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Factors affecting teachers' use of computer technology for promoting meaningful learning

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Chapter 2

Conceptual framework for the study of factors affecting teachers' use of technology

This chapter describes the development of one of the two conceptual frameworks used in this study. The importance of using a conceptual framework for research, in general, is discussed before describing the development of the framework for the investigation of factors impacting on teachers' use of ICT. This framework guided the factors investigation during both phases of the study. The development of the second framework, for the software evaluation conducted during the first phase of the study, will be described in Chapter 5, the chapter dealing with the evaluation of the EduRom package.

2.1 THE IMPORTANCE OF USING A CONCEPTUAL FRAMEWORK

Abd-El-Khalick and Akerson (2007, p. 188) emphasise the importance of using devices grounded in theory to guide research. Researchers use frameworks consisting of linked ideas, often gleaned from the literature, to provide a frame of reference within which to conduct investigations. These outlining structures are called 'theoretical' or 'conceptual' frameworks. Some researchers (Leshem & Trafford, 2007; Sinclair, 2007) use the terms as synonyms without explaining why they do so. Other researchers (e.g. Maxwell, 2005; Miles & Huberman, 1994) explain that that they consider theoretical and conceptual frameworks as the same thing, because they serve the same purpose. Maxwell (2005, p. 33) states that a 'conceptual framework' "*may also be called the "theoretical framework" for a study"*. In this study I will use the term 'conceptual framework', which Maxwell (2005, p. 33) defines as the framework of "*concepts, assumptions, expectations, beliefs, and theories that supports and informs your research*".

2.1.1 Benefits of using conceptual frameworks

Using a conceptual framework offers researchers a number of benefits. Firstly, researchers are more likely to have their research accepted as "*quality research*" by the broader community (Caliendo & Kyle, 1996, p. 226), because it will be clear from which perspective the research was approached and what underlying assumptions influenced the research design. Constructing a framework provides evidence that a researcher has reviewed the literature, selected relevant theories and/or concepts, and organised them into a structure which shows the boundaries of the present study and presents "*… the main dimensions to be studied – the key factors or variables – and the presumed relationships among them*" (Miles & Huberman, 1994, p. 18). While it is possible to conduct research without a clearly stated framework, Caliendo and Kyle (1996) assert that it is precisely the use of frameworks and the structure they confer on research that distinguishes scholarly work from journalism. Secondly, the use of a framework suggests that researchers understand what they are studying (Mertens, 2005). Thirdly, where a framework is used, researchers will approach the research with certain underlying assumptions arising from their theoretical perspective (Mertens, 2005). The researchers' underlying assumptions will permeate through every aspect of the research design and provide structure to the

design. The underlying assumptions will influence the phrasing of the research questions, the choice of strategies used to collect data to answer the research questions and, ultimately, the interpretation of the research findings (Mertens, 2005). Finally, the use of frameworks which are "*grounded in empirical data that have been verified and ... rest on sound postulates and hypotheses*" provides a body of evidence (Cohen et al., 2000, p. 12). Some researchers believe that such a body of evidence can be used as a base to which research findings can be compared when the new data is interpreted (Abd-El-Khalick & Akerson, 2007; Cohen et al., 2000).

2.1.2 Conceptual frameworks used in this study

The two conceptual frameworks used in this study (one of which is described in this chapter, and one in Chapter 5) are presented in graphic form, followed by descriptions. Conceptual frameworks can be presented in both graphical and narrative form, but some authors (e.g. Miles & Huberman, 1994) prefer conceptual frameworks to be displayed graphically. These authors believe that the discipline involved in naming concepts, mapping out the relationships between concepts and working "*with all the information at once*" (Miles & Huberman, p. 33) helps researchers clarify their thoughts, which ultimately contributes to better research.

2.2 CONCEPTUAL FRAMEWORKS FOR EDUCATIONAL TECHNOLOGY RESEARCH

This section deals with the importance of using conceptual frameworks to guide research in the field of educational technology.

