also used during the planning and evaluation of teaching process. MW18C found that he could adapt his teaching approach in such a way as to take full advantage of the vast resources offered by the Internet. When asked to comment on how the use of ICT has impacted on his teaching approach, he replied:

As I said, it has made my teaching less strenuous. I concentrate on the activities, demonstrations, main concepts and common problems. The students focus on understanding what we are doing rather than writing notes. They then use the notes I give them at the end of the lesson as reinforcements and reference materials. I can now also give them more individualized home work so that those gifted students get more challenging questions than others. (MW18C lines 48-55)

With the availability of more resources from the Internet, the teacher was able to develop a teaching routine which worked well for him and enabled him to provide individualised attention to his students. H28G amply clarified the full range of curricular materials that can be obtained from the Internet.

Courseworkbank contains lesson plans, notes and suggestions for teaching/ learning activities. *I find these to be very useful for my subject. In addition, the site materials are rated by other users so you know if you can trust the quality of the materials.* The exam.net has very good quality materials by topic some of it is free/ but to access the full range you need to subscribe. (H28G lines 77-81)

Thus apart from providing lesson notes, the Internet was perceived by the teachers as supplying the tools for effective teaching, such as ideas for demonstrations, tools for diagnostics and effective planning of learning experiences.

However, some of the teachers were more interested in increasing their 'procedural knowledge' (Ottevanger, 2001) and practical teaching skills development. For example, MW18C explained how he used computers at his school for developing his teaching schemes and lesson plans. He explained

that before the advent of computers at his school, he experienced organisational problems because he kept losing his lesson plans and therefore could not evaluate the effectiveness of his lessons. He also alluded to the fact that most experienced teachers were frustrated with having to write lesson plans every year, and ended up not even attempting. The computer enabled him to save and re-evaluate his lesson plans and thus improve on the delivery of his lessons.

This view was also supported by H31A, who explained that the use of ICT in planning his lessons enabled him to focus more on the teaching task, than on producing paperwork for staff appraisal. However, in some private schools, the use of computers in the development of teaching schemes and lesson planning was formalised:

They use the computers for planning their teaching schemes and also for processing assessment and records of work. We have developed templates for the administration of teaching, schemes, records and assessment and for uniformity (H32A lines 18-20).

However, one could argue that institutionalising the use of ICT masks the perceived impact that the technology might have on self-directed professional development. Nevertheless M41B was able to speculate on the benefits of developing procedural knowledge using ICT.

Like I mentioned before, I could have all my schemes typed and saved so that each year I spend less time on copying the schemes, and more time on re-thinking and modifying them by improving on the pupil activities, and also thinking of new areas to cover. With continuing modifications, I can actually become more reflective and say which approaches work best. I can even focus more on my teaching. Currently what is happening is that the first two weeks of each term, hardly any teaching takes place because of the schemes, but if it is already saved, all I have to do is spend a day or two, correcting for syllabus changes and other alterations then I can start teaching. (M41B, lines 89-97)

From the teacher's point of view, planning using ICT saves time (cost-benefit, Doyle and Ponder, 1978). Saving time enables the teacher to focus

more on consolidating the procedural knowledge by modifying content and methods and so engage in meaningful reflective practice (Ottevanger, 1998).

6.1.2.6 Ideas on teaching approaches

Apart from content notes, and organisational skills, teachers revealed that they have used ICT to search for ideas on innovative teaching approaches. Teachers sought for information on the use of group work (MW17C), reinforcement techniques (MW18C), and other active teaching techniques (H45Q).

MW17C indicated that the prescribed A-level Biology textbook is written in prose fashion and he had trouble getting students to engage with the content in an active manner. He was therefore interested in getting information on how to organise effective group work techniques.

Similarly, ME27M in describing the benefits he derived from using ICT, explained:

I did not have a particular approach to teaching using group-work, Worksheets and other activities were simply planned so as to provide variety to the learning experiences, but it was not systematic. But when I stumbled upon this (group-work) approach on the web-site, it was so simple and purposeful and provided an easy way of testing if the objectives had been met. I even began enjoying making some detailed lesson plans. Previously, I had given up the whole practice and used lesson notes to guide me through the activities. (ME27M, line 27 – 33)

Not only did ICT provide the teacher with possible solutions to the development of his own procedural knowledge, but through engagement with the innovative group-work approach, the teacher was able to re-discover the purpose of planning for pupil learning, possibly, because the success of the group-work method advocated depended on forward planning.

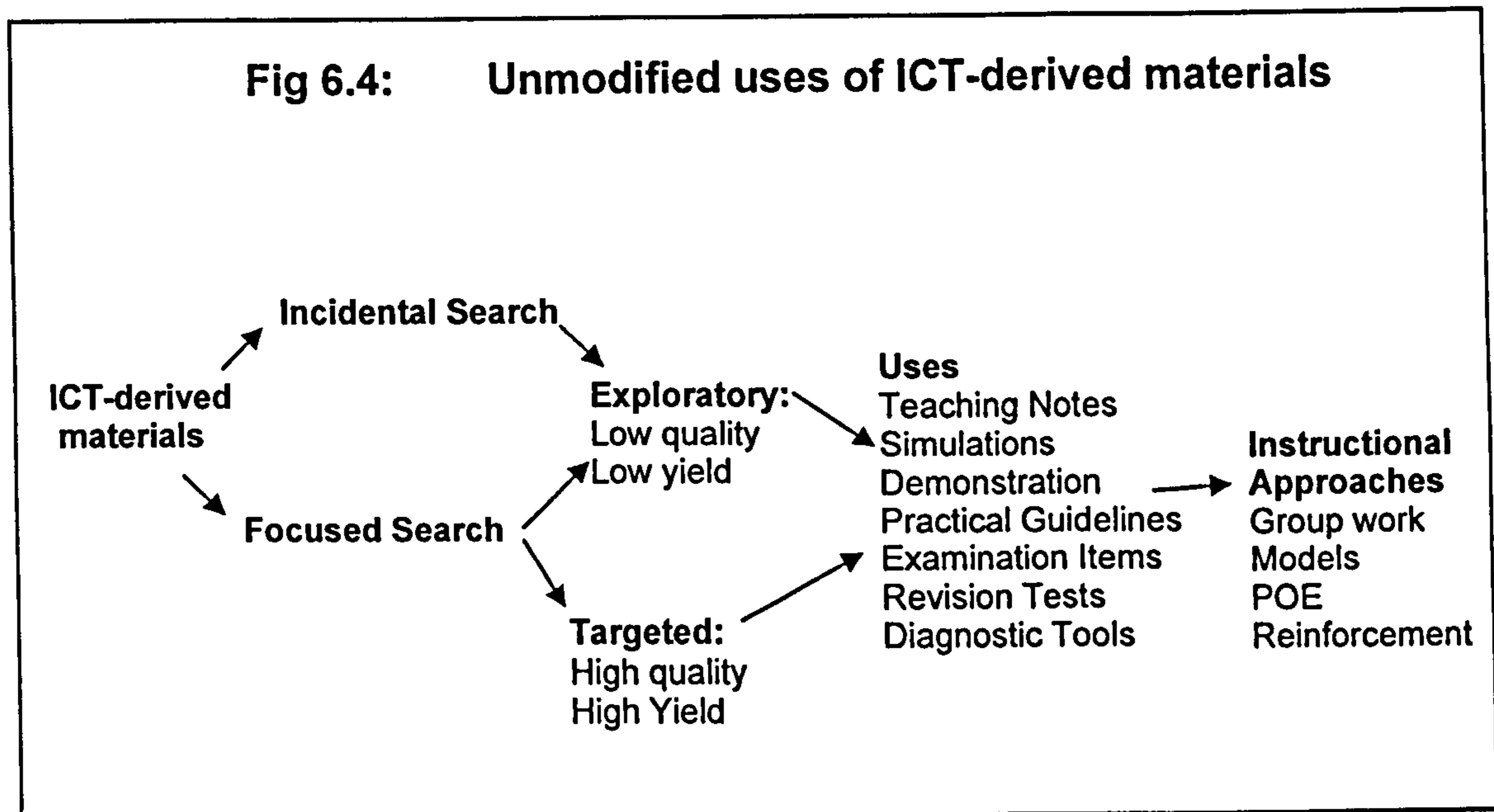
In a similar vein, M33S was able to use ICT-derived materials to develop a curriculum module based on the prediction, observation and explanation (POE) method of process oriented instruction.

The module was supposed to emphasise a process orientated instruction approach. I was not very familiar with this approach and needed exemplary materials to show how the prediction, observation and explanation stages could be covered. The Internet materials were designed to do this – to stimulate students to hypothesise, test and explain their observations. ... I could see that it enabled students to participate in the derivation / construction of mathematical theory from observations based in the real world (M33S, lines 37 – 43).

Deriving its basis from the social constructivist paradigm (Solomon, 1987; White and Gunstone, 1992) in the early 1980s, POE was conceived as a teaching approach that recognised the primacy of students prior knowledge and therefore helped teachers to design learning activities that start off from the students experiential perspectives (Liew and Treagust 1998; Mthembu, 2001). Although POE is now generally accepted as part of the repertoire of a teacher's problem solving and process oriented instructional skills (Kulm, 1983; Smiljkovic, 1996 and Kearney, 2002), in Zimbabwe in 2001 it was still a new concept that was just beginning to "catch on", hence the concerns noted by M33S in the first part of the quotation above. ICT in this case provided the stuff to bridge the gap in the teacher's knowledge and enabled him to grasp and understand the procedural knowledge required to enhance students' learning using these approaches.

A summary of how the interviewed teachers acquired and used unmodified ICT-based materials is illustrated in figure 6.4 below. Unmodified materials are obtained through two main methods: as part of an unrelated search (incidental), whereby the teacher comes across the material and downloads it because it might be useful in future (cf. MN50Ma). In this case, the quality of the materials

is uncertain and the material may or may not prove to be really useful to the needs of the teacher.



The majority of teachers also carried out focused searches for specific materials. The quality of the materials obtained in this case seemed to depend on the method of search chosen by the teacher. The use of highly targeted websites (e.g specific biology sites) as opposed to generalised (exploratory searches) yielded better results with lower investment costs in terms of money and time (cf.H29G). Once obtained, the materials were used to provide notes for different purposes. Some of the materials were also used as teaching aids in demonstrations, practical guidelines and diagnostic tools.

Evidence also showed that teachers went beyond mere content knowledge in their search and were interested in exploring new innovative ways of teaching including the use of group work (ME27M) and other active learning approaches such as predict-observe-explain (M33S). In seeking innovative approaches to teaching, teachers were trying to adapt to changing curricula needs. Kulm (1983) argued that new curricula were moving from content to process oriented instruction biases. In Zimbabwe, this assertion was supported by Mtetwa, (1992)

who argued that mathematics curricula were transiting from computation to problem solving.

6.1.3 Pedagogical content knowledge

In the previous sections, it was revealed that teachers used ICT to search for theoretical and content knowledge pertaining to their subject disciplines, as well as ideas for enhancing their practical knowledge and procedural skills.

Some researchers (notably Geddis *et. al*, 1993; Magnusson *et. al*, 1993) have argued that teacher decision making is influenced by teachers' understanding of their subject discipline. Disciplinary knowledge influences their selection, prioritization and sequencing of subject content to be taught (Shulman, 1987; Grossman, 1999).

Meade and McMeniman (1994) and Sawyer (2001) also argue that teachers acquire practical and procedural knowledge partly through initial teacher training, through experience of what works and also as a result of the way they themselves were taught in the past.

However, teachers' selection and use of both procedural knowledge and subject disciplinary knowledge is also tempered by the context in which they operate, i.e. the resources, curriculum demands, facilities and socio-cultural and economic milieu in which their practice is based. The context forms part of what is known as the teacher's wisdom of practice (Sarkim, 2004). The impact of ICT on issues pertaining to the context of A-level teachers in Zimbabwe was dealt with in chapter 5.

A blending of these three types of knowledge: disciplinary, procedural and contextual has been termed the pedagogical content knowledge (PCK) and is discussed in detail in chapter 2. Teachers build up a PCK structure which is held in equilibrium by the interactions of the above mentioned knowledge types.

Improvement of PCK is accompanied by change in teachers' conceptions, attitudes and procedures regarding both content and presentation of their subject discipline (Davis, 2004). Similarly, changing the initial conditions in the teaching context (e.g syllabus, examination requirements) or in pedagogy requirements (e.g changing focus from computation to problem solving in mathematics, or from recipe-style practicals to investigations in the sciences; cf. Mtetwa, 1992) or in the content (introducing a completely new topic such as astronomy, into the curriculum; cf. Jaji and Hodzi, 1992) results in changes in the teacher's PCK structure and this creates dissonance in the teacher's practice and reduces effectiveness.

The sub-sections below look at how the teachers in the sample used ICT to strengthen their PCK structures. The Interview analysis framework revealed that teachers strove to re-establish equilibrium through four different ways: (i) adaptation to syllabus depth; (ii) modification of materials to suit local conditions; (iii) linking concepts with current affairs and (iv); developing their own teaching and learning materials.

6.1.3.1 Adaptation to syllabus depth

Interviewed teachers were very concerned about being able to cover the syllabus to the correct depth. MAS01M for example, indicated that she found herself being the only one teaching A-level mathematics at her mission high school. This situation was exacerbated by the fact that she was recently qualified and inexperienced. She was concerned that she might have problems of depth and coverage and so resorted to communicating with colleagues in other schools by e-mail, to get ideas on these requirements. Other teachers indicated that they used ICT-based materials as exemplars to provide

information pertaining to the depth required for treating some topics in their subject:

I also wanted to be sure I was teaching the right stuff at the correct depth. The questions gave me an idea of the depth and rigours required (ME14N, line 81)

The use of exemplary materials to improve quality of teaching is advocated for by UNESCO (1988). Hoff and Leiker (1992) and Leftridge and Ingham (1995) also described the benefits of using exemplary materials for novice and inexperienced teachers. More experienced teachers on the other hand routinely checked any materials accessed to ensure that it was in-line with the syllabus requirements and also with their lesson objectives, before making decisions to incorporate the materials into their teaching repertoire:

Yes, because I have to follow the syllabus at the same time, so I keep my lesson objectives and select those activities that satisfy my objectives. I do the same even for discussion notes and theory test questions.(ME27M lines 23-25)

MAS23K reported that the challenge she and her colleagues in geography who had visited the Science and Mathematics Centre faced, was to correlate the materials they had downloaded from the Internet, with their subject's examination requirements. The teachers were therefore locked in discussion about aspects to include and not to include in their teaching schemes. According to Sawyer (2001) ICT thus enabled the teachers to establish powerful collaborative contexts, around which they examined and derived meaning from their practice.

Even so, use of ICT had its own drawbacks. The teachers were not always happy with the quality of the materials that they obtained. For example, MN46S, an experienced chemistry teacher, reported that several times he had to discard material because it was too shallow;

Sometimes I would run a search and download some materials, but at times I would just open a page, run through it and see over this and in some cases I would say no this is shallow so I can't take this for my students and so I just leave it from selection. (MN46S, lines 194-197)

In such cases, teachers incurred losses in terms of time wasted and money since they had to pay for access in most cases, as has been reported in chapter 4. However, the majority of teachers took measures described in section 6.1.2. above to ensure that they had access to reliable sites with good content coverage. MAS01M was one of the teachers who were satisfied with the depth coverage of materials that she accessed.

Traditionally, teachers would resolve issues of syllabus depth and examination coverage through workshops and other collaborative activities. However, because of the problems of professional isolation identified in chapter 5, teachers were increasingly finding it difficult to follow this route. Fortunately ICT provided a solution through online communication and the use of exemplars. Pogrow (1993) and Clarke et. al.(1996) argued that whenever curriculum change is introduced, it must be accompanied by exemplar materials that guide teachers on the depth and approaches envisaged. Exemplary materials are like product samples in industry and help teachers to determine what type of adjustments they need to make in their own practice. Thus through ICT, teachers were able to receive the support they needed to strengthen their PCK structures pertaining to syllabus and examination needs.

6.1.3.2 Modification of materials to suit local conditions

Frequently, and not surprisingly, teachers found that the materials they accessed over the Internet were not suitable for use in the classroom because it

referred to a different contextual background. Teachers recognised this problem and adapted their materials to local conditions:

The Physics websites provide some materials resources that have been used by other teachers and found to be useful. You can try out the resources, demos and practicals for yourself and modify them to suit your local conditions (H29G, lines 26-28).

At first I did cross check materials against resources available at the school / to see need for change or to modify according to what is available (H29G lines 82-83).

I do adapt them because sometimes I might not have the physical resources that go with the lesson plans, Sometimes I might not have the equipment for the demonstration part and might have to look for alternatives. So I have to modify and *sometimes even re-organise the work to suit my own objectives*. (ME27M, lines 15-20 – my emphases)

I also had to panel beat in terms of say if you say sodium hydroxide can substitute with potassium hydroxide generallybecause my selection is based on the availability of the chemicals in my store-room, (MN46S, lines 172, 178-179)

From the above quotations, it is evident that teachers considered several factors before deciding to adapt and use materials. For example, H29G cross-checked materials resources (equipment) with what they had available in the school, then pre-tested the materials to determine the suitability of the materials. In this way, he was able to modify the materials to suit local conditions.

However ME27M and MN46S also indicated that their modifications included substitution of chemical materials as well as re-organisation of the work to fit into already selected objectives.

Such modifications required active engagement by the teachers. As Buchmann (1983) argues, teachers saw themselves as part of a system and their actions were aimed at maximising the effectiveness of this whole. It was this systemic perception that enabled teachers to realise that they could benefit from ICT-derived materials prepared by people whom they had never seen and who lived far away from their own context. As systemic components, they were

not isolated by lack of local materials or ideas, but strove to benefit from the synaptic interconnections with other systemic components such as colleagues, through ICT.

Modifications and adaptations were also carried out in respect to the level of students targeted. Teachers in most cases identified universities as their main sources of materials – possibly because they tended to trust university – derived materials better than materials developed by some obscure teacher at another school (Doyle and Ponder, 1978; value congruence). However, in most cases, university-derived materials are not suitable for A-level students – hence the need to modify:

..... the materials are a bit too deep for A-level Biology that is why I wanted to check the materials out and modify them and write my own notes on them. (MW17C, lines 52-54)

One has to consider the context, the content and also the level and quality of materials.(H30G, lines 54)

..... what I provided to students was a re-organized frame of notes from all the different sources integrated and modified to their level. (ME14N, line 96-97)

Some teachers also tried to make adjustments to their teaching materials to cater for students' different abilities (eg. H28G), and this was reflected in the organisation of the teaching materials, and the use of a variety of teaching styles incorporated into the lesson sequencing and plans:

Once I get these (ideas) from the Internet, I try to fit them into my existing scheme. On my lesson plan, I indicate that at such and such a stage in my lesson development, I shall use this idea to do 1, 2, 3 activities and so forth. I have to go through the process myself, make notes and see if I can duplicate the experience using locally available materials. (M34S, lines 39-42, 45-46)

The ability to effectively adapt and modify materials to suit local conditions demonstrates a teacher's genius and expertise as a classroom practitioner. Sawyer (2001) defined adaptation as competency that enables teachers to use multiple approaches to teaching a topic – the ability to think outside the box. For

this reason, not all teachers were successful in their attempts and some were frustrated by the resulting failure.

6.1.3.3 Linking concepts with current affairs

For geography and biology teachers, the curriculum has undergone recent rapid changes due to developments that have taken place in the real world which have had far reaching effects on life in Zimbabwe and indeed, globally. Examples of such developments include the HIV/AIDS pandemic (H28G), the use of genetically modified organisms (Genetically Modified Organisms) in food production (MN47M) and the increasing instances of droughts in southern Africa, believed to be linked to effects of global warming (M35B). Teachers were finding that students had difficulties visualising some of the new concepts and needed to relate them to current events. Teachers then used the Internet materials to derive contextual examples of applications of the abstract concepts. For example, H28G used information derived from reports on the Internet, to stimulate discussions on genetically modified organisms and HIV/ AIDS;

.....did get some articles on genetically modified organisms – you know, in this country there is a debate about whether to accept gm grain or not. Had an interesting discussion with students on the merits – demerits of that / used the article as the basis of the discussion. (H28G, line 85-86)

Yes, I have used search engines for example to find out the reasons by S.A President to support his ideas of linking AIDS to poverty and not to HIV. We used these arguments in class to discuss the complexities of the AIDS crisis in developing countries. I have also used the listed websites to look for solutions to other problems in the teaching of Biology..... (H28G, lines 51-54)

Other teachers were more concerned with helping their students to visualise the concepts they were learning. H31G provides an example of such concern in Geography, whilst M34S, M35B and MAS54M were more concerned about their students' appreciation of mathematics:

You need to be able to help the students to visualise plate tectonics for example (H31G, line 69)

.... make mathematics relevant to their experience by placing it in context (M34S, line32)

I believe for students to appreciate mathematics, they must relate and interact with it in a very concrete manner (M34S, line 92).

I always try to make their experiences concrete. (M35B, line 139)

Sometimes I am more interested in the application side of mathematics andAs I said, I look for ideas and approaches, so – yes – I do modify quite a lot. I want to relate these approaches to my teaching (MAS54M, lines 33-35, 37-38).

It appears as if the need to concretize abstract concepts stems from the teachers' own conceptions of the nature of learning. For example M34S believes that students can only understand mathematics if they can relate to it in a concrete manner. For her, therefore, it is imperative to relate abstract concepts like calculus, to things which her students can relate to and experience. Grossman (1999) argues that beliefs such as M34S's inform a teacher's conception of teaching. This view is supported by Magnusson (1999) who also believes that a teacher's belief system is reflected in many other aspects of teaching, including their selection of teaching strategy, content and assessment. Thus it can be said in part, that the teachers' use of ICT and their modification of ICT-derived materials was motivated by their need to reconcile their practice with their values regarding teaching.

6.1.3.4 Developing teaching and learning materials

In a few cases however, teachers were involved in regional initiatives to develop teaching and learning materials for selected topics. These teachers were shown how to access and use exemplary materials from the Internet. Some of these teachers then went on to try and develop their own materials using these exemplars. For example, M07H is a chemistry teacher who was involved in developing exemplar materials for the chemistry module:

...I download materials on reaction kinetics for our SEITT materials development module. We went to the High School hub and downloaded experiments to use in the contextualised module. I also used chemistry simulations here at school, to teach some concepts on chemical bonding.(M07H, lines 19-22)

..... The module went through two trialing periods, so it should be ready by now. (M07H, line 30)

M09M, another chemistry teacher clarified the need for developing materials for this module:

The A level chemistry module was meant to address problems that teachers face when they teach the topics. (M09M lines 40)

Another example is provided by M33S, who was part of a team that helped develop the mathematics module. He describes his experience thus:

We were developing a mathematics module for mechanics and were shown some materials that had been downloaded from the Internet by the resource teacher. These materials were meant to supplement textbook materials and we were to use them in developing our units in the module. We found the materials to be very useful as illustrations and activity ideas. (M33S, lines 31-35)

..... The module was supposed to emphasise a process orientated instruction approach.The Resource Teachers had actually prepared a demonstration based on the method and I could see that it enabled students to participate in the derivation / construction of mathematics theory from observations based in the real world. It was quite uplifting. We were then asked to incorporate similar processes in our units. My only problem was getting relevant experiences where observations could be made. I did come up with something eventually and I could immediately see the benefits of using the method in my teaching and for myself. I have learnt quite a lot from the exercise. (M33S lines 37-48)

Whereas, from M07H's testimony, it appears that the chemistry materials developers were interested in addressing teaching and learning related problems through contextualisation (a local Salters equivalent?), materials development for M33S's group had a different aim, i.e. to introduce process oriented instruction (Searle and Gunstone, 1990). It is interesting to note the use of exemplary materials in both cases. M33S admits that it was quite difficult to come up with good POE cases, however the use of exemplars as guides, enabled him to succeed in the end. This experience supports the arguments for

the use of exemplar materials in teacher professional development (UNESCO, 1988; Pogrow, 1993 and Clarke et. al 1996)

At this juncture, it is pertinent to note that teachers did not have a blind faith in the use of ICT as a panacea to their professional development needs. Indeed teachers' attitudes ranged from outright scepticism (MAS02M) on the one extreme, to faithful discipleship (M33S) on the other. Even in the latter case, there was evidence that teachers' attitudes were mired in evidence and personal experience. Thus teachers were not blinded to the limitations of ICT, but took a rather cautious approach to using ICT. For example, in selecting content, MAS04V cautioned:

No, I think it depends on whether you look for materials at the right place. If you search for university materials on sites which cater for school you will be disappointed and vice-versa. MAS04V lines 68-70)

- A view that was also shared by MAS02M who insisted on evaluating any ICT-derived materials regardless of the credibility of its source (line 67).