Educational research, as carried out in this study, has been criticised for its failure to link existing theory and current practice (Austin, 2009; Boote & Beile, 2005; Mishra & Koehler, 2006), as can be done by using conceptual frameworks to guide new research. The failure to base research on previous work has inhibited the accumulation of a "*sound, reliable body of knowledge which can inform practitioners and ultimately improve education*" (Wellington, 2000, p. 28). One area which illustrates the difficulties which can arise when studies are not based on existing theory is the research which has been conducted into the factors which affect teachers' use of ICT in their teaching. Much research has been conducted in this field of study, resulting in "*a long, almost exhaustive list of factors that may affect the uses of technology in schools*" (Zhao & Frank, 2003, p. 809). These authors believe that

> *… these factors are often examined in isolation from each other or from the system in which they interact. Rarely are they studied together under a framework to sort out their relative importance and to identify the relationships among them.* (Zhao & Frank, p. 810).

Mishra and Koehler claim that while isolated studies of how and why teachers use technology may be valuable in contributing towards a better understanding of ICT in education, there still exists a need for a unifying conceptual framework that will "*identify themes and constructs that would apply across diverse cases and examples of practice*" (Mishra & Koehler, 2006, p. 1018). Mishra and Koehler cite Selfe (1990) as saying

> *[An] atheoretical perspective ... not only constrains our current educational uses of computers, but also seriously limits our vision of what might be accomplished with computer technology in a broader social, cultural, or educational context. Until we examine the impact of computer technology ... from a*

> *theoretical perspective, we will continue, myopically and unsystematically, to define the isolated pieces of the puzzle in our separate classrooms and discrete research studies. Until we share some theoretical vision of this topic, we will never glimpse the larger picture that could give our everyday classroom efforts direction and meaning.* (Mishra & Koehler, 2006, p. 1018)

A review of the literature revealed a number of frameworks and models for the factors affecting teachers' use of ICT (e.g. Al-Fudail & Mellar, 2008; Drent & Meelissen, 2008; Hermans, Tondeür, van Braak & Valcke, 2008; Hew & Brush, 2006; Hossain & Brooks, 2008; van Braak, 2001; Wood, Mueller, Willoughby, Specht & Deyoung, 2005; Zhao & Frank, 2003). However, the limitation pointed out by Zhao and Frank (2003), as well as by Wood et al. (2005), applied to many of these studies: they focused on the impact of a particular category or categories of factors (e.g. the impact of professional development or the effects of teachers' beliefs and/or attitudes towards computers on teachers' use of ICT) rather than looking holistically at all factors. In addition, none of the reviews I came across used frequencies of different factors to compare their relative importance. The Hew and Brush analysis of the barriers to ICT integration reporting on 48 studies published between 1995 and 2006 came closest to what I was looking for, but was not entirely suited for my purposes, for the following reasons.

1. Hew and Brush focused on the barriers to ICT integration, whereas I wanted to examine factors that both encouraged and discouraged teachers' use of ICT.
2. The Hew and Brush analysis was not sufficiently fine-grained for my purposes. For example, one of the categories they referred to as 'resources' included lack of technology (insufficient computers, peripherals, and software), access to available technology, time, and technical support. I wanted to investigate the separate components to better understand the impact of each component.
3. Due to the "*rapid advances in computer technology, and the changes within schools regarding the presence of technology*" (Wood et al., 2005, p. 185), new factors might have emerged since the Hew and Brush study or the impact of potential barriers may have changed. I wanted my list of factors to be as up to date as possible by including recent studies.

2.3 DEVELOPING THE CONCEPTUAL FRAMEWORK

Maxwell asserts that a conceptual framework is "*something that is constructed, not found*", and points out that "*the overall coherence"* of a conceptual framework *"is something that you build, not something that exists ready-made"* (Maxwell, 2005, p. 35). According to Maxwell there are four possible sources which can be used to derive a conceptual framework:

- the researcher's own experiences and knowledge,
- existing theory and research,
- exploratory research,
- thought experiments.