ME12M found himself in a very unenviable position when he discovered that the practical he wanted to use as a class activity was flawed and he had no idea how the flaws were going to affect the results students would get as a result:

.... the formula that was given for the period was incorrect and inconsistent with dimensional analysis. I had to think of ways of going round the problem because I wanted to use interrupted pendulums in my teaching. (ME12M lines 44-46)

The experience forced him to become more critical and reflective not only pertaining to Internet-derived content, but also in modifying materials for student activities. Other teachers had problems contextualising materials they obtained from the Internet, because they discovered that these materials were written for different audiences and they failed to reconcile the differences:

The site is for American Teachers and they discuss problems which Americans face in their schools, problems we do not have

here for example, problems of discipline are different in America to what we experience here. The Equipment and American Education Policy, the Biology curriculum in America and what they term benchmarks of achievement, are all very different from our own here. I wish we in Africa could develop our own Biology education websites that deal with the dynamics of our experiences. I think that would be relevant to what we want. (H28G lines 59 -65)

For example, richer countries would have models that can be used to teach various mathematical concepts which may not be easily available here. The Internet sites routinely refer to these models and they are taken for granted. Another example is the use of outcomes based education targets or benchmarks or attainment targets, which we do not talk about here so the content becomes meaningless as it is steeped in context. (H30G,lines 41-46)

However, most of the teachers were quite happy with the quality of ICT-derived materials. ME14N for example, felt that accessing materials from the Internet was a worthwhile activity.

This section has provided evidence that teachers used ICT-derived materials to strengthen their PCK structures and thus become more effective. PCK was strengthened through the adaptation of materials to suit local needs. These needs included syllabus requirements, relevance, contextualisation and the development of exemplar teaching materials aimed at introducing new teaching approaches. In meeting these needs, ICT also provided the teachers with opportunities to continue with their development through online collaboration and learning (Roffe, 2000). By helping teachers to directly engage with strategies that help students to learn, Hea-Jin (2001) argues that ICT also provided effective professional development experiences for these teachers.

6.2 What benefits do teachers perceive as being derived from the use of ICT-based materials?

Unlike other professional development activities, self directed professional development places the teacher at the centre of the professional development process (Clark and Lambert, 1985). The teacher is not under external pressure

or duress to undertake professional development activities and they exercise full freedom of choice in selecting and prioritising their areas of development.

Bouchard (1996) argues that professionals embark on self directed professional development, as a real means to solve a real problem. It is reasonable therefore to suggest that any activities that teachers choose to partake in will be ones that they perceive to meet the teacher's specific needs. What teachers perceive as benefits therefore, are ways by which their needs are fulfilled.

The perceived benefits were classified according to three of the four types of teacher knowledge discussed in 6.1.2 and 6.1.3 above. These are:

- i) Benefits to the teacher's theoretical content knowledge base
- ii) Benefits to the teacher's procedural (practical) knowledge base
- iii) Benefits to the pedagogical content knowledge base

All interviewees were asked what benefits they thought they derived from using ICT for their professional development. As this was an open ended question, teachers were free to provide their responses in any of the categories listed above. These benefits are discussed in detail below:

6.2.1 Benefits to the teacher's theoretical content knowledge base

Interviewed teachers identified two major benefits from using ICT under this heading. The first was that ICT use exposed them to the huge possibilities and opportunities available in terms of information processing. For example MW17C reported that the use of ICT had opened up many possibilities he had not dreamed of before. This benefit was termed awareness. The second major benefit, as identified by teachers pertained to the acquisition of information. M35B for example maintained that ICT enabled teachers to be informed about their subject discipline, while other teachers (eg. M13M and MW17C)

mentioned that using ICT kept them updated on developments in their subject discipline. Table 6.3 below provides a sample of some of the statements teachers made in connection to the two benefits cited above:

Benefits of keeping Informed	Benefits of being aware
I am updated in content and teaching skills (M10M, line 61)	I can appreciate the resources I can get from the Internet (ME12M line 96)
I am well informed about the topic I am teaching. (MW17C line 82)	I could appreciate more and more, the value of IT in gathering information about subject topics. MN48M, line 131-133
I am keeping in touch with modern trends. (MW19C, line 31)	I think ICT is a must for teacher to keep pace with modern trends and also to keep informed with the fast pace of knowledge production nowadays, books quickly become out-dated and expensive to upgrade. The Internet and ICT provides us with a cheap way of upgrading ourselves and getting up to date information on topics, MW17C lines 99 – 102
<i>vanhu vanowedzera</i> Knowledge with time <i>saka</i> ICT <i>inobatsira kuti tiite</i> keep in contact with <i>izvozvo zviru kureseachwa</i> on time <i>iyoyo</i> maybe <i>mateaching</i> skills. MAS52V lines 12-13	Even <i>zve</i> Biology <i>zvatangatichitaura izvi</i> you will not get in one text book. <i>Unotozviwana pa</i> Internet, <i>saka</i> if you don't use the Internet <i>hauna kana chekutura</i> . MAS52V, lines 218-220
You are kept up to date with information. You can also access some electronic textbooks and journals so you have a MAS52V, lines 204-205	

Table 6.3 Benefits of using ICT pertaining to theoretical content knowledge

From the table it can be seen that by “being informed” teachers meant keeping up to date. However sometimes teachers used variant expressions which suggested that for them, being informed meant more than mere acquisition of knowledge, and included being primed to take opportunities. For example, M10M felt that by using ICT in her professional development she was “being prepared for modern living” (Line 13), whilst MW17C felt that he was able to “.. use tit bits of information in my teaching, just to show students the frontiers of research in the topic we will be discussing” (Lines 78-79).

Similarly, awareness meant more than just knowing about existence of resources. It included being appreciative of the potentials of ICT use. MW17C

reported that he was able to get a lot of interesting resources from Biology websites because he knew where to look for them. H31G on the other hand felt “academically involved in my work” (line 116) as a result of his use of ICT.

Nespor and Barylske (1991) defined knowledge as:

A situated construction of social networks, a textually produced phenomenon rather than an entity with an existence independent of practice of our representation (p806)

Thus knowledge is more a product of social representation than a nomological body of facts. Several researchers point out that the nature of knowledge is changing (Thomas, 1992; Nonaka, 1995) due to the revolutionising effect of information communication technology. The exponential growth of knowledge makes it difficult, if not impossible for individuals to completely master knowledge within their disciplines or professions. It becomes more important therefore, for the teacher to know where and how to acquire knowledge and translate it into his / her social context (Habermas, 1972; Clark and Lambert, 1985; Nonaka, 1991 and Newman and Johnson, 1999). Thus focus should be on the process of knowledge acquisition rather than on the product. *Being informed* and *being aware* are therefore better representations of the theoretical content knowledge base for teachers.

6.2.2 Benefits to the teacher’s practical knowledge and skills base

Marland (1997) defined procedural knowledge as knowing what to do, when to do it and how to do it. Procedural knowledge embodies the teacher’s methodological know how- as a technocrat in his specialist field of teaching.

Interviewed teachers indicated that they gained benefits related to the quality of their teaching and they became more effective in their work. For example, MAS01M claimed that she had become more effective as a teacher (line 55) – a view also shared by MAS53V (*I think I’m teaching more effectively*

in some ways – line 117). The teachers' perceived improvement in their effectiveness as being manifested in three areas of their classroom practice: better teaching approaches; teaching methods which accommodated students' individual needs and more efficient administration.

Table 6.4 below provides a sample of illustrations of teacher statements in each category of the benefits described above. The table illustrates the fact that the teachers appear to have been much more concerned about the actual teaching than about the administrative aspects of classroom practice.

Table 6.4: Indicators of benefits to teachers procedural knowledge
<p>Better teaching approaches</p> <p>I can say the idea was there right from the beginning, but ICT made it easier for me to implement the approach. (ME14N line 89)</p> <p>-it has made my teaching less strenuous.(MW18C, line 48)</p> <p>You become aware of how other teachers given the same challenge, would approach the topic and you choose the best method from a number of approaches – (H29G, line 58- 60)</p> <p>Teaching is constantly evolving and approaches change over time. I have 18 years of experience and I feel the need to keep looking for new trends to avoid becoming deadwood. (M38W, line 30)</p> <p>...benefits in raising awareness about different approaches to teaching the topic (H30G, line 51)</p>
<p>Teaching methods which accommodated students needs</p> <p>.... select the best method for your students and so you become more responsive to their needs,M08H, lines 50-51)</p> <p>I can now also give them more individualized home work so that those gifted students get more challenging questions than others. (MW18C lines 51-53)</p> <p>-allowed me to let the students to express themselves a little bit more clearly than before. (MAS22V line 41)</p> <p>-it helps me to diagnose difficulties that my students may have.(ME14N, line 36)</p> <p>I can now focus my energies on meeting their individual needs. (ME38W, line 42)</p>
<p>More efficient administration</p> <p>I can retrieve information that teachers, administration and parents want in a short time(MAS04V, lines 33-34)</p> <p>... we are able to do a lot of things we could not do before because the work was laborious - for example updating chemical stock. (ME14N lines 13-14)</p>

6.2.2.1 Better teaching approaches

Three issues arise from the statements made by teachers pertaining to the way ICT helps them improve their teaching approaches (Table 6.4): Firstly, teachers stressed the need to maintain systemic development by constantly referring to the need to compare teaching approaches (H29G, H30G and

M38W). By striving to remain aware of the trends in the use of teaching approaches, the teachers ensure that they remain part of the transformative forces (as opposed to dissipative forces) within the education system (Bloch, 2003; Pryor and Bright, 2004). At the same time, keeping up with the trends in teaching helps teachers to meet the changing demands of the education system more effectively and thus “avoid becoming deadwood” (M38W).

Secondly, ICT increased teachers' awareness of the multiplicity of ways of decoding knowledge. Both H29G and H30G reported that being aware of the different ways with which a teaching topic could be approached, presented them with opportunities to choose the best methods appropriate for their students. The idea of choice is central to change theory (Fullan, 1997 and Hargreaves, 1997b) and also lies at the heart of teacher decision making and professional development (Hargreaves, 1997a and Bertani, and Tafael, 1992). Thus the teachers realised that ICT provided them with real choices to improve their practice.

Thirdly, ICT also acted as a support structure; facilitating ME14N's bid to develop a databank of teaching resources, question papers and ideas for teaching approaches – something he had always wanted to do before, but had been unsuccessful. Similarly, MW18C described how ICT enabled him to save time and money in preparing and organising his lessons. This meant that he could take his mind off the menial tasks and concentrate on delivering quality instruction.

6.2.2.2 Teaching methods which accommodate student needs

Table 6.4 also shows that the teachers were very much concerned with helping their students derive the best benefits out of their teaching. ICT provided teachers with the opportunities to:

- i) select teaching methods that were responsive to their students needs (M08H, ME38W);
- ii) provide their students with individualised homework (MW18C)
- iii) enable use of more student centred teaching approaches that allowed students to express themselves more freely (MAS22V) and
- iv) gain access to diagnostic tools which enabled the teachers to diagnose student learning problems and thus decide on the best way to help them (ME14N).

The fact that teachers were seeking better ways of accommodating individual differences among their students shows that they were aware of the limits and contextual constraints under which they operated. The exam driven curriculum requires them to teach for examinations and the poor resources and large enrolments limit their effectiveness and force them to use mass delivery methods in teaching (cf. Sarkim, 2004). ICT resources however provided them with ideas about strategies they can use to raise effectiveness in such an impoverished environment. Teachers strive towards higher self-efficacy, and in this case, effective classroom practice would increase their self-efficacy. Clark and Lambert (1985) argue that teachers will attempt to make their mark in teaching by re-designing their practice in such a way as to fit their ideas of what teaching entails. In other words, Clark and Lambert view teaching as a design profession, and argue that the behaviour of teachers described above, occurred simply because teachers were trying to reconcile their practice with their ideals.

6.2.2.3 More effective administration

For those teachers in positions of special responsibility, the use of ICT helped them to discharge their duties more effectively. MAS04V who is a senior master as well as physics teacher, felt that ICT placed information at his finger-

tips and this made him efficient when dealing with the school's stakeholders – parents, other teachers and the administration. ME14N on the other hand is a head of department and for him, ICT helped to keep track of the department's equipment and chemical stocks. The evident value of this use of ICT is that it frees the teacher to spend more time on improving other areas of service and thus increases the potential for increased effectiveness in other areas as well.

6.2.3 Benefits to the teacher's contextual knowledge base

Researchers have underlined the importance of a teacher's contextual knowledge base, in underpinning his / her success in the classroom. Sarkim (2004) identifies contextual knowledge as arising from socio-political, cultural, economical, organisational and school factors which may hamper or support effective classroom practice. Whilst some may argue that contextual knowledge factors are external and beyond the control of the teacher, other researchers such as Grossman (1999) believe that it is the teachers' struggle to control or limit the negative effects of these external factors that gives rise to what has been termed "practical teacher knowledge". Teachers develop a value laden system of do's and don'ts which provides existential and practical guidelines to what they perceive as effective teaching practice. Not surprisingly, the indicators of the contextual knowledge base were expressed in terms of values. Expressions such as "*I become a better teacher*" (MAS06V, line 62) were quite commonly expressed. The benefit in this case is expressed in terms of a value, eg. Better teacher, improved practice etc. Unfortunately, the values are written here in conjunction with stated actions and at the risk of duplication, these actions have to be reported as they give a clearer picture of the reasons for the value statements. Three value statements were isolated from the interviewees' responses. These were: *become a better teacher; enjoy teaching and reduce*

isolation. A fourth value: *it is worth my while* was also isolated, but only one teacher (H31A) mentioned this, therefore it was not possible to evaluate its meaning to the rest of the teachers. Table 6.5 summarises the statements and teacher conceptions associated with the first three values, bearing in mind that these values are indicators of the teachers' contextual knowledge.

Table 6.5: Contextual Knowledge (Values)
<p>Become a better teacher</p> <ul style="list-style-type: none"> - If, I have a wider resource base, I become a better teacher (MAS06V line 62) - I believe it helped me to become a better teacher.(ME12M lines 59 – 60) - Basically, I think it was the need to become better at my job, my primary interest in 1997 when I first used ICT was to improve my teaching and I can say it is still the same. Other methods available to me at the time were all limited (ME14N, lines 131-133) - I think practice has improved (MN16S, line 100) - ...it really improved my presentation to students.(ME26N, line 37)
<p>Enjoy Teaching</p> <p>...teaching becomes interesting and challenging also to yourself. You enjoy your teaching (MAS08 lines 53-54)</p> <ul style="list-style-type: none"> - This makes my lessons interesting (H29G, line 30) - The variety of teaching approaches available on certain topics makes physics an adventure for me as well. (H29G, lines 57-60) - so that you enjoy your teaching and don't get bored by your profession.MN49E line 49 -trying to implement them I find them very satisfying,(MAS53V line 44) - A lot of things I am doing now would be impossible without ICT. I am happy about using ICT.MAS02M, line 89-90
<p>Reduce Isolation</p> <ul style="list-style-type: none"> - enables us to access the global village in communication.(MAS05V, line 49-50) - I think it's certainly a benefit in feeling that you're not isolated which is very easy in a situation like ours at the moment where travel is practically impossible MAS22V, lines 29 – 30 - I also want to be part of the Global village (ME25B line 20) - I am now aware that there is a wider world out there. There is a lot of information on the Internet and it makes you feel as part of a global community.... it is an awareness that we are not alone, ME42M, lines 96, 98-101 - Computers put you in touch with the global community and this reduces your isolation MN48M line 163 - Yes, and you can also link with the outside world and also see kuti education system yavo yakasiyana sei neyedu. Izvi zvinotibatsira how to improve our education system here. MAS52V lines 211-212 - feeling of belonging in my community which is quite important to me professionally,MAS53V, line 159 - E-mail reduces my isolation and enables me to keep in touch with my friends and colleagues.MAS54M, line 68

6.2.3.1 Becoming a better teacher

From table 6.5, teachers believed that ICT helped them to become better teachers by providing them with (a) a wider resource base (MAS06V), (b) sources for more teaching methods (ME14N) and (c) more opportunities to improve presentation methods (ME26N). These three are all aspects of effective teacher characteristics (Penick and Yager, 1983; Tobin and Fraser, 1987). Thus the teachers realised that to develop high self-efficacy, they needed to improve their classroom practice in these areas, and ICT presented them with opportunities to achieve this goal.

6.2.3.2 Enjoy teaching

The teachers expressed aesthetic satisfaction with their work, and they attributed their use of ICT as the cause of this enjoyment. What is also interesting to note is that teachers associated enjoyment with the same activities they claimed, made them better professionals (H29G). Other researchers (Buchmann, 1983 and Hanifin, 2000) argue that teaching is as much an affective activity as it is professional. Hanifin further argues that enjoyment of teaching is a measure of self-efficacy in the teacher. Highly effective teachers have been found to be the ones who enjoyed their work / enjoyed working with students.

6.2.3.3 Reduce Isolation

One of the oft expressed values by teachers was the need for professional communion. In chapter 5 it was mentioned that one of the reasons why teachers engage in professional development was to minimise the effects of geographical isolation. When discussing about the benefits of ICT, teachers consistently referred to their awareness that they belong to a community of professionals whose practices are similar and therefore who can support each

other. In this context, the statements by teachers MAS22V, ME42M, MAS52V and MAS53V all hint at the support that these teachers are aware they can derive from their communities. Humankind are social animals and as such we derive satisfaction from developing support networks in all areas of our existence. The need to belong is ranked amongst the highest motivational drives on the Maslow Hierarchy of Needs scale (in O'Loingsigh, 1978) and thus activities which bring teachers together, are most likely to be pursued.

6.2.4 Benefits to the teacher's pedagogical content knowledge base

Proponents of the pedagogical content knowledge theory claim that it is the extent of this knowledge base that distinguishes highly effective teachers from those less so (Shulman, 1987; Adams and Krockover, 1997). Indeed, Cochran *et al.* (1991) argued that it is PCK that distinguishes science teachers from scientists:

...Teachers differ from scientists not necessarily in the quality or quantity of subject matter knowledge, but in how the knowledge is organised and used. Experienced science teachers' knowledge is structured from a teaching perspective and is used in helping students to understand. A scientist's knowledge is structured from a research perspective and is used to construct new knowledge.
(p.5)

Thus it is the knowledge structuring process that determines the effectiveness of both the scientist and the teacher, in their specific fields of endeavour. Since PCK is a blend of the various types of teacher knowledge, it provides the teacher with intuitive practical knowledge about all aspects of classroom practice, whilst enabling them to benefit directly from successful and failed teaching experiences. The statements in table 6.6 illustrate the process of PCK restructuring as experienced by the teachers. The teachers also realised that this restructuring was beneficial to them.

Table 6.6: Indicators of PCK restructuring

<ul style="list-style-type: none"> - I learnt to be critical and not to accept any printed words as gospel truth, thirdly, I was able to turn a potential problem to my advantage,(ME12M, line 59) - I think my practice is better far much more better, it has become more reflective.(MN16S, line 101 - I am now critical enough to accept the challenge I get from using these resources,ME12M, line 96 - I spend less time on copying the schemes, and more time on re-thinking and modifying them by improving on the pupil activities, and also thinking of new areas to cover.With continuing modifications, I can actually become more reflective and say which approaches work best. ME41B, lines 90 - 93
<ul style="list-style-type: none"> - But it is also possible that knowing what examiners look for, helps me to select IT materials and resources more carefully when planning my work.(H31A lines 125 – 127)
<ul style="list-style-type: none"> - ICT has helped me to cope with A-level teaching (M34S, lines 122-123)

The statements above highlight five indicators of PCK restructuring: being critical (ME12M), being reflective (MN16S; ME41B)), Modifying (ME41B), careful planning (H31A) and coping (M34S). Incidentally, these indicators also represent two ends of Sawyer's phases of teacher development (see section 5.1.4.2, page 192). Interpreted according to Sawyer's phases, M34S's statement is not surprising because she is a young and in-experienced female teacher (see Appendix 3.7) and is at the beginning stage of building up her PCK and was therefore concerned with survival issues. Statements from ME12S, MN16S, ME41B and H31A on the other hand are all descriptors associated with Sawyer's adaptation phase. Not surprisingly, all these teachers have over ten years of teaching experience. These observations seem to support the view that PCK is related to teaching experience as modelled on Sawyer's phases of teacher development.

6.3 Teachers' perceptions of ways in which students benefit from teachers' use of ICT-based materials

Although the research focused on teachers' professional development, both questionnaire respondents and interviewees made several references to

specific student benefits with regard to their use of ICT, suggesting that this might have been one of the reasons for using ICT.

Interviewed teachers constantly referred to their students, giving the impression that the self-directed professional development activities they were engaged in were more altruistic and meant to benefit the students. Four groups of student benefits could be identified from the interview transcripts, there were:

- (i) benefits relating to students' performance, (They perform better using this method than previously. H29G, line 63);
- (ii) benefits relating to students' affective and emotional development (stirs their interest. ME12M line 30);
- (iii) benefits relating to students' understanding / cognitive issues (I think it is important in the end as it helps them to make decisions on choices when answering questions. ME14N, lines 71-73) and
- (iv) benefits relating to students participation in class (students' attention is enhanced. So you may have less problems with discipline and students participate more. M08H, lines 58-59).

Tables 6.7-6.10 below summarise the teachers' responses in each category.

6.3.1 Student benefits with regard to performance

Table 6.7 below summarises statements made by teachers regarding the performance of their students as a result of the teachers' use of ICT.

Table 6.7 Students' benefits from teachers use of ICT	
<ul style="list-style-type: none"> -the quality of their passes improved. M09M line 88 - ...that particular class did very well. ME12M, line 62 - I think the change would be rather in the quality of the passes ME27M, line 38 	<ul style="list-style-type: none"> - Also I have had consistently high A-level results since I started to actively use ICT materials in my teaching. MN49E, line 96 - This is my second year, and already my class which I had last year, did much better than the other classes MAS54V lines 47-48

While it is tempting to draw a link between performance and any one activity of the teacher, it is suggested that such links if they exist at all, are tenuous at most since student performance in terminal examinations is dependent on many other factors besides what they retained from the teacher's teaching. For example, students do study on their own, read books, access the Internet and even watch television and movies. All these activities could act as sources of information from which they draw their answers to examination questions.

The above argument notwithstanding, it is still important to note the priority that teachers gave to the performance of their students as a measure of their own effectiveness as classroom practitioners (cf. statements by ME12M, MN49E and MAS54M). Davis (2004) argues that teachers' knowledge and beliefs about the nature of teaching affect the way they conduct their business. Student scores determine the prestige accorded to both the teacher and the school. Thus teachers can be forgiven for claiming credit for their students' success.

However, in the sample interviewed, some teachers (M09M and ME27M) were careful to ascribe credit to the quality of the passes. This is a much more defensible position as it assumes the widely accepted view that good teaching makes a difference in student performance (Clarke et.al, 1996; Wittrock, 1986).

6.3.2 Student benefits with regards to their emotional development

Three categories of emotional responses were identified by the teachers as arising from their use of ICT. Teachers felt that students benefited emotionally through enjoyment (eg ME39W), confidence building and motivation (ME14N and through awakened interest (MW19C). Table 6.8 shows a summary of these categories.

Table 6.8: Students emotional benefits from their teachers' use of ICT

<ul style="list-style-type: none"> - They have instead indicated that they do enjoy my lessons so far. ME39W, line 53 - they like the approach I am using. ME27M, line 36 - and certainly the students enjoy my lessons. MAS06V line 62-63 - the students enjoy your work if it is well planned M08H, lines 57 - -The students like and enjoy my lesson M09M, line 90 - My students also enjoy the subject. M34S, line 135 - The students liked the activities I prepared for them a ME40P, line 36 - students enjoy my lessons because they are full of surprises MN49E, line 94 - make my teaching more varied and interesting to my students. MW19C, lines 36-37 - The students trust me and my lessons are not boring to them, ME12M line 100 	<ul style="list-style-type: none"> - The students found it a very interesting and lively investigation ME12M, line 54 - None of my students had an F. This boosted their confidence because some boys even said to me " miss, we like your subject. You make it so interesting" M34S, line 146 - Yes, and that is why I get whatever information I can to make my teaching and their learning more interesting and worth while. M36M, lines 67-68 - Most of all I think to try to maintain an interest in interactions with the students, MAS53V, line 24 - I wanted my students to have confidence in my teaching, ME14N, line 80 - motivating for the students. MN44S, line 71, 100 - I really motivate students and they like it. MW17C, line 80
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From the attribution statements made by the teachers, student enjoyment is enhanced when lessons are well planned (M08H) and if the lessons have surprises (MN49E). Smith and Wesley (2000) advocate the use of active learning and teaching strategies, in order to help students to forge an emotional attachment to the subject. They argue further that when students forge positive emotional attachments to subjects, such as enjoyment or interest, they can stay focused on the task for longer and can even be motivated to develop independent learning behaviour in connection with the subject. Stephanek (1997) goes so far as to suggest that students generally find well planned lessons appealing and enjoyable, hence the emphasis on good planning in the new classroom standards for American science and mathematics teachers. ME40P also mentioned that students liked the activities that she prepared for them.

Both MW19M and ME12M refer to active learning techniques as the means by which they retain their students' interest by providing "lively" and "varied" activities with the help of ICT-based resources. The other benefits associated with active learning, which were also cited by teachers' were confidence (ME14N) and student motivation (MW17C and MN44S). Thus ICT is shown once again to positively impact on the professional development of the teachers.

6.3.3 Student benefits with regards to their cognitive development

Perhaps, the greatest impact of the teachers' use of ICT on the students, from the perspective of their teachers, comes from the benefits they derive in their cognitive development as a result of their teachers increased access to resources. Seven cognitive attributes were identified from the transcripts and these are presented in Table 6.9.

It is important again to note that the teachers were aware that students only acquired these benefits as a result of the activities that teachers planned and organised with the materials that they accessed from the Internet. Thus, the fact that such benefits accrued to the students is less a product of ICT access than a testimony of the teachers' genius in being able to plan, organise and implement activities that are conducive to the development of these higher order cognitive skills.

Table 6.9: Student cognitive benefits from their teachers' use of ICT	
Critical Analysis	<ul style="list-style-type: none"> - My students show more critical analysis of questions than before and I can even tell in the quality of their responses. M09M, lines 88-89 - my students also learnt to become critical ME12M line 61 - students get the chance to compare applications for different products and they appreciate the concepts behind the bio-technology processes his enables them to handle such contextualisation questions MAS52V, lines 290-293
Understanding	<ul style="list-style-type: none"> - The students focus on understanding what we are doing rather than writing notes.MW18C line 44, 50 - ... they will appreciate it better and will not see it as an abstract and difficult topic.MAS20N, lines 57-58 - my students can appreciate the meaning of the concepts. MAS24M, line 33

<ul style="list-style-type: none"> - my students benefit as they understand what I am talking about, MAS24M, line 46 - He was however impressed by the level of understanding that the students exhibited in answering my unusual questions and he asked to see my scheme of work and plan book. MAS54V, lines 82-84
<p>Access to varied information</p> <ul style="list-style-type: none"> - I was able to offer more than textbook materials to students and they loved it. ME26N, line 41 - Students do not rely on textbook information to answer questions a H29G, line 68 - Exposure to variety of methods gives fuller picture of topic and allows flexibility in learning. H29G, line 71 - students can use it to widen their knowledge so that when they write their essays they demonstrate greater knowledge in depth. H31A line 75
<p>Retention</p> <ul style="list-style-type: none"> - this makes it more meaningful to them and thus they retain more and even understand the processes better. M34S, line 34
<p>Investigative</p> <ul style="list-style-type: none"> - Using ICT in combination with normal methods sharpens their investigative skills and also their critical judgement, especially if the ICT materials are presented as worksheets. Comparison helps them to appreciate the effect of context on an experiment. ME37W, 87-89
<p>Creative</p> <ul style="list-style-type: none"> - This has made them much more creative in designing experiments. I get more variety of experimental designs than I used to get before and I think it is a result of exposure to more resources. The students have also become more critical and independent in their thinking. ME38W, lines 37-40

The fact that these teachers gave “lived” testimonies (Gibbs, 2000) of such activities in their statements seems to suggest that these teachers were among the best in their respective fields. These findings suggest that these teachers who sought to use ICT for their own professional development were not acting randomly, but had well planned professional development targets that they sought to achieve – i.e. their actions were purposive.

6.3.4 Student benefits with regard to their classroom participation

Another benefit that teachers believed their students had gained from their ICT-based professional development activities pertains to increased student participation in class. Teachers argued that student participation had improved since they started using ideas and materials derived from the Internet. Four “participation” benefits were identified from the transcripts. These were:

- (i) improved attendance (I had a full class attendance. ME12M line 55);
- (ii) increased student participation (..participation increased. ME26N, line 42);
- (iii) improved quality of discussions (...demonstrated in the quality and level of their debates and discussions. H31A, line 120) and;
- (iv) internalisation of locus of control for learning (...so the students will have more control over their own learning. MAS53V, line 15-16).

Figure 6.10 below illustrates teachers' statements describing these benefits. The teachers' attributions are presented beneath each of the identified descriptors of student classroom participation.

Table 6.10: student benefits with regard to their classroom practice
<p>Improved attendance</p> <ul style="list-style-type: none"> - I had a full class attendance ME12M line 55 - ..to encourage them to do their own researchesthey like my input because I have not had any absences or cases of truancy. MAS54V, lines 52-54
<p>Increased student participation</p> <ul style="list-style-type: none"> - Their participation increased. ME26N, line 42 - ...there is more activity in class – more confidence in seeking answers. H29G line 69 - Even those students whom my colleagues say are shy in their classes, in my class they are quite active. They show that they enjoy the subject by their high participation. M35B, line 136-139 - even those who normally are eager to leave the mathematics lesson as soon as the bell goes, were quite engrossed in their work ME40P, line 37
<p>Improved quality discussions</p> <ul style="list-style-type: none"> - ... demonstrated in the quality and level of their debates and discussions. H31A, line 120
<p>Internalisation of locus of control</p> <ul style="list-style-type: none"> - I feel liberated as they take responsibility for their own learning. ME38W, line 41 - so the students will have more control over their own learning MAS53V, line 15-16

From table 6.10 the message one gets is that the availability of ICT-derived resources enabled the teachers to conduct their lessons in such interesting ways that discipline problems such as truancy were reduced (MAS54V). In addition, teachers were able to engage in active learning activities, being guided by the ideas that they obtained from the Internet. This resulted in increased student participation and even normally shy students were participating more in

class (M35B). ME40P even claimed that she was able to retain the interest of students who used to show no interest in the past.

It is interesting to note that at least three teachers looked beyond mere participation to quality issues. H31A commented on the quality of the discussion in class, and ME38W and MAS53V both referred to issues involving students taking responsibility of their own learning. The inculcation of an internal locus of control in students would be the pinnacle of achievement of many teachers. The fact that these teachers claim to have been able to achieve this under the professionally restricted conditions operating in Zimbabwe confirms the suggestion that these were indeed high calibre teachers.

6.4 Conclusion

When considering the lengths to which the interviewees went in order to improve their effectiveness as practitioners, it is easy to overlook the context in which these teachers are operating. The highly restricted operating environment, with its dearth of resources pose a formidable challenge to most practitioners and it is difficult to understand how these teachers managed.

Literature shows that very little research (less than 100 mostly conference papers, with less than five published in Journals – according to the ERIC - CIJE, BEI and AEI databases. see table 2.2 p35) has been carried out so far in connection with self-directed professional development. It is a subject that is beginning to attract the attention of researchers and already one of the areas of fascination involves what motivates professionals to embark on self-directed professional development (Bouchard, 1996).

When the professional development efforts of Zimbabwean A-level science and mathematics teachers were viewed within their operating context, their tenacity in striving for excellence in teaching was quite amazing. In chapter 5 it

was suggested that self-directed professional development was purposive and targeted at solving problems facing the teacher at a particular moment in time. Some researchers (Gibbs, 2000 and Glatthorn and Shields, 1983) believe that this tendency towards problem-solving behaviour has its genesis in culture. For example, in Zimbabwe, ordinary people have experienced oppression before and after independence in 1980. People have learnt to rely on themselves if they want to progress in a society that will more likely add to your hurdles rather than facilitate your professional development. This explains why even among the interviewees, there was such a large preoccupation with using further studies as a way of pursuing career development (see chapter 5). Indeed Sanders (2005) made similar observations among Zimbabwean researchers. She concluded:

“In Zimbabwe signs of a cultural ethos amongst educational researchers emerged which suggested a strong community of practice based on firmly held attitudes and beliefs about controlling one’s life. This ethos seems to go beyond just the research community, revealing itself as a national ethos (at least amongst the older generation) involving a strong work ethic and a determination to succeed in spite of the odds.” (Sanders, 2005 p5)

Commenting on similar findings in another setting, Bouchard (1996) suggests that this unusual behaviour could be a characteristic trait of the process of self-directed professional development. He goes on to claim that where learning is perceived as a real means to solve real problems, hostile conditions will only serve to strengthen the resolve to succeed. These observations lead one to conclude that the observed tenacity in times of adversity might be an expression of systemic self-regulation mechanisms of complex systems or as Bouchard proclaims:

It is this problem-solving quality that makes self-directed learning in the context of professional development more likely to occur in conditions marked by a prevalence of opposing factors (Bouchard, 1996 p15).

In terms of complexity theory, if one considers self-directed professional development as an attribute of the system, then the more difficult the external conditions for the operation of the system are, the more resilient the system becomes.

At the beginning of this chapter, the question of how teachers perceived their use of ICT as affecting their classroom practice was posed. The discussions above have shown that ICT had far reaching impact on the teachers' classroom practice. ICT supported their search for content materials, teaching ideas and even the administration of teaching. Therefore the teachers' pedagogical knowledge, content knowledge, procedural knowledge and pedagogical content knowledge were restructured. Even the teachers' conception of their profession went through transformation and these changes had far reaching consequences on their views and the behaviour of their students. However, all this was only possible because, as Shedd (1986) stated, the teachers were ready to use ICT as an innovative empowerment tool. In empowering themselves, the teachers were able to achieve high levels of self-efficacy in spite of the inhibited environment in which they were operating.

Chapter 7: What model of self-directed professional development can be abstracted from the use of ICT by A-level Science and Mathematics teachers in Zimbabwe?

Effective professional development experiences are those that help teachers to build new understanding of teaching and learning through direct experience with the strategies that help students to learn (Hea-Jin, 2001).

7.0 Introduction

Chapters 4-6 provided evidence of the reasons why and how science and mathematics A-level teachers in Zimbabwe are using ICT. From the teachers' own perceptions, ICT has been shown to have had an impact on all the aspects of their professional activities.

Quinn *et al.* (1997) described a professional as having a body of knowledge which included five strands; i.e. cognitive (*basic disciplinary knowledge*), skills (*applications*), systemic (*complex problem solving*), affective (*creativity, motivation, adaptation*) and intuitive (*capacity to understand and predict relationships not directly measurable*). The teachers studied in this research have been shown to have used ICT to improve aspects of these knowledge strands. In this way, ICT helped the teachers to become more professional in the discharge of their duties.

In the quest to understand the impact of ICT on the teachers' self-directed professional development, the study has yielded two sets of information: i) information about the self-directed professional development itself and ii) information about how the teachers benefited from using ICT in their professional development. Thus in studying "impact" we have come to a better understanding of the process as well. In this chapter, a model of self-directed professional development is suggested, which integrates the two sets of

information in order to arrive at an intuitive understanding, not only of how ICT impacts on self-directed professional development, but also why it has that effect.

Section 7.2 will discuss the very scant literature of self-directed professional development with a view to see how far the findings of this research support or vary from what is known from other studies.

Section 7.3 will discuss the background to the designing of this model. The main research findings will be pooled and re-organised together with the literature available to provide a rationale for the design process.

Section 7.4 will discuss the two-in-one self-directed professional development model, starting with a generic representation of the professional development process as exemplified by the findings in this research and highlighting the empowering role of ICT. The model is presented in two versions emphasising the generic nature of the model. The second part of the model is a systemic representation of self-directed professional development highlighting the interrelationships between the various attributes as described in the findings of this research.

The chapter concludes by discussing the strengths and weaknesses of the two-in-one model.

7.1 Self-directed professional development: What do we know?

A database search has revealed that very few research records on self-directed professional development exist (see section 2.3.1 p35-36). One can explain this observation by arguing that we are undergoing a paradigm shift, in our understanding of the process of professional development. For example, Hea-Jin (2001) provided a time-line to show the shift in staff-development emphases over the years. Table 7.1 illustrates Hea-Jin's time line. From the

table, one can see that the focus for staff development has been steadily shifting from external influence to an internally determined programme of action. There has been a progressive shift from a focus on content to skills to processes. In addition, the methods used have shifted from “*developing subject experts*” through “*curriculum experts*” to the realisation, that the teacher is the “*expert*” and therefore only needs to be empowered to become effective.

Period	Staff development Goal	Method employed
1970s	In-service education - help teachers increase their content knowledge	Outside expertise / Tr workshops
1980s	In-service training – focus on technical view to teaching (instruction, curriculum reform); Term professional development used interchangeably with Inset.	School-based / outside expertise / Inset service providers
1990s	Professional development – Widened to include teachers and teacher organisations / systemic development. Focus on Leadership / effectiveness / Reflection	Collaborative practices / organisational / teachers individually responsible to a lesser extent.

Table 7.1: Staff development time line (adapted from Hea-Jin, 2001)

Hea-Jin, (2001) argues that empowerment comes through experiences that help teachers to construct new understanding about teaching and learning through direct experiences with strategies that help students to learn. For empowerment to take place the teacher has to take the initiative to develop by identifying and acting on his/her individual needs. This is the launching pad for self-directed professional development.

One of the first attempts to model self-directed professional development was carried out by Bouchard (1996). The model addressed characteristics of self-directed professional development for the established professions (medicine, engineering, law etc.). Bouchard's model described the self-directed professional development process as taking place in five stages:

- i) Need identification – the professional member identifies a strongly felt need for self development.

- ii) Valuation – the member ascribes values, characteristics or beliefs associated with the need.
- iii) Auto-didactic leap – the member experiences a leap in the urge to learn as a result of environmental pressures and opportunities associated with the identified need.
- iv) Contextual learning - Factors and events in the environment, which are associated with the identified need, are seen as opportunities to learn.
- v) Professional awareness - Once the individual has succeeded in learning and overcoming the identified need, their professional awareness grows.

Chapters 4-6 have shown that Zimbabwean A-level science and mathematics teachers have experienced all the five stages reported in Bouchard's model. Chapter 5 described how teachers identified development needs based on the experiential constraints they were experiencing as a result of socio-economic and political constraints (for example, the need for teaching resources). Chapters 4 and 5 also described how these teachers evaluated and prioritised their needs in order to justify their investing into ICT usage to meet those needs. In Chapters 5 and 6, factors iii) and iv) were demonstrated by teachers describing some of the pressures that they experienced, forcing them to acquire ICT skills. For example, ICT skills acquisition was considered a pre-requisite qualification for employment in desirable schools. This provided the impetus for the teachers to use available opportunities (eg. resource centres and Internet cafes) to train to use computers. Their success in using ICT opened up several possibilities in collaboration, classroom practice and career

development and this led to their professional awareness and reevaluation of what it means to be a teacher.

However, Bouchard's model is very general and does not identify the specific pathways by which self-directed professional development occurs. Maybe the reason for this was that the model was constructed for the general professional bodies and not specific to a profession. In being general, there is a danger that the details, which are relevant to individual practitioners, are lost. Thus the model would not be of much use to a school's professional development officer, hoping to find a way to encourage individual teachers to develop interest in self-directed professional development, or to a staff development officer at an institution of higher learning trying to understand and evaluate the pressures that academic members of staff experience in their line of duty, and determine how best to provide support.

The model is also silent on the possible attractors for self-directed professional development for example the role of innovation, knowledge management and critical reflection in the development of social and intellectual capital of professionals (Roffe, 2000).

The fact that very little research has been published pertaining to self-directed professional development, means that there are lots of gaps in our understanding of this phenomenon. The discussions in chapters 4 to 6 of this thesis have presented enough information to enable the development of a tentative systemic model that not only describes the process of self-directed professional development with respect to the teaching profession, but also identifies some of the attractors for this phenomenon. Such a model would present opportunities for staff developers to prioritise their activities and ensure that their programmes assist teachers and academic staff to identify and act on

their own needs with or without external support. It is hoped that such a model will become a useful tool in furthering our knowledge of self-directed professional development.

7.2 Informants of Model Design

Bearing in mind that this study was designed as a survey of teachers' perceptions of their use of ICT, it is important to note that the information presented represents a snapshot of the teachers' behaviours and actions. This presents limitations to the design of the model, as the data thus gathered, will only support a theoretically descriptive model. Model designers (Kenny, 1995; Calderon, 1997; Loucks-Horsley *et. al.*, 1998) argue that descriptive models have limited functionality when compared to process or interactive models which have the capacity to "grow" with the increase in knowledge. However, it is hoped that the tentative model proposed here, will serve as a nucleus for the purpose of stimulating and coalescing ideas aimed at helping us to understand better the process of self – directed professional development.

7.2.1 Sources of the design of the model

Researchers argue that good theoretical models should make clear the paradigm framework used (Calderon, 1997). Good models should also have clear statements describing what they can and cannot do (Specifications), what assumptions and attributions the model makes of the available data, what are the main features and limitations of the model (Kenny, 1995)?

7.2.1.1 Operating paradigm

The proposed models are designed and presented within the systems theoretical paradigm. This is informed by the firm belief that the education system is in a state of permanent change, inexorably moving towards a

progressive improvement of humankind (Sinkinson, 2002). If the direction of change is known, it is possible to isolate the iterative components of a system that are responsible for the change progression. Therefore, it is possible to perceive order within the chaos of human relations and experiences, by identifying the major attractors that stimulate individuals to behave the way they do (Cunningham, 2001). Once these are isolated, a holistic representation of self-directed professional development can be developed.

7.2.1.2 Aims and objectives

- i) To provide a holistic description of the process of self-directed professional development and in so doing;
- ii) Highlight the role played by ICT in the self-directed professional development process;
- iii) Identify the major attractors in self-directed professional development.

7.2.1.3 Design specifications

The model is presented in a two-in-one format. The data presented in chapters 4-6 indicates that ICT impacts on both the process and outputs of self-directed professional development. However, it is difficult to develop a process-product model that can describe both components in detail. Most such models either focus on the process or on the relationships of the products.

The first component of the model deals with the linear-flow process of ICT-based self-directed professional development. The second part of the model describes the systemic linkages between the major attractors of self-directed professional development.

7.2.1.4 Assumptions, attributes and limitation

The study derived its inspiration from the post modernist view of teachers as individuals who are capable of thinking critically and giving “voice” to their practice (Rosenau, 1992). In addition, teachers’ professional practice was seen as an act of social responsibility that helped in the espousing of the post modern values of reason, equity and freedom. This means that in designing the model, care was taken to interpret the teachers’ perceptions of the various components in the words in which the teachers themselves described them. This was achieved through the use of an interview analysis framework which was derived using grounded theory principles (Glaser, 1992).

The modelling of self-directed professional development was based on the following assumptions:

- (i) Professional development is an immutable property of the educational system and will occur irrespective of intervention. External support only helps to focus the process. This intuitive assumption was arrived at after realising that teachers from different regions of the country reported similar tendencies towards self-directed professional development. However, their degree of involvement in ICT-based professional development depended largely on their access to ICT, which was constrained by external / factors (chapter 4)
- (ii) The process of professional development is complex with system-wide interactions between individuals, institutions and society. It is also sensitive to initial conditions such as lack of resources. The problems which teachers experience and which demand professional development intervention are iterative and occur at different levels

within the teacher's professional development process (Cunningham, 2001 and Bloch, 2003). Specific problems relating to the science and mathematics teachers' use of ICT in their self-directed professional development were highlighted throughout chapters 4 to 6.

- (iii) The core-attractor for self-directed professional development is the drive for self-efficacy. This drive symbolises a process akin to Maslow's self-actualisation (Maslow, 1965) which enables teachers to respond spontaneously to felt needs. Analysis of the interview results in chapters 5 and 6 showed that almost all the teachers were concerned about improving their self-effectiveness as professionals and as classroom practitioners.
- (iv) Self-directed professional development is not limited to ICT use, therefore any model chosen should be generic enough to describe any method of empowerment that teachers might decide to use. In this study, ICT was the vehicle through which the generic properties of self-directed professional development were revealed.
- (v) The self-directed professional development process described in this model operates in an open system, with minimal influences from external support systems such as formalised professional development programmes whether these are alleged to be self-directed or planned. It derives from an internal locus of control. The teachers in this study used ICT voluntarily for their own professional development, not as part of a professional development programme. Thus their use of ICT was derived from an internal locus of control.