Three of these four sources were not an option for deriving a framework to guide this phase of my study. With reference to the first potential source, Maxwell believes that one's experiential knowledge is often overlooked as an important conceptual source. Whilst not ignoring my own insights, the extent of my own experience was too limited to use as a major source of concepts for developing the

conceptual framework for this part of my study. The third of Maxwell's four possible sources, 'conducting exploratory research' was not practical as I needed a framework to guide my study from its onset. Maxwell points out that using thought experiments (the fourth of the possible sources he mentions) draws on one's experiential knowledge. Having already acknowledged my limited experience, thought experiments were not an option I considered. I therefore relied mainly on the literature to identify as many of the factors other researchers have investigated as possible before constructing a concept map to represent the framework which would underpin this phase of the study.

I used content analysis to develop my conceptual framework from the literature. Krippendorf (2013) describes content analysis as a process of examining texts, and drawing inferences from the text which relate to the specific context within which the researcher is working. The steps I used in developing my conceptual framework are as follows:

1. **Finding suitable papers[4].** My search for suitable papers returned hundreds dealing with factors affecting teachers' use of ICT. However, in many studies the factors had emerged incidentally and were not the main focus of the paper. Narrowing down the papers to those which focused on factors influencing teachers' use of ICT left more than 67 papers. I then looked for papers based only on empirical research findings. After rejecting several literature reviews (e.g. Fabry & Higgs, 1997; Hew & Brush, 2006; Mumtaz, 2000) and papers focusing entirely on teaching computer literacy without any reported research (e.g. Bretz & Johnson, 2000), 48 empirical studies focusing on factors affecting teachers' use of ICT for instruction, published in peer-reviewed journals between 1992 and 2012, remained. One of the studies was part literature review and part research (Cox, Preston, & Cox, 1999). The methods used in the studies varied, involving qualitative, quantitative and mixed-method studies, and the educational settings included primary and secondary schools, and higher education institutions. A summary of the 48 studies is provided (Appendix D), which shows the country in which each study was conducted and a brief description of the sample, so readers can decide how generalisable the results of each study are. The summary also contains brief descriptions of the aims and the methods used for each study, which is useful to know when interpreting the results of a study.
2. **Identifying factors**. I read each paper and identified factors which emerged through open-coding, to provide a list of factors. Both the manifest and the latent content of articles were coded. Fraenkel, Wallen, and Hyun (2012) define manifest content as "*obvious, surface content*" that is easily coded without the need to draw any inferences. Latent content, as defined by these researchers, refers to the "*underlying meaning"* of content, and is more susceptible to subjective interpretations by researchers (Fraenkel et al., 2012, p. 484). On subsequent readings the list of factors was revised and updated using the process of constant comparative analysis (Strauss & Corbin, 1998), until no more factors emerged. Birks and Mills describe the process of constant comparative analysis as follows:

[4] Two online searches were conducted, one at the beginning of the first phase of the study (2009) and one at the beginning of the second phase of the study (2012). The *ERIC (Educational Resources Information Centre)* and *ScienceDirect* databases were searched using the combined search terms "factors", "teachers", and "technology/ ICT/ computers".

> *Part of the process of concurrent data collection and analysis is the constant comparison of incident to incident, incident to codes, codes to codes, codes to categories, and categories to categories. This is termed constant comparative analysis and is a process that continues until a grounded theory is fully integrated.* (Birks & Mills, 2011, p. 11)

I used two processes to improve the rigour for identifying factors from the papers. Firstly the scheme which was developed for the coding and data-capture process was face validated by a second researcher with experience in the field of instructional design and who is familiar with research in the area of factors affecting teachers' use of ICT. Face validating the coding scheme included checking it for comprehensiveness and checking whether the names and definitions of the codes accurately reflected the meanings of the texts, within the context of the study. Checking the accuracy of codes and definitions contributes to the semantic validity of a content analysis (Krippendorf, 2013). The checking process was iterative until both researchers were in agreement about the coding scheme that would be used to code the 48 papers. Secondly, inter-coder reliability was sought, by both researchers reading all the papers, coding the factors mentioned in that paper, and recording the instances of the codes in a spreadsheet. Where we had coded differently, a discussion ensued until we agreed about how to code the factor. As advised by Zhang and Wildemuth (2005) repeated checking of the coding scheme and the coding process promotes consistent coding and improves reliability.