7.2.2 Major components of the model

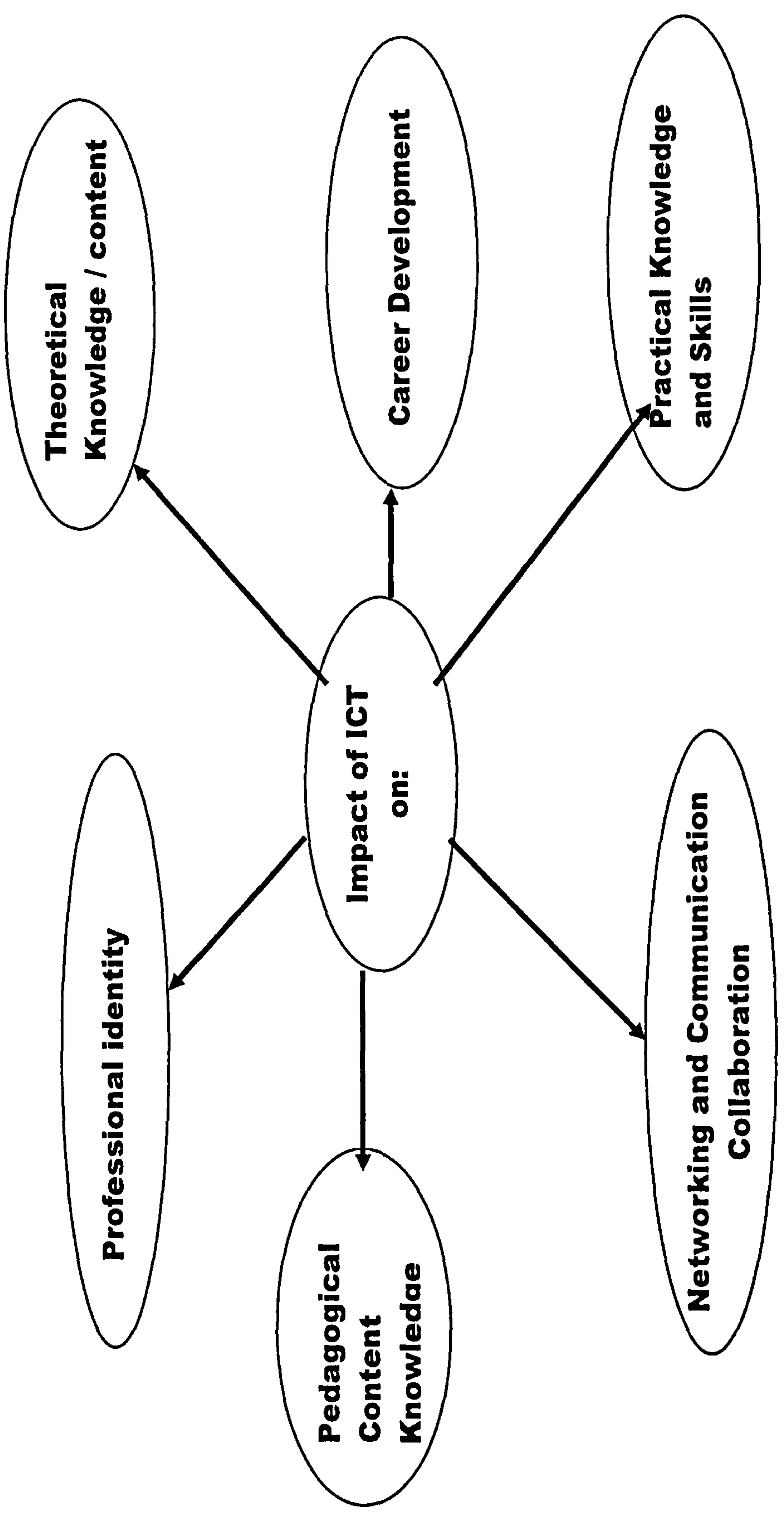
Figure 7.1 (page 319) shows the major impacts of ICT, as derived from the interview analysis framework (see chapter 3). Although the framework yielded 9 themes (see Appendix 3.10), Figure 7.1 only represents six of these because the other three themes (Access, Teacher and student benefits) can be subsumed and spread out among these. Thus in a way, Figure 7.1 summarises the major findings of this study:

- (i) **Theoretical knowledge:** Teachers' use of ICT helped to deepen the teachers' theoretical knowledge both as disciplinary knowledge and professional knowledge. In some cases, ICT provided the best source of content knowledge for the teachers. (cf. section 6.1.1)
- (ii) **Career development:** Use of ICT was also found to have an impact on the teachers' career development prospects. Those teachers who could muster ICT skills had a better chance of securing jobs in good schools, compared to teachers who did not have those skills. (cf. section 5.2.2)
- (iii) **Practical knowledge:** Through the use of ICT, teachers could also access ideas and practical knowledge about teaching. In the case of practical (experimental) subjects, such as biology, chemistry and physics, the ideas included tips for carrying out and evaluating experiments and practical activities. (cf. section 6.1.2);
- (iv) **Networking and Communication:** Science and mathematics teachers' use of ICT also had an impact on their networking capacity. Most teachers reported that their use of ICT made them feel that they were not isolated. Some of the teachers were even able to carry out collaborative activities with colleagues in other regions of the country by use of e-mail. (cf. section 5.3);

- (v) Pedagogical content knowledge: Chapter 6 chronicles teachers' perceptions that their use of ICT enabled them to improve their pedagogical content knowledge. Teachers were able to access information from the Internet and adapt it for their classrooms. (cf. section 6.1.3)
- (vi) Professional Identity: In chapters 4 and 5, it was shown that ICT had an impact on teachers' self image, as well as influencing the perceptions of others. In chapter 6, some teachers described how their own perceptions of teaching were altered after using ideas and materials derived from the Internet. Professional identity was also linked to the development of the teacher's professional value system – an important ingredient in the development of self-efficacy. (cf. section 5.2.1)

Teachers operating in disadvantaged environments, especially in developing countries are most vulnerable to the negative professional factors (such as teacher burnout) which may act as triggers for self directed professional development. However, teachers need to be assisted to realize potential opportunities for growth that their circumstances present. The findings from this research seem to indicate that not all teachers automatically adopt strategies for self-directed professional development when presented with similar circumstances – indeed, in chapters 4 and 5, events were described, whereby teachers exhibited symptoms of extreme burnout, but were apparently resigned to this condition. For example, in chapter 5 (section 5.2.2.1.4 p 220-221) MAS52V and MN50Ma complained that they felt teachers were not appreciated by their employers and were not recognised as professionals. Therefore, they did not see any reason why they should invest in professional development.

Figure 7.1: ICT as a vehicle for Professional Development



Thus self-directed professional development should not be seen as an automatic process, but that in some cases "trigger events" are needed to nudge the teachers in the right direction. The model presented below helps in identifying the best moments for the "nudge" to take place.

7.3 Two-in-one Model of Self-directed Professional Development

The model is made up of two components. The first component is a linear flow representation of the process of self-directed professional development. The second component represents the interaction of the major attractors of self-directed professional development with teacher-efficacy. Professional efficacy was identified in chapter 5 as being the primal driving force behind teachers' efforts to develop themselves through career development and collaboration with peers. Classroom efficacy on the other hand was found to be behind teachers' efforts to improve their classroom practice through improvements in their content knowledge, practical knowledge and skills and an increase in their PCK.

7.3.1 The Linear Flow model

The first section of the linear-flow model provides a generic description of the process of self-directed professional development. It shows that professional development moves the teacher from a state of lower self-efficacy to a state of higher self-efficacy. The second section is an expansion of the same model to illustrate the impact of an empowerment intervention - in this case – the impact of ICT on the professional development process.

7.3.1.1 The self-directed professional development process

Available research (Bouchard, 1996) shows that teachers engage in self-directed professional development mainly as a response to a felt need.

Whereas developed cultures have evolved mechanisms to detect and deal with these needs so that teachers readily find support in their professional development, developing countries, such as Zimbabwe do not have the resources or expertise to provide such services and teachers have to rely on their own resourcefulness in dealing with problems.

If these needs are not addressed, they accumulate and induce negative feelings of dissatisfaction and frustration in the individual teachers. Loss of confidence, disenchantment and lower self-perception can result in learned helplessness and ultimately, burnout. Low self-efficacy is constantly associated with teacher burnout (Maslach and Leiter, 1999). However, teachers are naturally motivated to avoid low self-efficacy and will strive to fight burnout effects. Where teachers are not empowered, they can lose hope and resign themselves to their fate. In time, they lose faith even in their own ability to help themselves – a condition known as learned helplessness; i.e. they simply give up trying. Chapter 6 presented findings supporting these observations on teacher burnout.

However, if teachers are empowered, they seek solutions to their problems using the acquired skills. In this study ICT was used as a method of empowerment and in so doing increase confidence in their ability to help themselves. The study also showed that as their self-efficacy improved teachers were ready to meet more demanding challenges.

Results from the study also suggested that the process depicted in the model is iterative in either direction and the results of one tentative attempt could have far reaching effects on the choices and successes of future attempts.

7.3.1.2 Interpretation of the linear flow (generic) model diagram

Figure 7.2 highlights a systems theory description of the self-directed professional development process as experienced by Zimbabwean A-level science and mathematics teachers. The stages (numbered 1-3 in the diagram) are described in more detail below:

1. Chaos theory postulates that the professional development process is sensitive to initial conditions. In this case, the reported initial conditions are listed and include lack of resources and professional isolation. If these conditions are not addressed or addressed inadequately the system will tend towards lower self-efficacy. This process is illustrated in figure 7.3.

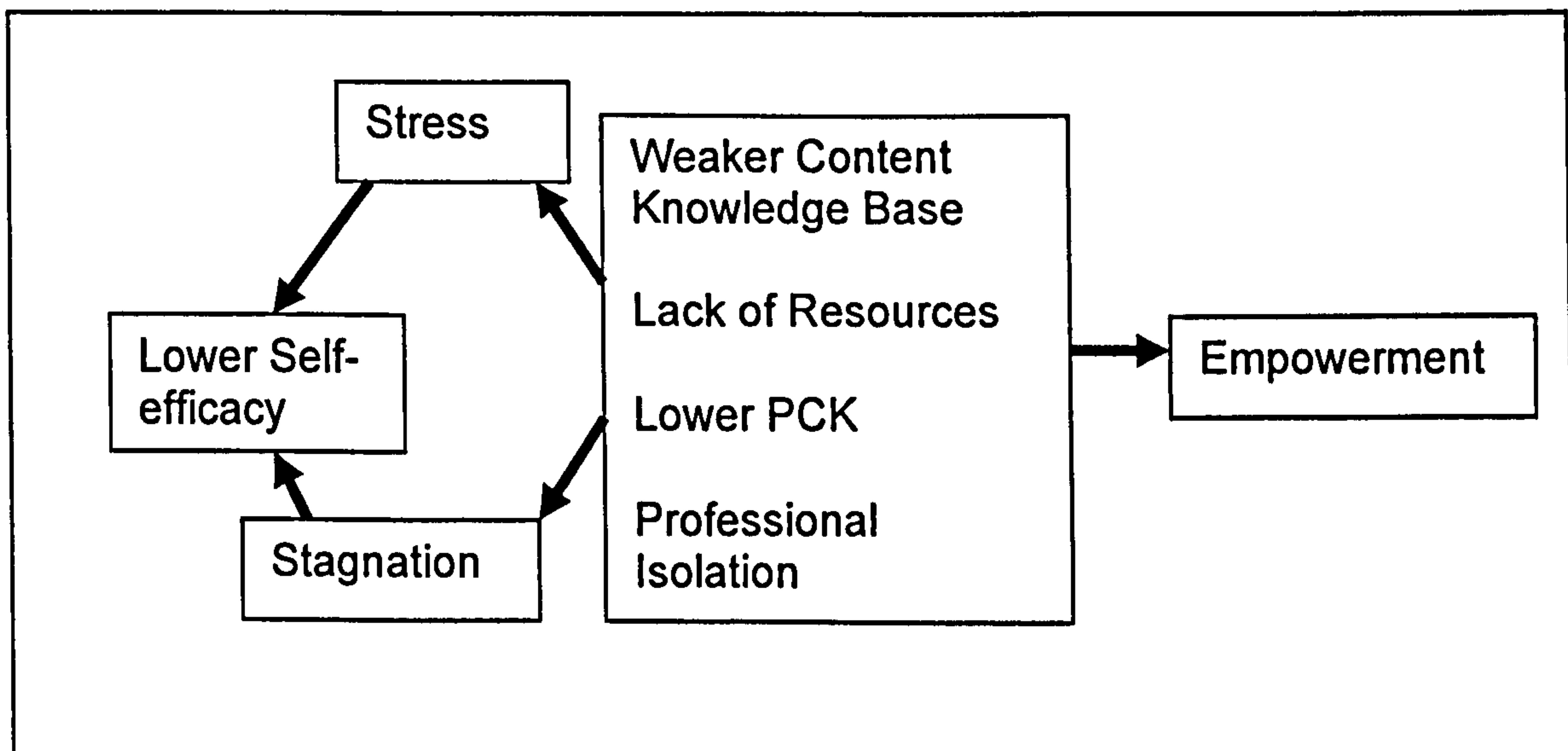
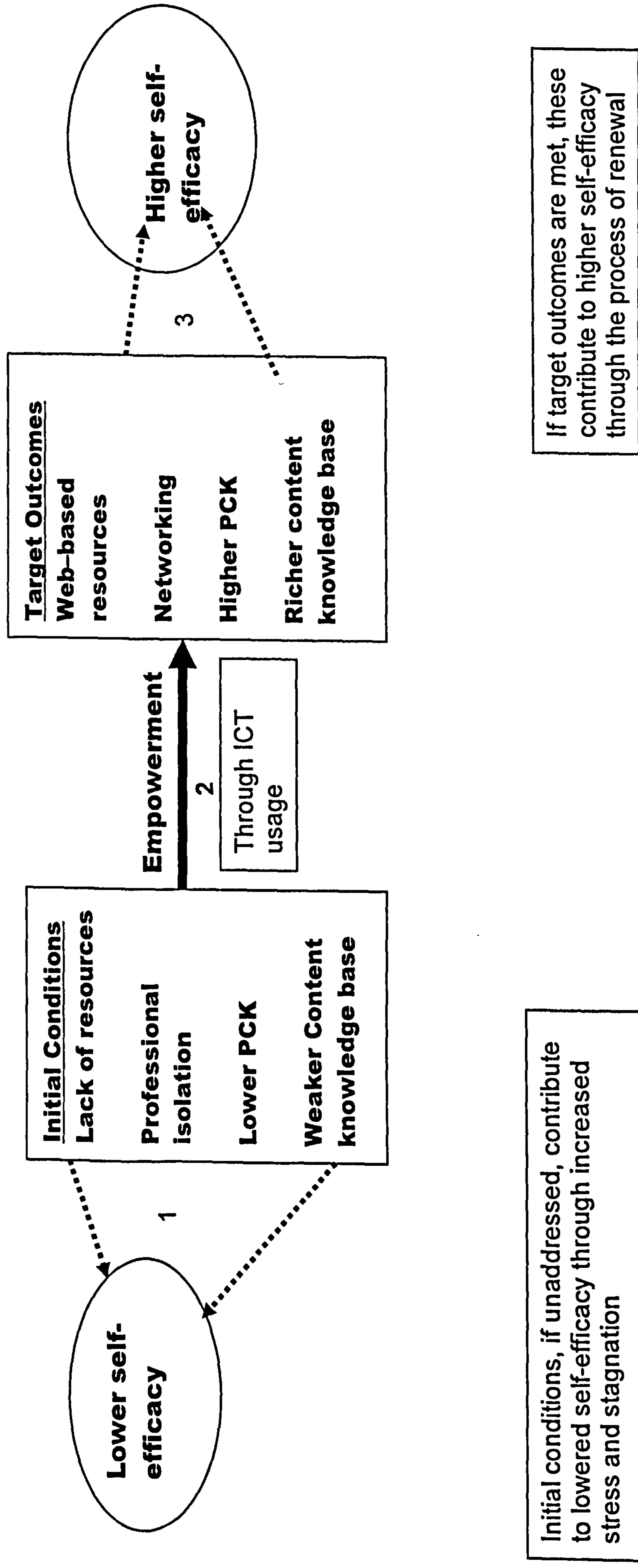


Fig 7.3: Initial conditions

2. The first step towards self-directed professional development is awareness. A chance event can trigger awareness of new opportunities for growth. In the case of Zimbabwean A-level teachers, some teachers reported that they were introduced to ICT accidentally.

Figure 7.2: Linear Flow Model (Generic strand)

Self-Directed Professional Development process



However, they recognised the opportunities that this technology offered towards their professional growth and undertook to empower themselves through both formal and informal training as reported in chapters 4 and 5. In terms of chaos theory, teachers seek ways to empower themselves in order to address the conditions that cause dissonance.

3. Successful empowerment induces further awareness of growth possibilities. Once ICT skills were acquired, teachers were able to use these skills to access web-based resources and content to address the initial conditions of lack of resources, to use e-mail to communicate with other teachers and professionals, thus reducing their professional isolation. Empowerment led to change of behaviour and acquisition of new skills, attitudes and values. The end result was that teachers reported feeling more confident and more effective, i.e. their self-efficacy was improved. In terms of chaos theory, the system transforms towards higher self-efficacy.

The process of renewal is illustrated in Figure 7.4

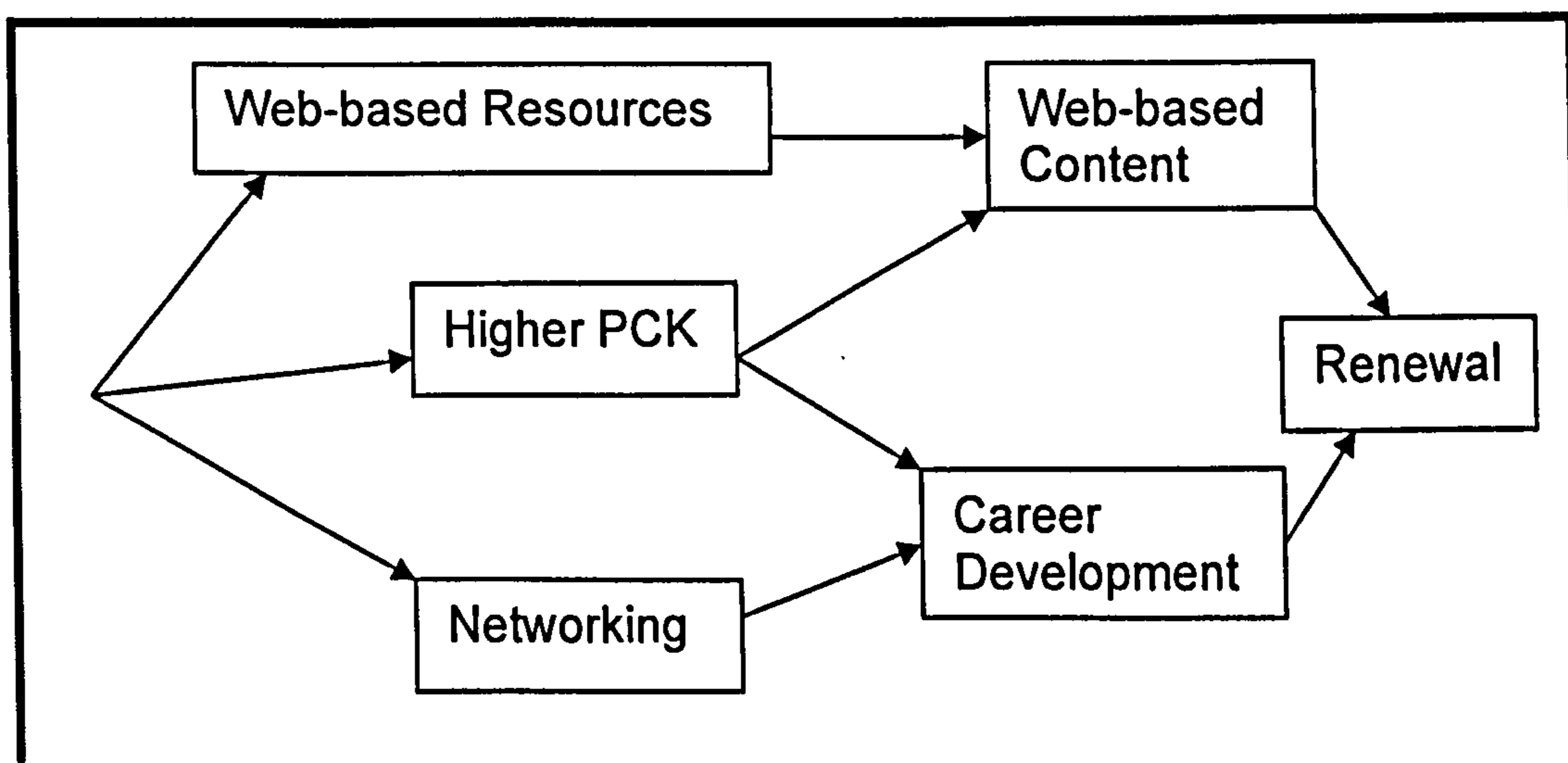


Figure 7.4: Outcomes of the empowerment –through- ICT process

Since the process of self-directed professional development is a lifelong continuing process, it is also iterative, i.e. once the initial conditions are addressed the products (outcomes) in themselves become the new initial conditions for the new cycle (Cunningham, 2001; Pryor, 2003). There will

always be new challenges requiring refinement of old skills or the mastery of new ones. Thus there will not come a time when teachers feel they have reached the highest self-efficacy level. In chaos terms, self-efficacy is an attractor or drive, which is never achieved, but aspired towards.

7.3.1.3 Teacher Empowerment through ICT use

The second part of the linear flow model relates specifically to “empowerment through ICT use”. Figure 7.5 presents a diagrammatic representation of this model. This model also highlights the decision-making process, which is an integral part of self-directed professional development.

The two broken lines in the model are intended to show the empowerment section of figure 7.2. Since the study was concerned with the impact of ICT on self-directed professional development, this section illustrates the process and use of ICT in terms of inputs and outputs.

7.3.1.4 Model description

The cycle begins with the teacher experiencing low self-efficacy as a result of professional and contextual constraints as illustrated in figure 7.3 Either through a chance event or such other “trigger”, the teacher is made aware of the possible use of ICT as a solution to his/her problem. In the study, teachers reported that they made chance encounters whilst surfing the web, others were forced to acquire ICT skills as a condition for employment. Either-way, the end result was an increased awareness of ICT as a possible solution to professional development problems.

1. Initial bifurcation point:

Once awareness had been raised, the teacher decided whether or not to access ICT. In the study, this also meant that some teachers had to include

basic ICT training on their expenditure list, as they had to pay for access. In such cases, the teachers had to use Doyle and Ponder's practicality ethic (Doyle and Ponder, 1978), to determine whether it was worth-while investing in ICT. Favourable decision-making resulted in the teachers "crossing the threshold" (broken line) of the first bifurcation point and either acquiring ICT skills or (if they already had them) going on to use them. The way teachers in this study made decisions, was discussed in chapter 5.

2. Inputs:

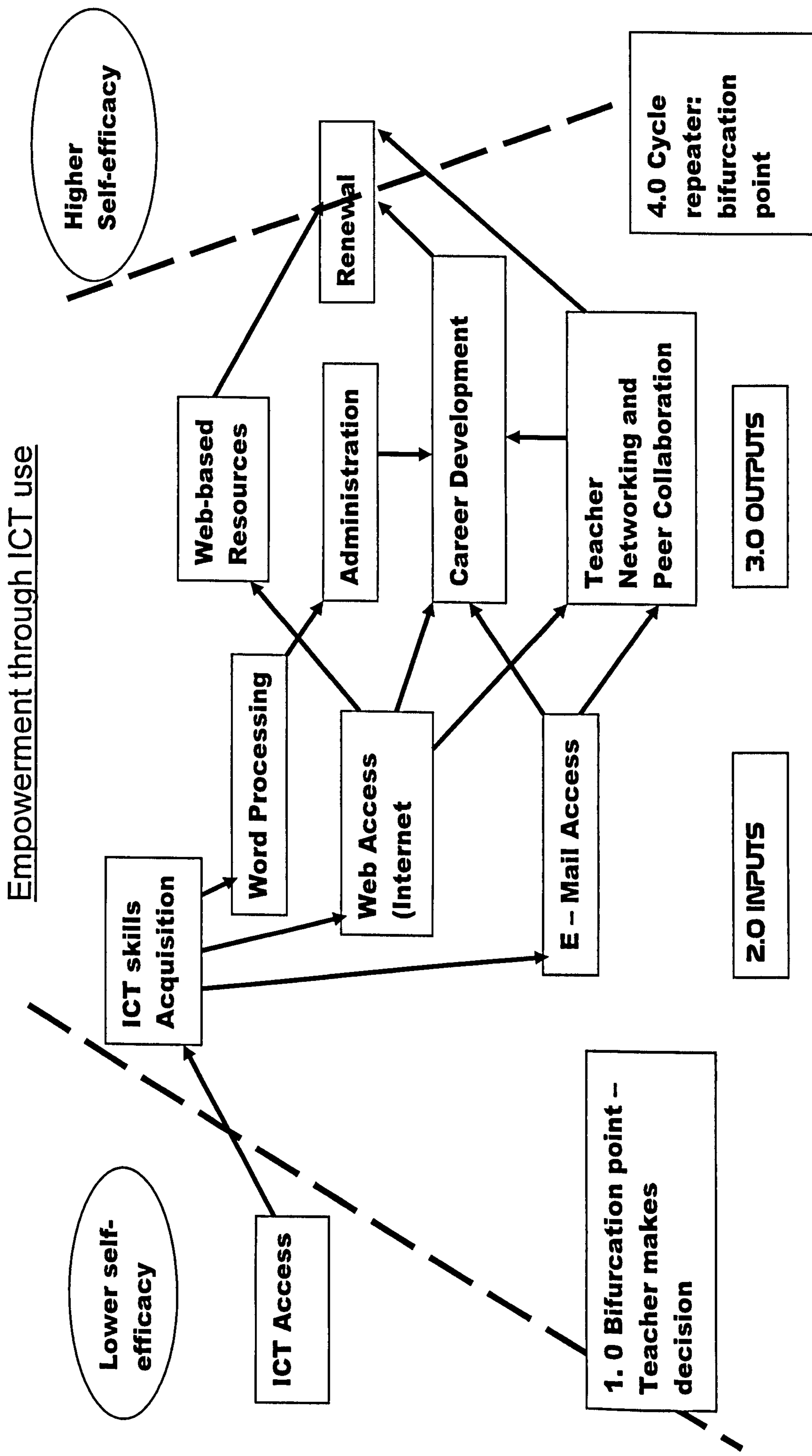
ICT skills acquisition led to transferable skills in word-processing, e-mail and web – access. Both questionnaire respondents and interviewees who reported using ICT for their own professional development identified these three skills as being useful to them. (cf. Chapter 4)

3. Outputs:

Interviewed teachers identified the following as the products of their ICT-based self-directed professional development:

- Word processing skills led to improved teaching administration and facilitated career development and leadership opportunities. Several teachers reported that they used word-processing to design worksheets, schemes of work and test banks for their subjects, whilst two teachers with positions of responsibility reported that they used their skills to keep records up to date.

Figure 7.5 Linear Flow Model:



- E-mail access was used to promote teacher networking, peer collaboration and career development. Some interviewed teachers reported that they used e-mail to communicate with colleagues. Others even reported collaborating in developing teaching materials with their peers using e-mail. Teachers also used e-mail to communicate with institutions in their quest for better career prospects and further study. Examples of these uses are discussed in chapters 4 and 5.
- Web access facilitated access to web-based subject and professional resources, career development and web-based peer collaboration and networking. Most interviewees reported using the Internet to access subject content materials and professional articles. Some teachers also used the Internet to access institutional websites for information on vacancies and study opportunities – at least one teacher reportedly benefited directly from such access. Other teachers also subscribed to subject-based online discussion groups and benefited from sharing ideas with teachers from diverse backgrounds.
- All these outputs had the effect of invigorating the teachers so that they felt renewed. Teachers reported that they were more confident, had gained more esteem among their students and peers and felt less isolated. Bolin (1987) argues that renewal promotes the development of self-efficacy and thus reduces stress associated with day-to-day teaching.

4. Second bifurcation point: Cycle repeater

The second broken line indicates the end of the current cycle. At this point, the teachers feel renewed and their self-efficacy increases. However, the state of achieved renewal enables teachers to advance to the next level in their professional development. Their increased self confidence ensures

that they will not balk at accepting new challenges. Changes in their pedagogical content knowledge, as a result of their recent achievements heighten their awareness of the discrepancies between their changing ideal practice and the conditions on the ground. Thus they are ready to meet new challenges and advance to the next level. Teachers who participated in the research indicated that they were engaged in a continuing process of development (cf. chapter 4 and 5)

In summary, the linear-flow model illustrates the self regulatory – homeostatic nature of self – driven professional development. It is a generic model whose parameters for empowerment depend on the intervention method chosen. It describes the individual teacher's fractal behaviour in decision making. The model also demonstrates the interconnectedness of the initial conditions, to the overall professional development process.

7.3.2 The systems model of Self-directed professional development

The second model provides a holistic view of the professional development process. To understand the complexity of the systems model, professional development could be compared to a bee-hive system. To understand the interconnectedness of a hive structure, and behaviour (complex social organisation), it is necessary to view the individual bees as parts of a hive system. A bee on its own does not make a hive. Similarly, many bees acting independently do not constitute a hive. It is the interaction or processes between the bees that form the complexities of a hive system. Similarly, individual unconnected activities by a teacher do not constitute the professional development process.

Professional development is a targeted process, which is characterised by self-regulated and organised fractal behaviour patterns aiming towards self-efficacy.

The process constantly recycles itself and adopts new properties that aid in its development whilst dissipating (making obsolete) those that do not. The second model describes these systemic interactions.

7.3.2.1 Systems model description.

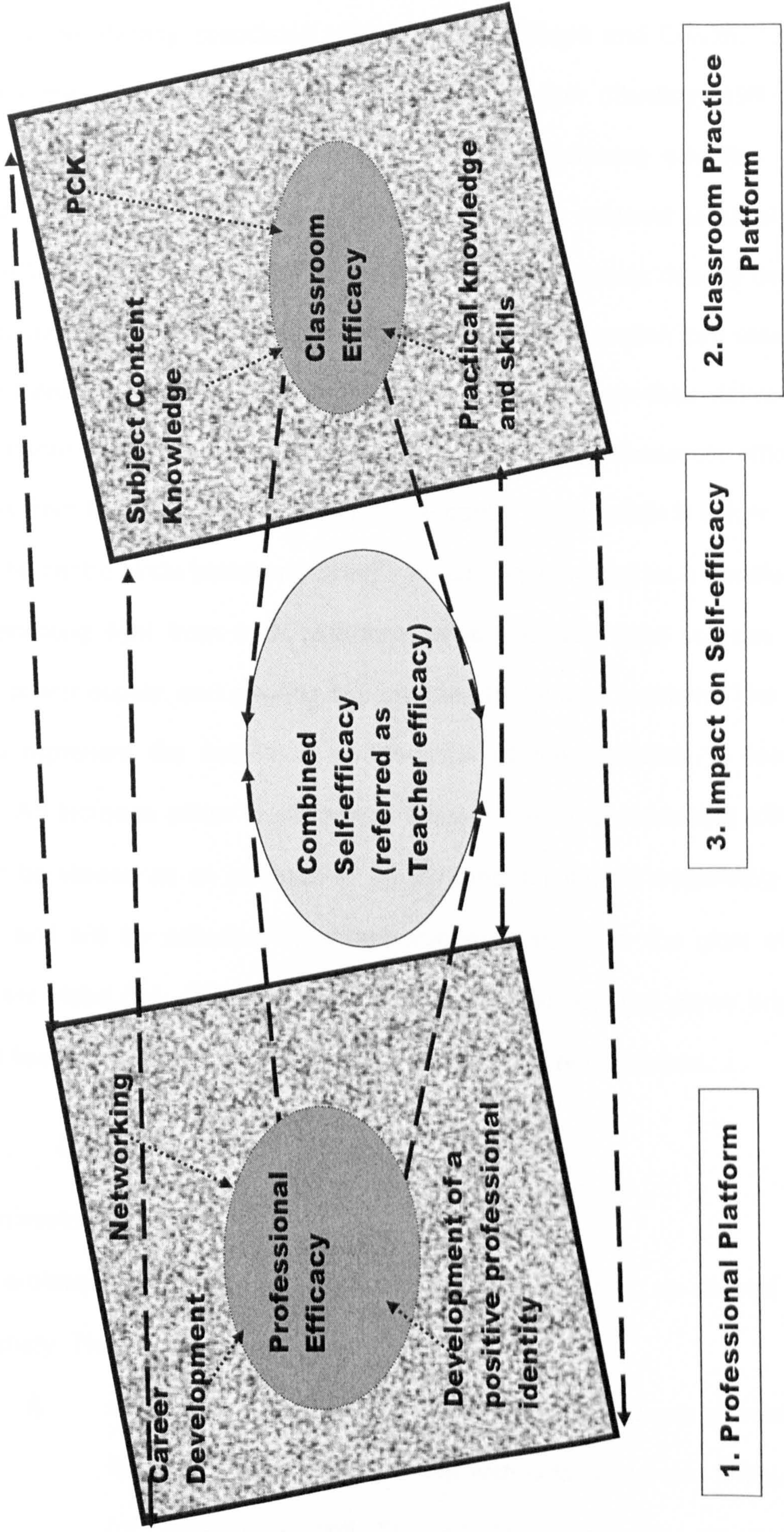
Figure 7.6 depicts a representation of the second component of the self-directed professional development model. This component is called the systems model of ICT-based self-directed professional development. The model is based on the data from the study, as organised through the grounded theory analysis framework described in chapter 3.

The systems model is a holistic representation of the interconnected fractal behaviour patterns that constitute the professional development process. It is characterised by two platforms that are interdependent and interconnected. The professional platform provides links to the teacher's institutional development and other concerns associated with the teaching context whilst the classroom practice platform is linked with classroom practice. The two platforms define the professionalism of the teacher.

Both platforms individually feed into the teacher's sense of self-efficacy. The professional platform enhances the teacher's *professional efficacy* (McLaughlin (1992). Lasley (1989) and Lee (1991) both see professional efficacy as being related to the environment in which teachers operate. Lasley further associates the development of professional efficacy in teachers with institutional development and increased responsibility, i.e. the development of leadership. The classroom practice platform enhances the teacher's classroom efficacy.

Figure 7.6 Systemic Model:

Systems / complexity model of ICT-based self – directed professional Development



This is the efficacy associated with instruction (Yaghi and Ghaith, 1997), classroom management (Labone, 2004) and innovation (Guskey, 1988), in short, it is associated with the actual teaching and learning situation. The aggregate of these two efficacies is what is commonly referred to simply as teacher efficacy. The broken lines connecting the two platforms directly denote the interconnectedness of the layers. For example, collaboration can result in increased procedural knowledge, which can in turn, enhance their delivery in the classroom, resulting in satisfaction and an increase in classroom efficacy. The lines from the two efficacies meet at the centre circle which is lighter than either. The centre circle (teacher efficacy - te) can be imagined as a translucent globe receiving light from both platforms, which act like light sources with variable power supply, and glowing in proportion to the light received. The light received represent the individual contributions of the platforms to teacher efficacy. An increase either in classroom efficacy (ce) or professional efficacy (pe) can be viewed as an increase in the currents for the corresponding light sources and will be reflected by a proportional increase in the glow of the translucent globe (te). Thus, under normal circumstances, (te) glows brighter than the two light sources because it radiates light from both sources. .

7.3.2.2 Explanation of the model

1 Professional Platform

The professional platform was composed of three aspects, as derived from the study. These were found to be:

- i) networking – associating with special interest groups whereby teachers were communicating with colleagues and institutions (cf. Chapter 4 and 5). Led to opportunities to develop collaborative practice and personal development – for example,

section 6.1.2.4 presents several teachers who reported that they were collaboratively developing subject modules, in Chemistry (M07H) and in Mathematics (M33S), with colleagues;

- ii) career development: links personal needs to institutional needs / supports organisational development – whereby teachers were using ICT skills and resources to apply for jobs or to effect career progression (promotion) (cf. sections 5.2.2.2 and 5.2.2.3);
- iii) a positive professional identity:- development of values, attitudes, ethics and morals associated with being a teacher: the development of personal skills / a positive professional identity – teachers also reported that ICT made them aware of educational standards, reinforced their beliefs about teaching and what it means to be a teacher. Some of the values and attitudes were quite immanent in what they said about themselves and their profession (cf. chapters 4 and 5).

The research established that activities in these areas on the professional platform resulted in teachers feeling empowered, respected and confident among their peers. Thus it can be concluded that their professional efficacy was raised (chapter 5).

2. The Classroom Practice Platform

This platform has four areas as well. These are:

- i) Subject content knowledge – teachers used ICT to access subject-based web resources from educational sites like the high schools hub. From these sites teachers were able to

access and download teaching materials and notes, which improved their teaching resource-base (cf. chapter 6);

- ii) Practical knowledge and skills: - Knowledge about teaching methodology and presentation. Teachers reported that they were also able to benefit from new innovative teaching techniques. Teachers also revealed that they were now engaged in more reflective teaching and developing their classroom expertise (cf. Chapter 6);
- iii) Pedagogical content knowledge (PCK): - Adaptation of teaching to suit context / Integration of expertise. Teachers cited several examples in which they were able to modify and adapt Internet-derived teaching materials for use in their classrooms. Adaptations involved making use of current events or contextualising materials, modifying materials to suit the local conditions and adapting and organising materials to the depth required by the syllabus. Chapter 6 reports on several specific instances in which teachers demonstrated an increase in their pedagogical content knowledge.

An increase in expertise at classroom practice level results in increased confidence in teaching, higher self-esteem and higher passes for the students. In return, the teacher's classroom efficacy increases.

There was also evidence of the interplay between factors in the areas on the professional platform and those on the classroom practice platform. For example, the modules referred in 1. above, which were produced through collaborative activity were then used in class to teach those topics. In addition the acquisition of ICT skills originally intended to enhance one

teacher's promotion prospects also resulted in the teacher being able to access ICT facilities at the new school, to make use of web-based teaching materials (Chapters 5 and 6).

3. Impact of ICT on self-efficacy

From the foregoing discussion, an increase in both professional efficacy and classroom efficacy results in an increase in the combined self-efficacy of the teacher. To use the translucent globe analogy, an increase in brightness of either the classroom efficacy platform (ce) or the professional efficacy platform (pe) will result in a proportional increase in brightness of the teacher efficacy globe (te).

Model 2 shows that the impact of the teachers' use of ICT on their self-directed professional development was to increase their self-efficacy, thus making them more effective and confident contributors to the education system.

In chapter 6, teachers reported on the benefits that they and their students allegedly gained from their use of ICT. Among the benefits for students cited, teachers claimed that students were more motivated, their interest in the subject was re-kindled, and they participated more readily than before. Clearly, in this case, the use of ICT in self-directed professional development yielded new experiences that helped the students to learn. For the teachers themselves, the use of ICT also enabled them to keep informed and aware of developments in their professional and subject disciplines. Being kept up to date and aware helped them to build new understanding of their practice. Thus self-directed professional development meets Hea-Jin (2001)'s idea of an effective professional development strategy (see caption at beginning of chapter 7).

7.3.3 Holistic view of the model

With regard to ICT, the first component (figure 7.2) is a fractal pattern for the development of the second component (figure 7.6). Each pathway in the linear flow diagram is an iteration process that eventually leads to higher self-efficacy. The models thus demonstrate the triangulation of teacher relationships as professionals; individuals and classroom practitioners, and how this has helped in understanding the professional development process as a whole.

7.4 Conclusions

It is important to highlight that the self-directed professional development model was developed from theory grounded in data and as such presents an authentic attempt to describe the behaviour of Zimbabwean A-level science and mathematics teachers who participated in the study. The model, however has the following limitations:

i) Generalisability

The model cannot be generalised to account for the behaviour of all Zimbabwean A-level science and mathematics teachers because it was impossible to obtain a representative sample for both the questionnaire and interviews that produced the bulk of the data used in the study. Teachers were constrained in volunteering to participate in the study by the unfavourable socio-political and economic conditions that were existing in the country at the time of the field-work. In addition, the limited time-line for the research precluded the use of ethnographic designs that would have greatly improved the richness of the data used in the model design. However, the model is used in this study to describe the behaviour patterns emerging from the teachers who participated in the study.

ii) Access to ICT

The model does not address issues of ICT access. The study showed that many teachers had problems accessing ICT and these problems, together with problems of skills acquisition could actually cloud the picture. The researcher therefore intentionally left these issues out of the modelling process in order to remain focused on the impact of ICT on the self-directed professional development of those teachers who were successful in their acquisition of ICT skills and access to ICT resources. This might compromise the validity of the model – if applied to the whole A-level science and mathematics teacher population. However the researcher remains convinced that the model remains valid if it is taken to represent only the views and perceptions of the 101 questionnaire respondents and 55 interview participants who took part in this study.

However, these limitations can be overcome. The model provides a basis for both a longitudinal study of self-directed professional development and also for more representative studies in the future. The analysis framework matrix identified themes that teachers are concerned about, and these could be used as a basis for developing more refined future models.

Whilst one cannot do much about external socio – political constraints, it is also useful to consider that some researchers on self-directed professional development have noted that this process seems to become evident in conditions of adversity; i.e. when teachers are fighting for professional survival, they tend to become tenacious in their bid to improve themselves. As Bouchard (1996) noted:

It is this problem-solving quality that makes self-directed professional development more likely to occur in conditions marked by a prevalence of opposing factors (p15)

This means that although, self-directed professional development is a continuing process, under normal circumstances it is masked by other

professional development processes such as planned programs. It is the researcher's firm belief however, that the benefits of self-directed professional development as demonstrated by this study are worth investing in the process for every teacher, for as Hea-Jin (2001) argues, the goal of professional development should be to help teachers become effective in all spheres of their work. Self-directed professional development provides an internal locus of control that ensures that the teachers continue to build new understanding of teaching and learning.

Chapter 8: Conclusions

8.0 Introduction

This study has provided me with a very good opportunity to engage critically with current theories in the professional development of teachers. This engagement has resulted in the appraisal of the Zimbabwean A-level science and mathematics teachers' perception of the impact of information communication technology in their self-directed professional development as described in this study. I am of-course aware that mine was but one interpretation in a myriad and that someone else could have used other approaches to come up with possibly a different interpretation to the one I made. However, I have no regrets because the particular path I chose provided me with a very rich and cogent learning experience.

In interpreting data from my investigations, postmodernist theory helped me to shift my focus from looking for formal structures and universal values, – a feat that would have been impossible to accomplish given the diversity of the data I had accumulated – to just trying to understand my own shifting construction of knowledge in the context of the multilayered data that I had. For as Lather (1991) claims:

“Contexts and meaning in everyday life are posited as co-constructions, multiple, complex, open, changing neither pre-given or explainable by large causal theories, but made and re-made across a multiplicity of minor scattered practices (Lather, 1991 p 42)

The use of the principles of grounded theory, as organisational tools proved to be invaluable in the development of the analysis framework, which also led to the development of the two-in-one model of self-directed professional development.

Chaos theory proved to be a very versatile tool for analysing the often confusing and complex data that emerged from this research. It provided a powerful way of identifying and focusing on repeatable incidences (as shown in appendix 3.8) as fore-runners of impact. Previous chapters have presented a record of this sense-making process.

This final chapter presents a synopsis of what has been done, what has been achieved, and what still needs to be done. Section 8.1 presents a critique of the study i.e. a reflection of the whole process – what were the strength and weaknesses? What could have been improved upon and how? A summary of what has been learned from the study is presented in section 8.2 together with a summary of the answers to the research questions. In section 8.3, the implications of this research to professional development are explored. This is followed by some recommendations arising from this study in section 8.4. Section 8.5 provides a reflection on what this study has meant to me as an individual, as a researcher and professional developer and as an educator. Section 8.6 will present my general concluding remarks.

8.1 A critique of the study

The study was carried out at a time when the socio-political climate in Zimbabwe was experiencing some upheavals. New legislation had been enacted to try to control social and political unrest. Unfortunately, some of this legislation also imposed controls on “freedom of expression” and “freedom of movement”, making it very difficult to gather data, especially in the year 2003 which had been set aside for field work. The difficulties associated with the data collection are described in detail in chapter 3. Some would argue that such difficulties might influence the research outcomes – that perhaps the results could be different if the research was carried out again in a “normal situation”. It

is conceivable that more teachers for instance, would have been able to participate in the interviews, thus increasing the representativeness of the sample. In addition, the refusal of some respondents to be audio-recorded during interviews limited the details and depth of the data set that could have been used in the analysis. Nevertheless, since the main reasons why teachers followed the path they chose in their professional development, was because ICT provided the most viable way to overcome their concerns pertaining to resources and context (cf. Chapter 4), it is doubtful that the actual responses to the interviews would have been affected in any appreciable way. The reason for this is that, in “normal” circumstances in a developing country, the educational context would not be very different from that which was being experienced presently, for example, there would still be shortage of teaching resources. Therefore, one would expect that the overall themes, as indicated in the analysis framework, would remain largely the same. Thus, one would expect the findings of this research to remain valid.

The socio-political climate also forced changes in the methods of collecting data, as described in chapter 3. Due to the perceived difficulties in getting teachers together to answer questionnaires, in the light of the effectively dysfunctional postal system, it was decided to actively support the regional programmes of activities, as a way of facilitating the meetings of teachers. This deviation from the original research design had the effect of increasing the return rate of the questionnaires as well as providing convenient access to teachers for the interviews. However, there was always the danger of inadvertently manipulating teacher perceptions. By co-funding workshops, literature reports that, the researcher tended to increase the perceived power distance (Stevenson and Beech, 1998) between the teachers and himself, so

that he was perceived, not as an equal, but as a “donor” or benefactor. Such a perception was undesirable, as it tends to induce the desire to please among recipients – a phenomenon known as functional deification among researchers (Fairley 2002). Deification arises from the observation that recipients feel indebted to the researcher and are anxious to provide the researcher with the information that they think the researcher needs to complete his/her work. Thus recipients become followers, looking for cues from the researcher to guide their behaviour. They will not proffer opinions that they think might be contrary to the aims of the researcher. This phenomenon is commonly observed among action-research participants and programmes where the researcher is both a participant observer and a facilitator. However, it can also be argued that the second data collection visit in early 2004 helped to offset some of this negativity, as the political situation had stabilised and teachers were visited at their schools.

It is pertinent to note that the socio-economic and political situation in Zimbabwe has been depressed for the past five years. As reported in chapter 7, self-directed professional development appears to become more immanent in situations deprived of structural and organised support – i.e., when teachers’ are left to do the best they can in isolation. Thus in an ironical way, one can also say that the situation in Zimbabwe provided the ideal conditions for studying self-directed professional development.