After reviewing the 48 papers a list of 43 different factors emerged which impact on teachers' use of ICT. I compiled a table of the factors and their definitions. Weber (1990) advocates recording category names and definitions to promote consistent coding. I had also seen how useful a table of factor definitions could be from a paper by Hossain and Brooks (2008). The conceptual framework is presented in graphical format on page 26, followed by the table of factors on pages 27 and 28.

3. **Clustering the factors**. To facilitate handling and understanding the factors which emerged from the 48 papers reviewed, I clustered factors with a common theme together into categories. For example, all factors related to ICT hardware (the availability of ICT resources, how accessible the ICT resources were, and the functionality of equipment) were clustered together into the category 'hardware-related resources'. Aggregating the categories revealed three levels at which the factors operate. I refer to the first level as the 'institution-level' because it includes factors operating at the level of the educational establishment. Similarly 'learner-level' factors operate at the level of learners, but impact on teachers' use of ICT and 'teacher-level factors' are factors internal to teachers (e.g. their beliefs and attitudes). I constructed a concept map to represent the hierarchical relationships between the factors, the categories of factors, and the levels at which the factors operate. Maxwell (2005, p. 54) believes that concept maps are useful tools "*for developing theory and making that theory more explicit*". Visual models are useful for communicating the relationships between different components (Maxwell, 2005; Miles & Huberman, 1994).

4. **Frequency counts**. Frequency counts are often used in content analysis to show the extent of a category (Fraenkel et al., 2012; Krippendorf, 2013). I counted the number of papers mentioning a factor. Each paper which mentioned a factor was regarded as a '**case**' of that factor. For example, 13 papers mentioned the factor 'adequacy of finances to supply needs', thus the case count for that factor is 13. The frequencies for each of the 43 different factors are provided in Appendix E.

2.4 SUMMARY OF FACTORS AFFECTING TEACHERS' USE OF ICT

Maxwell (2005) regards 'concept mapping' as a useful technique for developing and displaying conceptual frameworks. A concept map is a visual display using text boxes to represent concepts and lines or arrows to show relationships between the concepts (Maxwell, 2005). As Maxwell points out, concept maps allow you to visualise and evaluate your conceptual framework, and provide a convenient way to visually display the framework. The concept map shown in Figure 5 on page 29 is a graphical representation of the conceptual framework derived from the factors identified from the 48 papers.

According to Maxwell (2005, p. 54), initial frameworks may be fairly diffuse, with large categories, which the researcher should focus over time to "*develop a real theory of what's going on*". The concept map on page 28 shows the hierarchy of relationships between the factors, the categories into which the factors are clustered, and the levels at which the factors operate. The factors are in the small print on the outside of the map. The framework shows how factors with a common theme have been clustered into categories of factors (yellow boxes in Figure 5) and how the categories have been aggregated into three levels, based on whether the factors within that category operate at the institutional-, teacher- or learner-level (green boxes in Figure 5), to give the following hierarchical relationship:

operational level → categories → factors

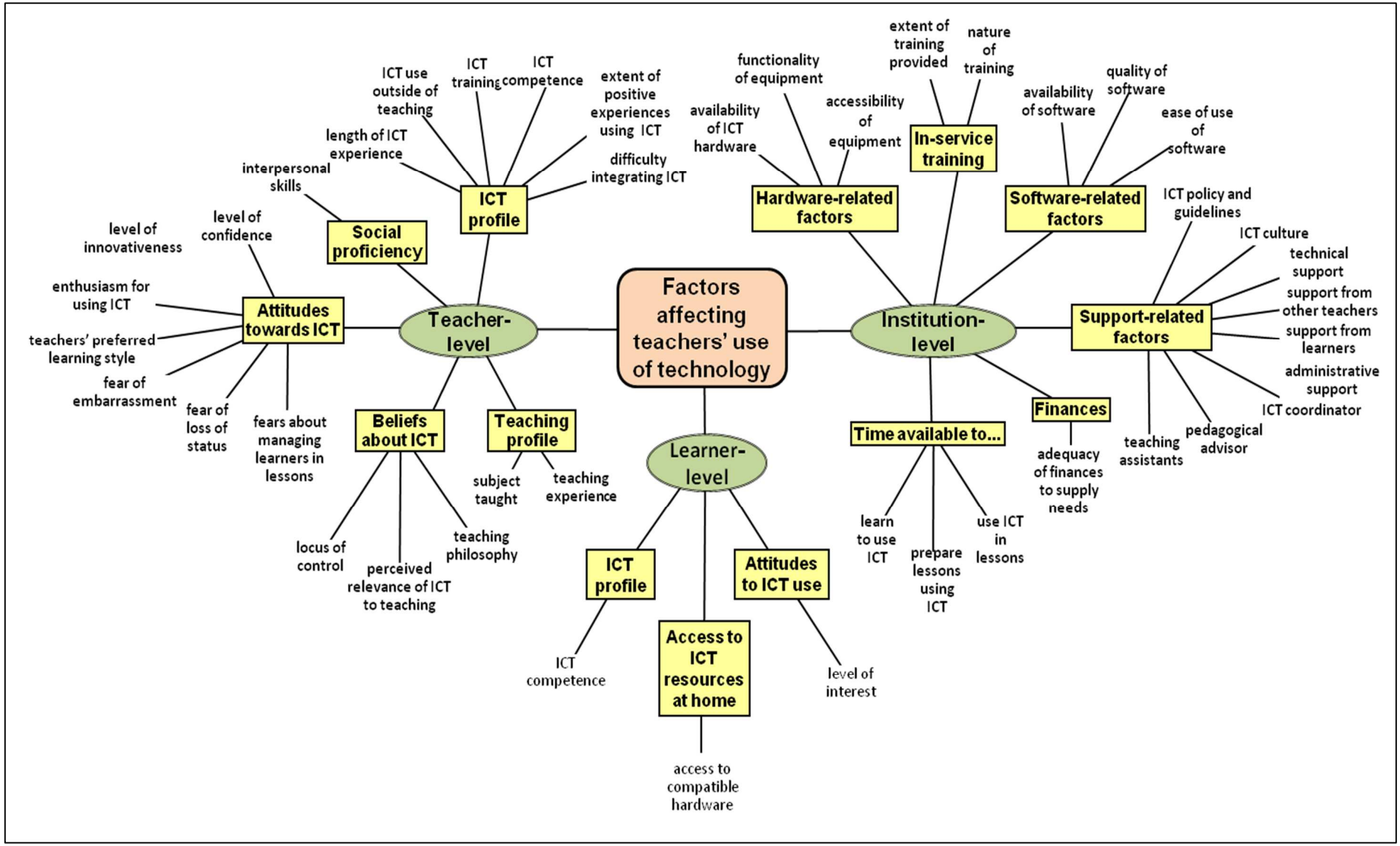

Figure 5. Theoretical framework of factors and their groupings derived from 48 papers reviewed