Grounded theory is normally associated with ethnographic studies (Strauss and Corbin, 1998). By departing from this traditional practice and seeking to apply grounded theory analysis elements to semi-structured interviews in a survey, it would seem to call into question the validity of the analysis. On the contrary, the use of grounded theory methods in interviews is gaining wide acceptance and indeed some researchers such as Bryman (2001) argue that

combining desirable elements of analysis from various research methods might be a good way of getting the best out of the data. In this case, applying grounded theory coding was much more desirable to using content analysis techniques on the transcripts, as the researcher needed a qualitative framework for the design of the model.

8.2 The Research Questions

As reported in chapter 1, the study arose in response to the need to develop a sustainable support structure for the self-directed professional development of A-level science and mathematics teachers in Zimbabwe. The growing use of ICT among Zimbabwean A-level teachers presented itself as a sustainable professional development structure worth investigating. The focus on teachers' perceptions, made it possible to go beyond behaviour and focus on mental processes that caused the behaviour, in the belief that the teachers' behaviour is pre-meditated (Sherif et. al., 1965). The aim of the research was therefore defined as *"What is the perceived impact of ICT on the self-directed professional development of Zimbabwean A-level science and mathematics teachers?"*

Sections 8.2.1-8.2.4, provide a summary of the findings for each of the research questions that guided the study. A summation of the findings is provided in section 8.3.5, as a response to the aim quoted above.

8.2.1 To what extent is ICT used by science and mathematics teachers in Zimbabwe for their own professional development?

The research (chapter 4.1-4.2) has established that ICT is generally accessible to most A-level science and mathematics teachers in Zimbabwe. Of the 254 teachers who responded to the questionnaire, 40% (101) had used ICT in the last twelve months and of these teachers, 64% (64) reported that they

regularly accessed ICT (at least once a week). 80% (203) of the teachers who responded to the questionnaire also indicated that they worked in schools that had ICT facilities, but only 46% (93) of these teachers had used ICT in the last year.

ICT use was found to be dependent on the type of school (i.e. government, mission or private) where teachers worked, the location of the school (i.e. rural or urban) and the subject the teachers were teaching.

The level of access was found to be dependent on the type of school. In section 4.2.3, it was reported that teachers from private schools generally reported better support and networked facilities. They were required to use ICT as part of their professional activities. Teachers from public schools had more restricted access to ICT facilities due to availability of resources. These teachers relied more on Internet cafes and regional resource centres.

As a result of the point made in the previous paragraph, for public school teachers, urban teachers had easier access to ICT facilities than rural teachers. The reason given for this observation was that ICT facilities were more abundant in the urban centres, where teachers had access to internet cafés and Resource Centres.

Sections 4.2.2 and 4.2.4, highlighted the fact that, although the most common uses of ICT were word-processing, e-mail and Internet access (see section 4.2.4), ICT use appeared to be significantly related to the subject taught, with teachers of A-level Physics, and those teaching a combination of subjects being more likely to have used ICT than the other teachers (section 4.2.2).

There was great demand for ICT skills training among the teachers since these skills were viewed as transferable skills. In section 4.1, it was reported

that ICT users could be grouped into two; those who underwent formal ICT training, and those who had no formal ICT training. Most of the younger teachers belonged to the former group, whilst the older teachers belonged to the latter group, suggesting that ICT was only recently introduced into the institutions of higher learning (universities) in Zimbabwe. Acquisition of ICT skills was associated with improved career opportunities especially in private schools where these skills were often regarded as essential recruitment points. The need for training was also highlighted by the fact that approaches to Internet use ranged from exploratory browsing to focused, purposeful searches. Exploratory browsing was cited by more interviewed teachers despite the fact that it is a very inefficient and expensive method of searching for resources. In chapter 4, it is therefore suggested that training would help teachers focus their searches more. For teachers in public schools, the high access demands led to frustration as the regional resource centres were unable to cope and teachers were forced to use commercial Internet cafes.

Chapter 4 also highlighted the fact that teachers were prepared to invest money, time and resources into the use of ICT for their professional development. This was because they perceived ICT to be a worthwhile investment (cf. Doyle and Ponder, 1978). Teachers also received some support for ICT from Parents Teachers' Associations who assisted in providing funding and donations for ICT resources. Teachers from public schools in rural areas also demonstrated their determination to benefit from ICT use by pooling resources together in order to access Internet facilities at Internet cafes.

8.2.2 How do teachers perceive the use of ICT as affecting their professional development?

In chapter 5, evidence was presented from the questionnaire and interviews, highlighting the fact that teachers perceived ICT as providing them with support in two main areas; i.e. as a teaching resource, and as a networking resource. The science and mathematics teachers were also able to identify benefits of using ICT to their professional development and the development of their students.

In section 5.3 of the study, it was suggested that teachers experienced professional constraints due to shortage of resources, career frustration and professional isolation. As a result, teachers made decisions to use ICT for their professional development for three major reasons:

(a) To enhance their professional identity – ICT enabled teachers to make decisions that affected the way in which they perceived themselves, and were perceived by others. Their use of ICT transformed their values, attitudes and belief systems about what it means to be a teacher.

(b) To enhance their professional careers – The study also showed that teachers are subjected to stressors arising from their work environment and that they frequently had to balance out individual interests against the interests of the institution and the education system as a whole. The interplay of these complex forces is illustrated in figure 5.8 (p 230). Therefore, teachers used ICT to provide the balancing torque between individual and institutional interests. This was achieved by: firstly, using ICT to improve their work effectiveness as school administrators for example; secondly, using ICT to enhance their chances of getting promoted in their present jobs or enhance their chances of successfully changing their teaching posts and thirdly, using ICT to enhance

their chances of securing positions for further study as illustrated in figure 5.9 (p 231).

(c) to enhance their professional status among their peers through professional networking; In section 5.2, it was suggested that teachers appeared to define themselves both through internal processes and also through their relationships with the institution and the education system at large. Thus the teachers' professional-efficacy was described in terms of both social and personal aspects.

Teachers used ICT to help define themselves amongst their peers through e-mail communication, comparing and sharing ideas about teaching and through collaboration in developing teaching materials using e-mail and the Internet. In so doing, teachers seemed to seek "the second opinion" to confer on them the legitimacy of being professionals.

By improving the three areas described above i.e. professional identity, career development and professional networking, teachers aimed to improve their professional efficacy. Teachers also claimed that enhancing their professional-efficacy made them feel good about themselves, they felt less isolated, better at their jobs and enjoyed their work. Professional efficacy is summarised in figure 7.6 (p330).

In conclusion, teachers' use of ICT was found to enhance their professional development by facilitating processes that increased their professional efficacy.

8.2.3 How does the use of ICT affect classroom practice?

Teachers reported that they faced three major constraints in the classroom. These were the shortage of teaching resources, isolation leading to stagnation in the use of teaching approaches and effective coping mechanisms in the

classroom. In chapter 6, teachers reported using ICT to access and use material resources from the Internet. The materials were used mainly in two forms: unmodified and modified materials.

Unmodified teaching material resources were used in the form of subject content knowledge (notes, supplements) and practical knowledge and skills (teaching resources – such as practical work guides, notes on teaching approach). Figure 6.4 (page 275) summarises the form and use of unmodified teaching materials resources.

The modified materials were adapted to cater for various contextual variables such as local conditions, current affairs and syllabus depth. There was also evidence that some groups of teachers were using ICT to develop teaching materials for problematic topics in their subject disciplines. Teachers also reported that using ICT in this way helped them to become more critical of their teaching as well as allowing them to cope with the constraints that they faced in the classroom. In addition, teachers also felt that their students benefited from their use of ICT by becoming more critical, more interested and motivated to learn and by improving in their participation in class.

Figure 7.6 (page 330) shows how the interactions of subject content knowledge, practical knowledge and skills and PCK are related to the classroom efficacy of the teacher.

To answer the research question, teachers claimed that their use of ICT improved their professional development by increasing their classroom efficacy.

8.2.4 What model of effect of ICT-based professional development can be abstracted from the study?

Using principles of data analysis derived from grounded theory (cf. Appendix 3.8) it was possible to draw a two-in-one model to illustrate the

process of self-directed professional development. The model was based on the premise that the process of professional development is aimed at improving the efficacy of the teacher – one of the main findings in chapters six and seven. The generic dimension of the model illustrates the self-directed professional development process (cf. figure 7.2 page 322) whilst the systemic dimension of the model illustrates the relationship between professional efficacy and classroom efficacy with teacher efficacy (cf. figure 7.6). The impact of ICT on the self-directed professional development of Zimbabwean A-level science and mathematics teachers is also shown as a corollary of the generic model and is illustrated in figure 7.5 (page 326).

8.2.5 Research Aim: *What is the perceived impact of ICT on the self-directed professional development of science and mathematics teachers?*

The study has also managed to provide a possible solution to the major question raised in the research aim. From the study it appears that teachers perceived the major impact of their use of ICT on their self-directed professional development to be an aggregate increase in their self effectiveness as a result of partial increments of their professional and classroom efficacies respectively.

This study identified self-efficacy as the hallmark of professional development in general and particularly – in self-directed professional development. Whilst the link between self-efficacy and professional development is not unique to this study - as similar suggestions have been advanced (Langford, 2001) in the realm of learning communities – no other study has been able to model the nature of this relationship (between self-efficacy and professional development) with regard to self-directed professional development.

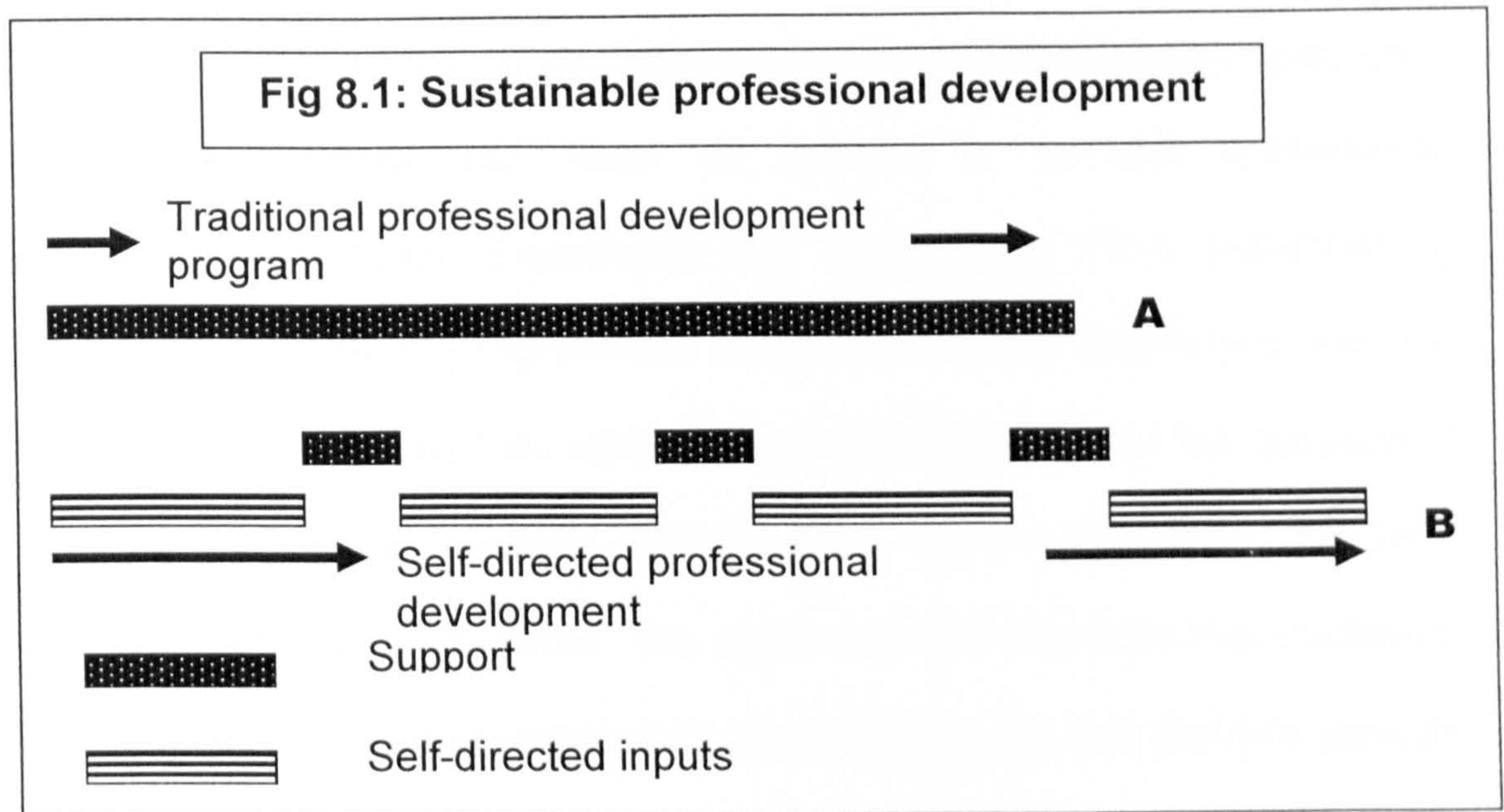
8.3 Implications of the research.....

8.3.1 On the nature of the professional development process;

One of the issues arising from this study is the fact that professional development is not only a continuous process, but also takes place regardless of whether or not there is external intervention. The genre of professional development studies published so far places a lot of emphasis on issues of external intervention. There is much discussion on managed professional development programmes suggesting various designs of effective professional development (cf. Kinder *et al.*, 1991; Ingvarson, 1993; Bell and Gilbert, 1996; Jones *et al.*, 1997; Loucks-Horsley *et al.*, 1998). Yet few of these authors recognise the influence of self-direction on the whole professional development process. In terms of chaos theory, these studies focus on the attributes of the system instead of focusing on the whole. This would account for the fragmented views of professional development which seem to arise from these studies (cf. the hive analogy, section 7.3.2 page 328). Whilst researchers do recognise that one of the targets of professional development is empowerment (Downes *et al.*, 2001; Reeves *et al.*, 2001), empowerment is itself associated with external interventions.

The issues that have emerged from the study suggest that self-directed professional development is a natural process that has the potential to take place in every professional, as a response to their natural drives towards self-efficacy. Although many of these self-directed professional development attempts do not appear to succeed (for reasons given in chapter 7) - hence the need for intervention, failure appears more to do with lack of the relevant support at the right time. It is therefore suggested that managed professional development programmes that take into account the self-directed component of

the professional development process stand a better chance of sustainable success. Figure 8.1 illustrates the proposed structure of such a program.



From figure 8.1, most donor funded professional development programmes in developing communities take the route given in A, i.e. all the programme activities are supported and funded. When the funding ends, the activities also come to an end partially because there is no more funding and also because during the funded phase, the programme inadvertently inculcated a dependency syndrome in the stakeholders and they need more external guidance to progress. Another possible reason could also be that the self-directed element of the professional development process has been thwarted and stakeholders do not identify with the aims of the programme enough to feel motivated to continue the process.

In B on the other hand, the self-directed professional development process is the mainstay of the programme. External support is applied drip-feed fashion at crucial points in the programme. This ensures that the teachers maintain an internal locus of control and continue with the activities longer because they identify with them. Thus support would only be used to enable the teachers to acquire the necessary means to progress to the next phase in their

development and would be determined by the needs of the teachers themselves rather than by the project document specifications.

8.3.2 ...On sustainability of professional development programmes

The above findings can even be applied to general professional development programmes. Experience has shown that most well-meaning professional development programmes initiated externally (especially with the help of donors) have a shelf life which is not much longer than the duration of the external support mechanisms (Mushayikwa, 1999a; Miti, 1997; Sanders, 2005; Lubben and Sanders, 2005). The reason for this could be that traditional professional development programmes tend to ignore the self-directed aspects of the professional development process and thus end up developing dependency in teachers and professionals by taking away the internal control of the professional development process. Once the formal programmes can no longer function – maybe due to lack of funding – the programme activities cease and there is no sustainability.

What has been learnt about the self-directed professional development process from this study seems to suggest that the sustainability of both programmes described above could have been enhanced if elements of the programmes had been built to support self-directed professional development. Such a programme would be structured around the generic linear-flow model (figure 7.2 page 322) and would provide interventions necessary to support the self directed professional development process at specific identified bifurcation points (cf. figure 8.1 page 350) as described earlier in relation to ICT skills acquisition and access (see figure 7.5 page 326).

When understood in the light of the above arguments on sustainability, the generic linear-flow model (figure 7.2) might even be adapted and applied to the

general development programmes. For example, human development programmes are in the final analysis concerned with improving the quality of life (World-Bank, 2004). This study has shown that for professional teachers, increasing self-efficacy is associated with the same values one would associate with an increased quality of life, for example, enjoyment – being happy (content) with one's life. An adaptation of the linear-flow model could therefore be used in community development projects on managing HIV / AIDS and other such development projects aimed at achieving the millennium development goals (World-Bank, 2004; UNDP, 2003) The key lies not just in community involvement, but in the provision of timely support for self-directed community projects as illustrated in figure 8.1.

8.4 Recommendations arising from the research

Finally the models developed during the course of this research are still part of work in progress, in a field that is still very much in its infancy. It is hoped that further studies will be carried out both in Zimbabwe and other countries to validate and build on these models, so that they can enhance our understanding of self-directed professional development and become effective tools to support the self-directed professional development of teachers.

In their self-directed professional development, science and mathematics teachers in Zimbabwe used ICT to overcome systemic constraints which threatened to reduce their efficacy. It is also noted that the success that these teachers experienced can be enhanced if support is provided as suggested in figure 8.1. The recommendations below are directed at stakeholder institutions who might be interested in promoting the use of ICT for self-directed professional development by teachers. Such institutions might include the Ministry of Education, Sport and Culture (Curriculum Development Unit) in

Zimbabwe, the country's seven state universities, colleges and schools, as well as any other private participants and prospective donors. Four major recommendations were identified and these address the issues of access of ICT facilities, skills acquisition, access and use of ICT resources and collaboration in using ICT resources. These recommendations are discussed in detail in the sections that follow.

8.4.1 Access of ICT facilities

As reported in chapter 4 most ICT resources were beyond the financial reach of the teachers. Even where schools had ICT facilities available, in most cases for public schools, these were not networked as the school could not afford the telephone and ISP charges. Teachers were thus forced to use ICT facilities at Resource centres (which were over-subscribed) and Internet cafés (which were very expensive compared to the salary of the teacher). With reference to Doyle and Ponder's *practicality ethic* (Doyle and Ponder, 1978), accessing ICT was an expensive investment as teachers lost more in terms of time and money. Teachers had to decide whether or not, it was worthwhile to make such an investment. Figure 7.5 shows that this was the first bifurcation point for teachers and most decided not to cross the threshold and use ICT for their professional development. It is suggested therefore that more teachers could be persuaded to invest in ICT in terms of money and time, if structural support was provided to enable them to access ICT resources more easily.

Access could be improved by:

1. Fostering partnerships between business, Internet services providers (ISPs) and Education Regional Offices. If business concerns could be persuaded to support the computerisation of schools for example, by providing computers, telephone links and subsidised access to Internet

Service Provider (ISP) services, more teachers' would be able to access and use ICT resources for their self-directed professional development. Experience and teacher testimonies suggest that such partnerships are possible and viable. Almost all private schools were benefiting from such partnerships – as reported in chapter 5. Extending that kind of support to Government and mission schools should therefore be feasible if the points below are also taken into consideration.

2. For such an initiative to work, the Regional Offices of the Ministry of Education, Sport and Culture would need to maintain a positive partnership with organisations and companies that support ICT and teacher professional development by providing industry with feedback. It is suggested that feedback should be supplied by Regional Offices rather than the Head Office, to ensure local involvement and participation in such programmes, and cut bureaucratic bottlenecks in communication. In private schools, business participation was achieved by electing supportive business bosses to the school board. It is suggested that regional education panels could invite business captains onto committees that deal with local ICT issues to ensure continued support. Local action will ensure that businesses remain fine-tuned to the particular professional development needs of teachers in their local area, and thus the locus of control will not be wrested from the teachers and super-ceded by “national” agenda.

8.4.2 ICT Skills Acquisition

Once they had crossed the threshold (Figure 7.2), another hurdle that faced teachers was the acquisition of ICT skills that they could use in their professional pursuits. In this study, informally trained teachers frequently

reported having less ICT skills on the CBAM and factor analysis scales. Systematic training could be provided, through one-on-one training clinics, to help them acquire the skills they needed most to become effective in what they were doing. For example, administrators might need word-processing skills more than e-mail and internet browsing. Such training clinics could possibly lead to a Ministry-recognised competency certificate. Teachers could be asked to pay nominal training fees as payment ensures that teachers have control over what they learn. Teachers will not invest in activities that they feel are superficial or irrelevant to their needs. This suggestion is again viable because the teachers have demonstrated in the study that they were willing to invest money in services if they perceived the benefits to be worthwhile. Also, from the discussion in chapter 5, more than half (52%) of the questionnaire respondents who had reportedly used ICT in the last twelve months also reported having taken informal (self-taught) ICT skills training. If such people were provided with affordable training targeted at their specific needs, it is much more likely that they would welcome the opportunity.

8.4.3 Accessing ICT Resources

Another recommendation arises from the observation that some teachers in the study used ineffective methods (see section 4.3) of accessing resources from the Internet and therefore wasted time and money. There is a need to

8.4.3.1 Develop local (contextualized) online resources for teachers

The Universities and the resource teachers for the SEITT programme could provide leadership in this case and build on the work introduced by Dr. Mckenney in her web-based version of Cascade-SEA (McKenney, 2000). The universities have the expertise and natural leadership to carry out a needs

analysis and identify areas of concern to most teachers. They can also provide the leadership required in the materials development process – for example – such activities could become the logical sequel to the SEITT programme (described in Chapter 1).

8.4.3.2 Facilitate localized materials review workshops

Research in other parts of the world seems to indicate that teachers' use of ICT improves if the teachers are encouraged to share and analyse the benefits with colleagues (Bracewell, 1998; Marx *et al.*, 1998) Therefore funding bodies could provide support for workshops aimed at analysis and discussion of benefits of online resources. These workshops could be self-funded. As mentioned before, teachers have shown willingness to invest in professional activities they deem worthwhile.

8.44 Collaboration and mentoring

The study provided some examples of effective use of ICT for self-directed professional development by teachers. One recommendation arising from these observations was that other teachers could benefit from the strengths of promising individuals if these were identified and encouraged to share their innovative materials resulting from their professional development experience. Using programmes such as the web-based version of CASCADE-SEA (McKenney, 2000) which was developed with the help of some of these teachers, teachers could be encouraged to build up curriculum materials which can be shared over the web – in the same way as they are currently relying on foreign web-based materials. Expert master teachers (Steffy *et al.*, 2000) who have been shown to be adept at developing materials for their classrooms, could be asked to lead such initiatives. They could be asked to review the

online curriculum materials made by others. As incentives, and to ensure high quality of materials these reviewers could be paid for rating the materials. Teachers who access and use such materials could also be asked to pay for them to ensure that the programme sustains itself. By supporting these teachers who are already engaged in ICT use, the responsible authorities support the renewal of teachers and enable them to progress beyond the second bifurcation point in figure 7.2

8.5 Personal Moments of Learning

8.5.1 Professional development as a change process

If one were asked to summarise what this study has been all about, only one word comes to mind – *change*. During the course of this research, I came to appreciate that I was documenting A-level science and mathematics teachers' accounts of how ICT had changed their professional lives. It also took me slightly longer to realise that in carrying out the study, my own perceptions about the process of professional development had undergone some fundamental changes.

8.5.2 Value of inter-personal relationships in research

During the data collection process, I had to travel the length and breadth of Zimbabwe distributing questionnaires and interviewing teachers in six of the ten educational regions of the country. Each time I had to negotiate access to teachers and schools, I came to appreciate that interpersonal relations building is as important as the design of research instruments in the data collection process. Teachers presented themselves as individuals who are working in busy and complex environments and often within social relationships that are fragmented and fragile, so that when visiting schools, at any one time, there was no guarantee that the teacher who agreed to participate over the phone,

would be willing to do so when I arrived. I was acutely aware that my visits not only intruded on their social and professional agendas, but also forced them to re-examine and re-evaluate their commitment to the profession in the light of the constraints and risks they faced by granting me the interviews. Through these frustrations, I began to appreciate and value those contacts that became successful. It was humbling to note, even with the difficulties and uncertainties faced by teachers with respect to the restrictions noted in chapter 3, that there were some teachers who valued my work enough to consider it worth the risks.

8.5.3 Order in chaos – a new paradigm?

The following researchers, Sawyer, (2001); Davis (2003), and Pryor and Bright, (2004) in the application of chaos theory to the fields of professional development and the development of educational systems greatly influenced the direction set for this study. It was through the work of Davis (2003) in the related field of career development that I realised how applicable chaos theory was to professional development. Chaos theory deals with change processes in systems and thus provided me with insights into the organisation of the seemingly chaotic change processes operating in self-directed professional development. Using chaos theory as an organising tool helped to me to piece together the disparate data into the models described in chapter 8.

9.6 Concluding remarks

This research has provided me with a very rich, challenging and unique experience to contribute to our understanding of the process of self-directed professional development. In as much as it has highlighted the primacy of self-efficacy as the driving force of human development, this research is also a celebration to the enduring nature of the human spirit.

Appendices

Appendix	Title
3.1	Science and Mathematics Centre Attendance Register
3.2	Design of Questionnaire Instrument
3.3	Research Questionnaire
3.4	Interview schedule
3.5	Copy of Access letters
3.6	Copy of letter accompanying postal questionnaires
3.7	Interview coding system
3.8	Interview Analysis Framework
5.1	Reliability analysis
5.2	Teachers' responses to Item 22

Appendix 3.2: Design of Questionnaire Instrument

PD Process	Model	Description	Characteristics	Rationale for inclusion
Context Items 1 – 12	TCS models (Steffy, 1978; Vonk, 1995)	General Biographical information and information pertaining to the ICT environment	<p>Biography</p> <p>9. Gender</p> <p>10. Geographical location</p> <p>11. School type</p> <p>12. Classification of school</p> <p>13. Subject(s) taught</p> <p>14. Teaching experience</p> <p>15. Qualifications</p> <p>16. Training institution</p> <p>ICT environments</p> <p>4. Computer facilities at school</p> <p>5. Access to computers at school</p> <p>6. Use of ICT in the last 12 months</p>	<p><u>Biography</u></p> <p>Provides data for the Teacher Career Stage</p> <p>Models and delineates the characteristics of the teachers thus making it easier to group them.</p> <p><u>ICT environments</u></p> <p>Provide insights into the dynamics of ICT access both at school and outside.</p> <p>Provides initial answer to Research Question 1</p>
Inputs Items 20, 21	Concerns Based Adoption Model (Horsley and Loucks –Horsley, 1998)	Model quantifies the change process in teachers. It incorporates 7 stages of concern, levels of use and innovation. Treats change as a process	<p>Level Concerns</p> <p>9.r Self</p> <p> vii) Awareness</p> <p> viii) informational</p> <p> ix) Personal</p> <p>2. task</p> <p> x) Management</p> <p>9.r Impact</p> <p> xi) Consequence</p> <p> xii) Collaboration</p> <p> vii) Refocusing</p>	<p>Provides input in the form of teachers concerns and provides basis for evaluating their professional development</p>
	Teacher	Identifies 3 important areas	Social:	Provides possible

<p>18 a, b, d, e 19 a, b, 18 c, 19 d, 18 e 19 c, e</p>	<p>Development Model (Gilbert and Bell, 1996)</p>	<p>of teacher development, i.e. social, professional and personal development. These areas can also be seen as areas of need / motivation centres</p>	<p>1. Isolation 2. Collaboration Professional: 1. New ideas 2. Transfer to Classroom Practice Personal: 1. Self Critical 2. Coping strategy 3. Empowerment</p>	<p>motivation for teachers initiating self driven professional development</p>
<p>Output 13 18 c, d, e 19 c, d, e</p>	<p>Pedagogical Content Knowledge (Shulman, 1987)</p>	<p>Model recognises the existence of four categories of knowledge for practitioners: Content knowledge; pedagogical knowledge; professional knowledge and at the union of these three is Pedagogical Content Knowledge (PCK)</p>	<p>1. Content knowledge i) Subject related knowledge e.g Physics content, nature of science / Scientific Method 2. Pedagogical Knowledge i) Teaching skills and strategies ii) Depth Required for e.g A-level 3. Professional Knowledge i) Curriculum design (Schemes) ii) Examinations iii) What it means to be a Science teacher. 4. PCK i) Integration of knowledge into new entity.</p>	<p>Useful when impact is assessed in terms of reflective practice as contrasted with competence in classroom practice. Independent components of PCK, existing on their own, would indicate low impact of the professional development process, on the individual's practice.</p>
<p>13 18 a, b, c, d, e 19 a, b, c, d, e</p>	<p>Professional Development Outcomes (Harland and Kinder, 1997)</p>	<p>Model tries to systematically provide a taxonomy of Professional Development outcomes based on teachers reflection upon their practice.</p>	<p>9. r Material and provisional outcomes ii) Information Outcomes iii) New Awareness iv) Value Congruence 9. r Affective Outcomes vi) Motivation 9. r Knowledge and Skills 9. r Institutional Outcomes ix) Impact on Practice</p>	<p>Useful in providing items to assess outcomes in similar manner to the Gilbert and Bell Model.</p>

Appendix 3.3: Research Questionnaire

Impact of ICT on Teacher Professional Development

For distribution to A – level Science and Mathematics Teachers

The purpose of this study is to assess the impact that ICT has had on your professional life. For the purpose of this research, ICT will be taken to mean the use of computers for communication i.e. e-mail and Internet only. The information you submit will be used only for the purposes of this research, and will be treated as confidential.

A. Biographical Details

(Please tick (✓) the answers that apply to you)

1. Gender: Female Male
2. Type of school where you teach:

Government High School <input type="checkbox"/>	Mission High School <input type="checkbox"/>
Private School <input type="checkbox"/>	College <input type="checkbox"/>
3. Where is your school located?

Within an urban area <input type="checkbox"/>	In a peri – urban area <input type="checkbox"/>
In a rural area <input type="checkbox"/>	
4. In which Region is your school located ?
5. What is / are your specialist subjects?
6. What subject (s) is / are you actually teaching?
7. How long have you been teaching this/ these subject (s)?
8. Where did you obtain your current teaching qualification?
9. Does your school have computer facilities? Yes. No.
10. If your answer to 9. above is "Yes",

Can you access the computer at your school?	Yes <input type="checkbox"/> No <input type="checkbox"/>
---	--
11. Have you used ICT in the last 12 months? Yes. No.

If your answer to question 11 is NO, then this is the end of the questionnaire. Thank you very much for your co-operation.

If your answer to question 11 is Yes, please turn over the page and proceed to part B.

B. ICT skills

12. How did you acquire your ICT Skills?
(please tick (☑) only one appropriate response)

- Through undergraduate degree courses
- Through initial teacher education
- Through the WORLD Links and BSPZ Centres
- Through Science and Maths Centres
- Through Internet cafes
- Self taught

13. How experienced are you with the following ICT activities?
(Please circle the appropriate response)

a)	Word processing:	Extensive	Moderate	Minimum	None
b)	e-mail:	Minimum	Moderate	Extensive	None
c)	Internet Searching:	Extensive	Minimum	Moderate	None
d)	e-conferencing:	Moderate	Extensive	Minimum	None
e)	record keeping:	Extensive	Moderate	Minimum	None

14. Where do you normally access ICT facilities?

15. How often do you access the ICT facilities? Please tick (☑) one box only.

- Daily At least once a week At least once a month
 At least once a term Less than once a term

16. How far are these facilities from your place of work? (estimate distance)

17. Do you have problems accessing ICT facilities? Yes No

If YES, please answer the questions below. If NO, please go to question 18.

If your answer to question 17 was YES, what problems have you experienced in accessing ICT facilities?

- Problem 1: _____
 Problem 2: _____
 Problem 3: _____

C. Purpose for using e-mail and Internet facilities

18. The questions below are about some purposes of using E-mail.

Please cross (X) the response that best describes your answer to each question.

How useful do you consider e-mail		Very Useful	—————→			Useless	
a)	to communicate with colleagues?	①	②	③	④	⑤	Don't Know
b)	to communicate with friends?	①	②	③	④	⑤	Don't Know
c)	to seek assistance on problematic topics in your area?	①	②	③	④	⑤	Don't Know
d)	to develop teaching materials collaboratively with others far away?	①	②	③	④	⑤	Don't Know
e)	to compare your teaching methods with those of your colleagues?	①	②	③	④	⑤	Don't Know

19. The questions below are about some aspects of using the internet.

Please cross (X) the response that best describes your answer to each question.

How useful do you consider the internet		Very Useful	—————→			Useless	
a)	to communicate with colleagues through online based discussion groups?	①	②	③	④	⑤	Don't Know
b)	to entertain yourself?	①	②	③	④	⑤	Don't Know
c)	to get information on problematic topics in your area?	①	②	③	④	⑤	Don't Know
d)	to get ideas on how to develop teaching materials for your subject	①	②	③	④	⑤	Don't Know
e)	to get ideas on how to improve your teaching	①	②	③	④	⑤	Don't Know

20. Which one of the eight statements below best describes the role of ICT in your professional development?

Please place a cross (X) on the circled number of the appropriate response.

- ① I have little or no knowledge of the use of ICT in professional development and I do not need it.
- ② I need more information about how to use ICT for professional development purposes and I am actively making enquiries.
- ③ I am preparing to use ICT for the first time, for my professional development.
- ④ I am primarily interested in mastering ICT skills for use in my professional development
- ⑤ I am reasonably comfortable with using ICT for professional development. I am now considering how to maximize its effects on my professional development.
- ⑥ I use ICT in different ways for my professional development in order to maximize its effects with my students

Appendix 3.4: Interview Schedule

The Impact of ICT on Science and Mathematics Teachers' Professional Development

1. Introduction: Background Information

- a) Where are you teaching at present?
- b) School type (Rural, urban, independent?)
- c) Teaching experience?
- d) Teaching qualification (CE, B.Ed, B.Sc, B.Sc+GradCE, Licentiate, etc)?
- e) Teacher Training Institution?
- f) Major subjects of specialisation?
- g) Subjects currently taught?
- h) If subject is different from (f) above: Why are you teaching this subject?
- i) How do you feel about teaching this subject?

9.1 Concerns

- a) computer facilities at school?
- b) Access? Why?
- c) How do you feel about your access to computer resources at your school? Why?
- d) How often do you visit this centre? Why?
- e) Internet access? If "yes" why? Where?
- f) Which Internet sites do you frequently visit?
- g) Why do you visit these sites?
- h) e-mail access? If "yes" Why? Where? Quality?
- i) What is the main use of your e-mail? Why?
- j) Are there any other reasons why you come to this centre?

9.1 Activity

- a) What materials do you usually access on the computer? Why?
- b) other services accessed using the ICT? Why?
- c) Material downloads from the Internet? Examples? Why?
- d) How sites were selected?
- e) Use of downloaded materials? How? Why? Where?
- f) Benefits to teacher:
 - a. As a professional?
 - b. As a classroom practitioner? Justify
- j) Quality of materials? Justify – examples.
- k) Depth coverage? Justify – examples
- l) Benefits of e-mail communication :
 - a) Professional life?
 - b) classroom practice?
 - c) Social life?
 - d) Personal life (prompt for examples for {a – d})
- n) Why have you chosen this method of communication? How convenient is it to you?
- o) What can you say about the quality of the e-mail service at this centre? Does it meet your expectations?

9.1 Problems accessing and using ICT?

- a) Description of problems, why these problems are there? Solutions
- b) What can the Centre's administrators do to lessen your problems?
- c) Any other suggestions? Comments

Appendix 3.5: Copy of Access letters

Letter 1: Pilot Study access letter

Ref: C/426/3

*All communications should be addressed to
"The Secretary for Education Sport and Culture"
Telephones 734051/39 and 734071
Telegraphic address: "EDUCATION"
Fax: 734075; 794505*



Ministry of Education Sport and
Culture
P.O Box CY 121
Causeway
Zimbabwe

29 August, 2002

Mr Emmanuel Mushaikwa
Science and Mathematics Education Department
University of Zimbabwe
P O Box MP167
Mt Pleasant
HARARE

**PERMISSION TO CARRY OUT RESEARCH ON "THE IMPACT OF ICT ON
TEACHERS PROFESSIONAL DEVELOPMENT IN ZIMBABWE SCHOOLS"**

With reference to your application to carry out research on the abovementioned topic in the Ministry of Education's Institutions, permission is hereby granted. You are, however, required to liaise with the Regional Directors of Matabeleland North, Masvingo and Manicaland Regions for clearance before carrying out your research.

You are also required to supply the Ministry of Education with a final copy of your research which may contain information instrumental to the development of education in Zimbabwe.

J. Chinamasa

J. Chinamasa

for: **PERMANENT SECRETARY FOR EDUCATION, SPORT AND CULTURE**

Letter 2: Field work access letter

*all communications should be addressed to
"The Secretary for Education Sport and Culture"
Telephone: 734051/59 and 734071
Telegraphic address: "EDUCATION"
Fax: 794505*



ZIMBABWE

Ministry of Education Sport and Cultu
P.O Box CY 121
Causeway
Zimbabwe

11 March 2003.

Mr. E Mushayikwa
Educational Studies
University of York
Heslington
York, YO 10 5DB
United Kingdom

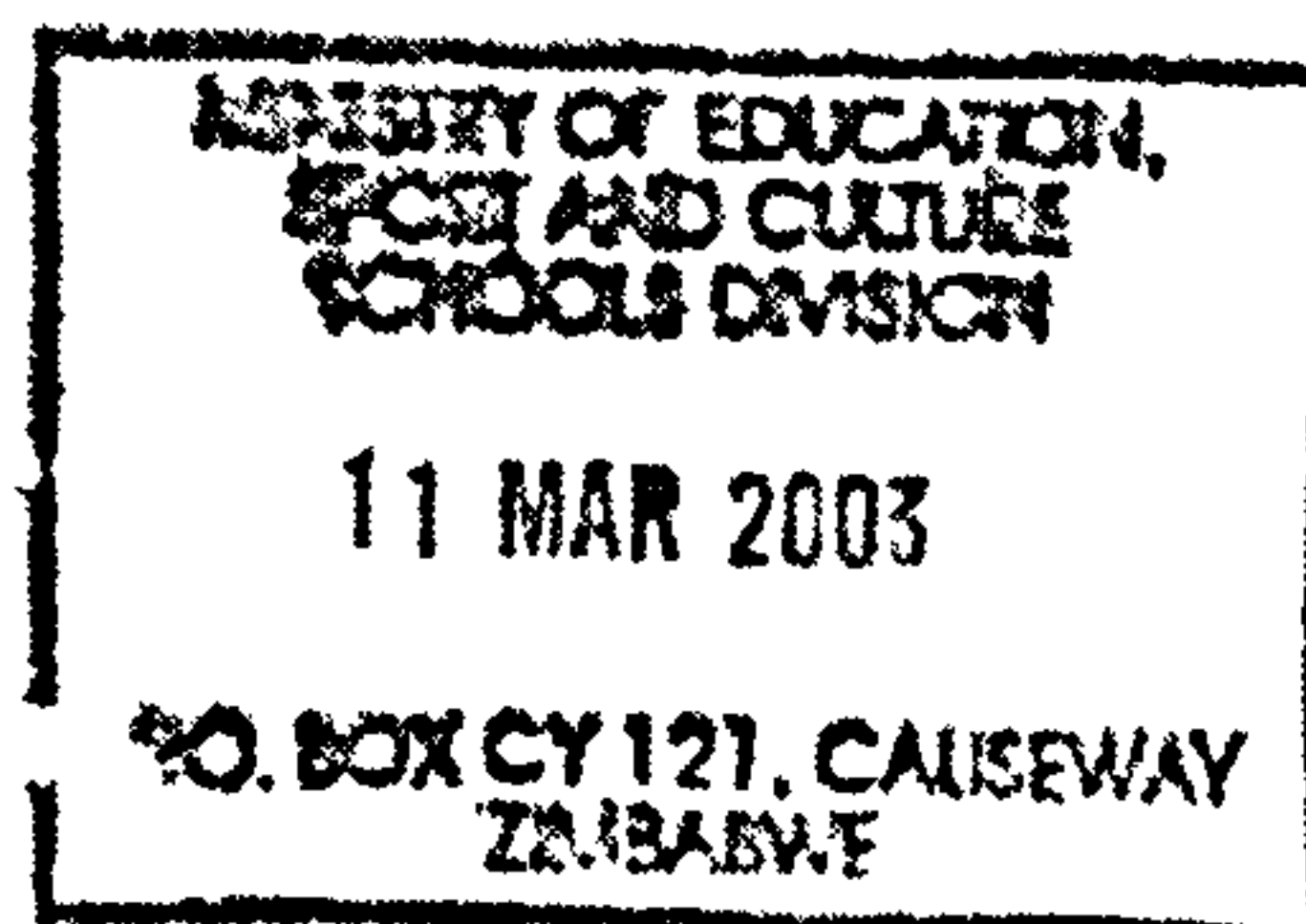
**RE: PERMISSION TO CARRY OUT RESEARCH ON DATA COLLECTION
FIELDWORK IN ZIMBABWE A - LEVEL SCHOOLS.**

With reference to your application to carry out research on the above mentioned topic in the Ministry of Education's institutions, permission is hereby granted. You are, however, required to liaise with the Provincial Education Director Harare for clearance before carrying out your research.

You are also required to supply the Ministry of Education, Sport and Culture with a copy of your research that may contain information instrumental to the development of Education in Zimbabwe.

A handwritten signature in black ink, appearing to read 'L.P. Muranzi'.

L.P. Muranzi
For: SECRETARY FOR EDUCATION, SPORT AND CULTURE



Letters 3 and 4: Sample regional access letters

Ref:

*all communications should be addressed to
"The Provincial Education Director"
Telephone: 067-23083/4/5
Telex: 067 41133
Fax: 067-23320*



Ministry of Education Sport and Culture
Mashonaland West
P.O Box 328
Chinhoyi

4 June, 2003

TO HEADS OF THE FOLLOWING (A) LEVEL SCHOOLS

1. Chemungamba High School	6. Matocanhembe High School
2. Chikangwe High School	7. Sanyati Baptist High
3. Nyambunga High School	8. Jameson High School
4. Kiso - Inyanga-Mhondoro Sec. School	9. Ngezi High School
5. St. Enns High School	10. Sandingham High School
	11. Moleli High School
	12. Kutama College
	13. Chicheyi High
	14. Nemaikonde High

Dear Sir/Madam

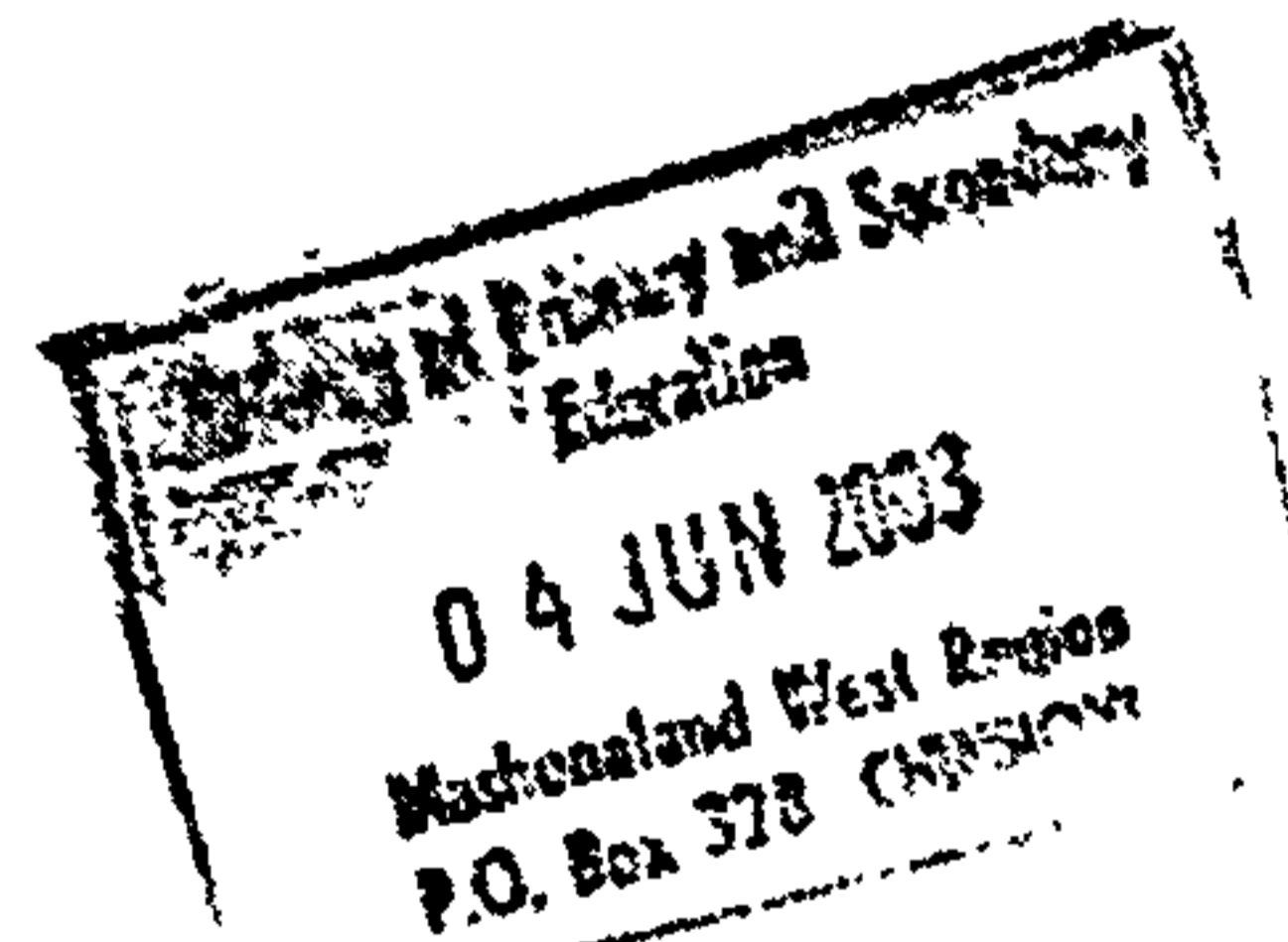
APPLICATION FOR PERMISSION TO CARRY OUT AN EDUCATIONAL RESEARCH IN SELECTED SCHOOLS IN MASHONALAND WEST PROVINCE

Permission to carry out a research on the specified topic and in specified areas in Mashonaland West has been granted on these conditions.

- a) That in carrying out this you do not disturb the learning and teaching programmes in schools.
- b) That you avail the Ministry of Education, Sport and Culture with a copy of your Research findings.
- c) That this permission can be withdrawn at anytime by the Provincial Education Director or by any higher office.

The Provincial Education Director wishes you success in your research work and in your University studies.

Education Officer Professional Administration
for: PROVINCIAL EDUCATION DIRECTOR
MASHONALAND WEST
/cdc



Reference:

*All communications should be addressed to
"The Provincial Education Director
Mashonaland East Province"
Telephone: 079-24811/4 and 24792
Telex : 81023
Fax: 079-24791*



Ministry of Education, Sport & Culture
Mashonaland East Province
P.O. Box 752
Marondera
Zimbabwe

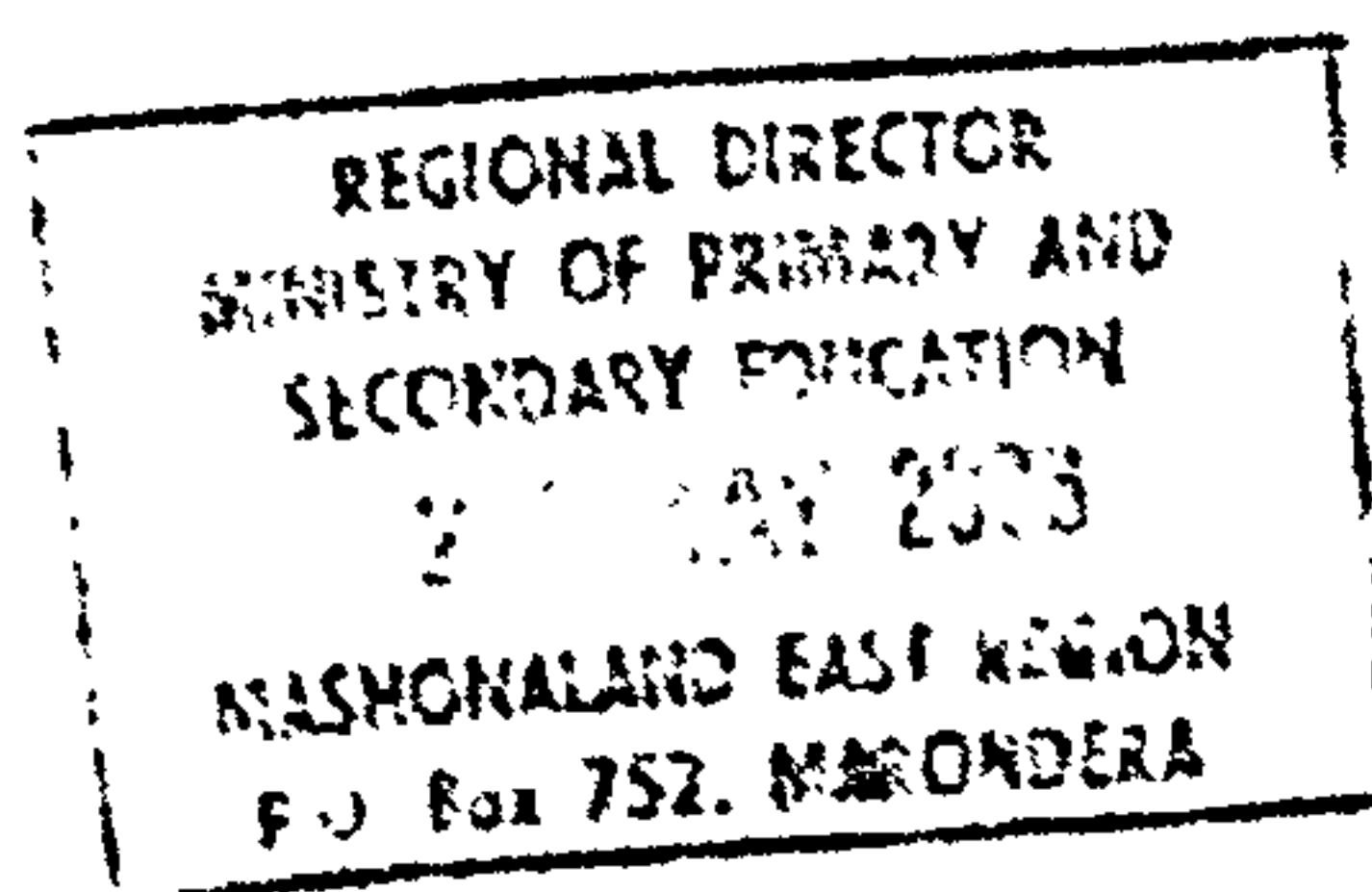
27 May, 2003

TO WHOM IT MAY CONCERN

**RE : PERMISSION TO CONDUCT RESEARCH ON DATA COLLECTION
FIELDWORK IN ZIMBABWE 'A' LEVEL SCHOOLS : MR E. MUSHAIKWA**

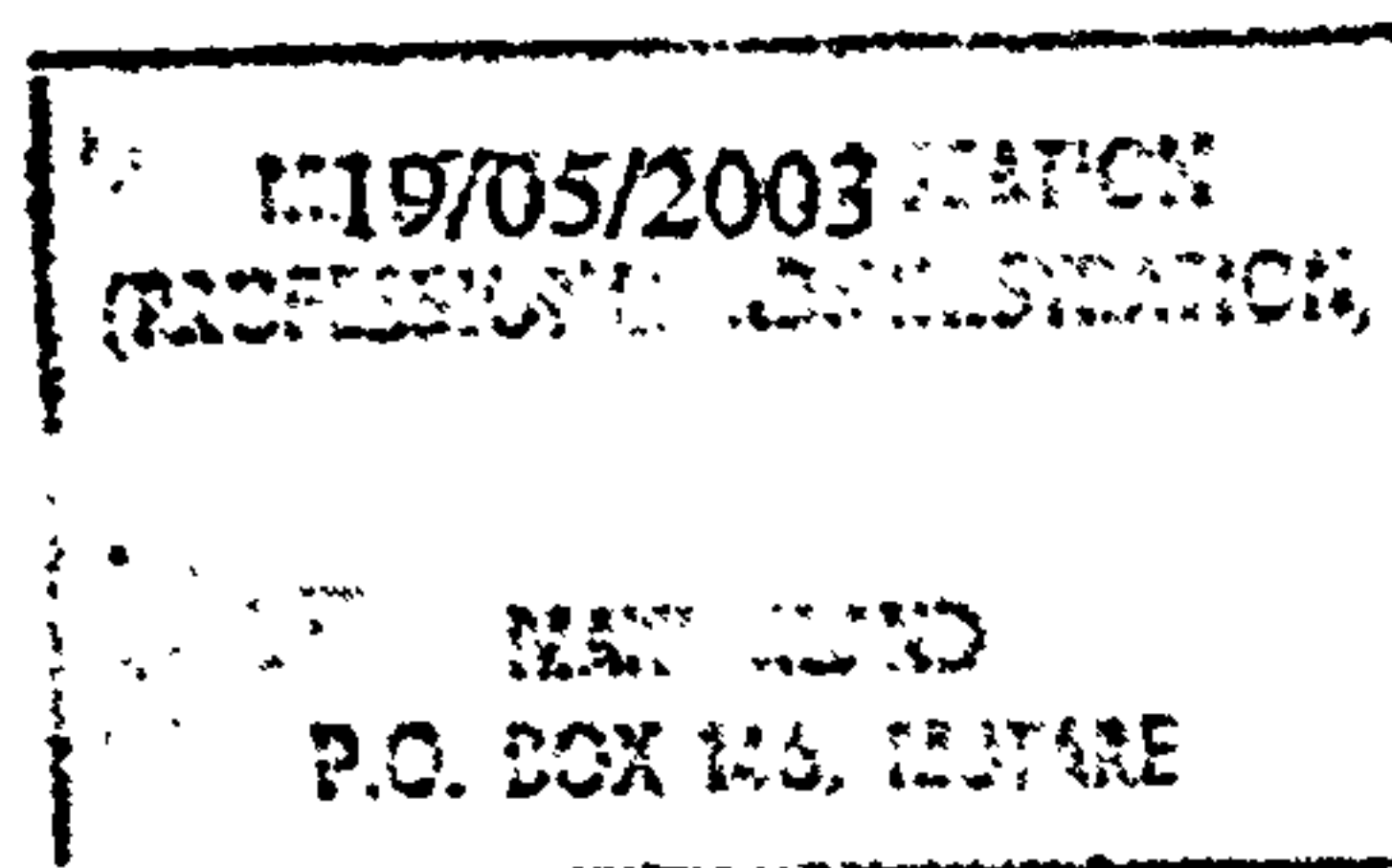
The above named has permission to access schools of his choice in Mashonaland East Province to enable him to carry out his research.

A handwritten signature in black ink, appearing to be 'S.M. Mutomba'.



**S.M. MUTOMBA
A/PROVINCIAL EDUCATION DIRECTOR
MASHONALAND EAST PROVINCE
SMM/cc**

Ministry Of Education
Box 146
MUTARE



Mr E. Mushayikwa
Educational Studies
University of York
Heslington
York, YO10 SDB
United Kingdom

**RE: PERMISSION TO CARRY OUT RESEARCH ON DATA COLLECTION
FIELDWORK IN ZIMBABWE A-LEVEL SCHOOLS**

The bearer is a student at University of York Heslington. He has permission to do research in our 'A' level schools. Please assist him.


A. Chigumira
FOR D.E.D MANICALAND

Appendix 3.6: Copy of letter accompanying postal questionnaires

**Science and Mathematics Education Department
University of Zimbabwe
P. O. Box MP 167
Mt. Pleasant
Harare
Zimbabwe
e-mail: Mushayikwa@hotmail.com
Tel: 091-334227**

22 May, 2003

To Whom It May Concern:

Re: Research Instrument on “*Impact of Information Communication Technology on Teacher Professional Development.*”

I am carrying out a Ph.D research study on the above topic. I have been granted permission to carry out the research in Zimbabwean A-level schools, by the Ministry of Education Permanent Secretary. I have also obtained regional authorisation and clearance to work in your school.

I am therefore requesting for your assistance to distribute the enclosed instrument to A-level Science and Mathematics teachers in your school. Science in this context is taken to include Biology, Chemistry, Physics and Geography and excludes computer science / studies for obvious reasons.

I would be very grateful if you could ask the teachers to complete the questionnaire carefully and if you could return the completed questionnaires in the self addressed stamped envelop provided.

I apologise for the intrusion in your busy schedule, and assure you that the results of this survey will provide useful insights into the ways teachers approach issues of their own professional development and thus will be vital to all those responsible for the planning and managing of staff development programs both at the local, regional and national level. Therefore the results of the survey will be disseminated to all contributors.

I will be available for any queries and am prepared to travel to your school, should the need arise. In particular, I would be very interested to interview those of your teachers who have personally used the Internet as a resource in the teaching of their subject. I would be grateful if such teachers could indicate on their questionnaires if they are willing to be interviewed by me at school, so as to provide deeper insights into their experiences.

Looking forward to your assistance

Yours Faithfully,

Emmanuel Mushayikwa

Appendix 3.7: Interview coding system

Teacher	Gender	Qualification	Subject	Experience	Date of interview
MAS01M	Female	BSc and GradCE	Mathematics	0 – 4yrs	15/05/2003
MAS02M	Male	BSc and GradCE	Biology	4.1 – 10yrs	15/05/2003
MAS03M	Male	Licentiate	Chemistry	4.1 – 10yrs	15/05/2003
MAS04V	Male	BSc and GradCE	Physics	4.1 – 10yrs	15/05/2003
MAS05V	Female	BSc and GradCE	Mathematics	4.1 – 10yrs	16/05/2003
MAS06V	Male	Licentiate	Chemistry	4.1 – 10yrs	16/05/2003
M07H	Male	Licentiate	Chemistry	4.1 – 10yrs	19/05/2003
M08H	Male	Licentiate	Biology	4.1 – 10yrs	19/05/2003
M09H	Male	Licentiate	Chemistry	4.1 – 10yrs	20/05/2003
M10M	Female	BSc and GradCE	Biology	0 – 4 yrs	20/05/2003
M11M	Female	BSc and GradCE	Biology	Over 10 years	20/05/2003
ME12M	Male	Licentiate	Physics	Over 10 years	22/05/2003
ME13M	Male	Licentiate	Chemistry	Over 10 years	22/05/2003
ME14N	Male	Licentiate	Physics	4.1 – 10yrs	22/05/2003
ME15B	Female	BSc and GradCE	Biology	0 – 4 yrs	22/05/2003
MN16S	Male	Licentiate	Chemistry	Over 10 years	31/05/2003
MW17C	Male	Licentiate	Physics	4.1 – 10yrs	05/06/2003
MW18C	Male	Bed	Physics	0 – 4yrs	05/06/2003
MW19C	Female	BSc and GradCE	Biology	4.1 – 10yrs	05/06/2003
MAS20N	Male	BSc and GradCE	Mathematics	Over 10 years	13/06/2003
MAS21M	Male	Licentiate	Physics	4.1 – 10yrs	13/06/2003
MAS22V	Male	BSc and GradCE	Mathematics	Over 10 years	13/06/2003
MAS23K	Female	BSc and GradCE	Geography	Over 10 years	13/06/2003
MAS24M	Female	Bed	Mathematics	0 – 4yrs	13/06/2003
ME25B	Female	Bed	Biology	4.1 – 10yrs	20/06/2003
ME26N	Male	BSc and GradCE	Physics	Over 10 years	20/06/2003
ME27M	Male	Bed	Chemistry	Over 10 years	20/06/2003
H28G	Male	BSc and GradCE	Biology	4 – 10yrs	23/06/2003
H29G	Male	BSc and GradCE	Physics	Over 10 years	23/06/2003
H30G	Female	BSc and	Mathematics	0 – 4yrs	23/06/2003

		GradCE		Over 10	
H31A	Male	BSc Ed	Geography	years	24/06/2003
H32A	Female	BSc	Mathematics	4.1 – 10yrs	24/06/2003
M33S	Male	Licentiate	Mathematics	4.1 – 10yrs	27/06/2003
M34S	Female	BSc	Mathematics	0 – 4yrs	27/06/2003
M35B	Female	Licentiate	Geography	4.1 – 10yrs	27/06/2003
M36M	Female	BSc and GradCE	Geography	Over 10 years	27/06/2003
ME37W	Male	Licentiate	Chemistry	4.1 – 10yrs	01/07/2003
ME38W	Female	BSc	Physics	Over 10 years	01/07/2003
ME39W	Male	Bed	Biology	0 – 4yrs	01/07/2003
ME40P	Female	BSc and GradCE	Mathematics	Over 10 years	04/07/2003
ME41B	Male	Licentiate	Geography	Over 10 years	04/07/2003
ME42M	Female	Licentiate	Chemistry	4.1 – 10yrs	04/07/2003
MN43L	Male	Licentiate	Physics	4.1 – 10yrs	21/01/2004
MN44S	Male	BSc and GradCE	Chemistry	Over 10 years	22/01/2004
H45Q	Female	BSc	Biology	0 – 4yrs	26/01/2004
MN46S	Male	Licentiate	Chemistry	Over 10 years	28/01/2004
MN47M	Male	Licentiate	Physics	4.1 – 10yrs	28/01/2004
MN48M	Male	BSc and GradCE	Chemistry	0 – 4yrs	28/01/2004
MN49E	Male	Licentiate	Mathematics	0 – 4yrs	29/01/2004
MN50Ma	Male	Licentiate	Physics	Over 10 years	29/01/2004
MAS51Mu	Male	Licentiate	Biology	4.1 – 10yrs	30/01/2004
MAS52V	Female	Licentiate	Biology	4.1 – 10yrs	30/01/2004
MAS53V	Male	BSc	Mathematics	Over 10 years	30/01/2004
MAS54M	Female	BSc	Chemistry	4.1 – 10yrs	27/01/2004

Appendix 3.8 Interview Analysis Framework

Themes	Repeating Ideas	Research Question
<p>1. Perceived Professional Identity</p>	<p>1.1 well-being / self (esteem, respect, confidence) 1.2 Social status / (commanding) respect / trust from / fellow teachers / students / society / social expectations 1.3 Perceived role of teacher: (/ control / facilitator / guide) [red =control / black = facilitator / guide]</p>	<p>RQ2</p>
<p>2. Career Development Needs</p>	<p>2.1 Career change / applications / greener pastures 2.2 Continuing professional development / training / ICT induction / school ICT policy / Continuing professional learning / keeping abreast with developments in teaching/ support for lifelong learning 2.3 Further Study / Seek study opportunities / better qualifications /</p>	<p>RQ2</p>
<p>3. Management of the ICT environment</p>	<p>3.1 Access concerns (access / speed / cost / queues / ICT access censorship) 3.2 ICT resource distribution (Computers available / provision / where accessed / distribution / 3.3 Reliability of ICT resources / convenience / (need for) caution / contingency / appropriateness / discretion in use / 3.4 Support / encouragement from school / peers / society / community / ICT seen as enhancing school status 3.5 Approaches to ICT use : directed / purposeful surfing / curious / exploratory / accidental / prioritization of access and usage</p>	<p>RQ1</p>

	<p>3.6 Access rating: [black = satisfaction; red = dissatisfaction]</p>	
<p>4. Theoretical and Content knowledge</p>	<p>4.1 New content / interest in new knowledge / Deepening / broadening understanding of content / updating / enrichment / search / browse / download materials for self 4.2 Textbook Supplements / background reading / alternatives to textbooks / variety of content / unmodified Teaching / classroom notes / used as reinforcement / revision / new skills / correct misconceptions / search / browse / download materials for students / save materials to disk / print out materials / make photo copies</p>	<p>RQ3</p>
<p>5. Practical knowledge and Professional skills</p>	<p>5.1 Teaching resources / demonstrations / simulations / practicals / equipment / models / illustrations / Rating of use of ICT resources [red = not useful; black = useful] 5.2 Organisation of teaching and assessment / Syllabus / examination materials / Teaching administration / schemes of work / records / assessment / reports / mark schedules / management / lesson preparation / lesson planning / organisation of materials 5.3 Ideas on teaching approaches / improvements / variety of teaching approaches / more systematic / more innovative / creative ideas / brings about change in practice</p>	<p>RQ3</p>
<p>6. Pedagogical Content Knowledge</p>	<p>6.1 Adaptation to syllabus depth / requirements / different student abilities and learning styles 6.2 Modification of materials to suit local conditions / local context / language levels / learning needs 6.3 Linking concepts with current affairs / relevance of content / making concrete / concretising 6.4 Developing teaching / learning materials / modules / Test and evaluate materials before student use / Quality of materials [red = poor ; black = good]</p>	<p>RQ3</p>

<p>7. Professional networking</p>	<p>7.1 Collaboration / Comparing / sharing experiences / updating each other on teaching skills and innovation / relevance of shared experiences / Collaboration studies / jointly developing ideas</p> <p>7.2 Peer Support / Coaching / peer review / peer encouragement / mentoring / tutoring / Search /browse / download materials for teachers</p> <p>7.3 Professional Communications / peer communications / making contacts / Institutional communications / subscriptions / online discussion / chat groups</p>	<p>RQ2</p>
<p>8. Perceived benefits of ICT use to students (perceived by teacher)</p>	<p>8.1 Performance / Student achievements / quality of passes</p> <p>8.2 Affective Issues / Student enjoyment / motivation / interest / confidence in learning</p> <p>8.3 Cognitive issues / Student understanding / appreciation /critical reasoning / analysis / creativity / innovation /</p> <p>8.4 Participation / Student participation / attentiveness / Student discipline /memory retention</p>	<p>RQ3</p>
<p>9. Perceived benefits to the teacher (self)</p>	<p>9.1 Affective Issues /Teaching becomes interesting / enjoy teaching / become a better teacher / improve teaching</p> <p>9.2 Being informed / Teacher is more up to date / in line with modern trends / informed</p> <p>9.3 Reflective Practitioner / Teacher is more reflective / critical / innovative / creative / develop coping mechanism</p> <p>9.4 Professional networking / Teacher is less isolated / feels being part of global village / widens horizon</p> <p>9.5 Effectiveness / Teacher is more responsive to student needs / more effective / achieves better results</p> <p>9.6 Awareness / Teacher is more aware / appreciative of ICT use /sees ICT as labour saving / indispensable</p>	<p>RQ2</p>

Addendum: Issues (bold); Ideas (normal)

Appendix 5.1: Reliability Analysis

** Method 2 (covariance matrix) will be used for this analysis ***

RELIABILITY ANALYSIS - SCALE
(ALPHA)

Cases		Mean	Std Dev
1.	IMPROVE	2.1461	1.3276
89.0			
2.	DEVELOP	2.0562	1.3087
89.0			
3.	INFORM	1.8989	1.1486
89.0			
4.	GROUPS	2.2921	1.4632
89.0			
5.	COMPARE	2.7528	1.3840
89.0			
6.	COLLABOR	2.3371	1.3224
89.0			
7.	ASSIST	2.1685	1.3419
89.0			
8.	COLLEAGU	1.5955	1.0946
89.0			

Correlation Matrix

	IMPROVE	DEVELOP	INFORM	GROUPS
COMPARE				
IMPROVE	1.0000			
DEVELOP	.9174	1.0000		
INFORM	.8147	.8430	1.0000	
GROUPS	.3639	.3711	.3491	1.0000
COMPARE	.5146	.4532	.4774	.4681
1.0000				
COLLABOR	.4959	.5208	.4940	.4184
.6918				
ASSIST	.5091	.4669	.5273	.3335
.5917				
COLLEAGU	.1115	.1430	.1840	.2307
.3308				
	COLLABOR	ASSIST	COLLEAGU	
COLLABOR	1.0000			
ASSIST	.7232	1.0000		
COLLEAGU	.2994	.3177	1.0000	
N of Cases =		89.0		

Statistics for Variables	Mean	Variance	Std Dev.	N of
Scale	17.2472	57.8473	7.6057	8

Item Means Range	Max/Min	Mean Variance	Minimum	Maximum
1.1573	1.7254	2.1559 .1140	1.5955	2.7528

RELIABILITY ANALYSIS - SCALE (ALPHA)

Analysis of Variance

Source of Variation	Sum of Sq.	DF	Mean Square	Chi-square Prob.
Between People	636.3202	88	7.2309	
Within People	631.3750	623	1.0134	
Between Measures	71.0211	7	10.1459	
70.0790	0.0000			
Residual	560.3539	616	.9097	
Total	1267.6952	711	1.7830	
Grand Mean	2.1559			

Coefficient of Concordance W = .0560
 Reliability Coefficients 8 items
Alpha = .8742 **Standardized item alpha = .8733**

Appendix 5.2: Teachers' Responses to Item 22

Have you ever used materials obtained from the Internet for teaching? If you have, Explain briefly what you did and whether you think this use of ICT was beneficial for your students? (continue on additional paper if necessary)

Responses were coded using by identifying common keywords used by teachers. Teachers who mentioned uses which were non educational were coded zero. Examples of such uses were use of e-mail to communicate with friends, apply for jobs or use of Internet to access news websites, or to access music.

Coding in hierarchical order:

- 0 Not used for Educational purposes
- 1 Teaching notes/Lesson Notes/
- 2 Teaching Resources /Simulations/ Lesson Plans/ Demonstrations/
Supplementary information / notes / Textbook alternative
- 3 Student Notes/ Student Resources
- 4 Revision / tests/ exams

Frequencies:

Code	Total Frequency	% Frequency	Cumulative Frequency %
0	26	36	36
1	18	25	61
2	21	29	90
3	4	5	95
4	3	5	100
Total	72	100	

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