Table 3. Definitions of factors

Level	Category	Factor	Definition
Institution-level	Finances	Adequacy of finances to supply needs	Availability of finances for costs associated with the provision of ICT resources, e.g. the initial outlay for equipment, the costs of maintaining the equipment and providing in-service training for teachers.
	Hardware-related factors	Availability of ICT hardware	Provision of the machines and associated equipment (e.g. keyboard, mouse, speakers) as well as computer infrastructure like internet connectivity.
		Accessibility of equipment	The extent to which computer equipment can be accessed for use during lessons when required by teachers and learners.
		Functionality of equipment	The operational level of the computer equipment provided: includes issues like compatibility, age, state of repair.
	Software-related factors	Availability of software used in teaching	The extent to which educational programmes are provided by the institution.
		Quality and suitability of software	'Suitability' refers to how well subject-specific software addresses the curriculum requirements (e.g. content coverage for a particular educational level). 'Quality' refers to how well the programme's design features (e.g. the level of interactivity) support learning.
		Ease of use of software	The level of difficulty involved with using a software package (e.g. how easy icons are to interpret).
	In-service training	Extent of training provided	The number and duration of opportunities provided by an institution for staff to improve their computer skills.
		Nature of training provided	The type of staff development opportunities provided by the institution (e.g. developing ICT skills or using ICT in a pedagogically effective manner).
	Support-related factors	ICT policy and guidelines	The extent to which the institution has a clear policy for integrating ICT in the teaching and learning practice, including the provision of guidelines.
		ICT culture	The level of ICT usage considered to be the norm in the institution.
		Technical support	The level of help available for dealing with the functionality of hardware and software, enabling staff and students to have trouble-free access to, and usage of, the computing facilities.
		ICT coordinator	The presence of a person responsible for overseeing the budgeting, planning and strategising with respect to ICT facilities and their use in the institution.
		Pedagogical advisor	Having a person who assists teachers to implement ICT in teaching and learning in ways that enhance learning.
		Support from other teachers	The extent to which other teachers at the institution or from other institutions provide assistance to teachers wanting to use ICT in their lessons.
		Administrative support	The provision of personnel who implement instructions issued by an ICT coordinator relating to organisational matters around ICT use.
		Teaching assistants	Support staff (e.g. parents or learners) to assist teachers with managing classes when learners are using technology.
		Support from learners	The extent to which learners help or hinder teachers using ICT in their lessons.
	Time available to...	learn to use ICT	Time provided for teachers to learn how to use computers in their teaching (includes learning to use new software).
		prepare lessons using ICT	Time provided for teachers to prepare lessons involving ICT (includes adapting previous lessons for an ICT format).
		use ICT in lessons	Time available for teachers to use computers during lessons.

Level	Category	Factor	Definition
Teacher-level	Teaching profile	Subject culture	Impact of differences in content, pedagogy and assessment associated with a teacher's subject area.
		Teaching experience	The length of time teachers have been teaching for.
	Social proficiency	Interpersonal skills	Teachers' knowledge of the institution's culture and their ability to negotiate social aspects of the institution's culture to impact on their use of computers for teaching.
	Beliefs about ICT	Teaching philosophy	Teachers' beliefs about teaching and learning and how they impact on the use of computers for teaching.
		Perceived relevance of ICT to teaching	Teachers' perspectives about the value of computers in teaching and learning.
		Locus of control	The extent to which teachers perceive they are in control of events relating to their ICT use in the classroom.
	Attitudes towards ICT	Level of confidence	The extent to which teachers feel at ease using computers.
		Level of innovativeness	Teachers' willingness to use technology for teaching and learning, or their resistance to change.
		Enthusiasm for using ICT	The extent to which teachers displays a positive attitude towards using computers.
		Teachers' preferred learning style	The method of perceiving and processing information preferred by teachers.
		Fear of embarrassment	Teachers' self-consciousness that their lack of ICT skills might show them up in front of learners.
		Fear of loss of status	Teachers' viewpoint that computers might usurp their role.
		Fears about managing learners in lessons	Teachers' perceptions about their inability to maintain discipline when using computers in lessons.
	ICT profile	Length of ICT experience	The length of time for which teachers have been using computers.
		ICT use outside of teaching	The extent of use of ICT by teachers outside of the classroom, both for work (e.g. for preparing lessons) and for personal use.
		ICT training	The nature and extent of the opportunities teachers have had to develop their ICT skills.
		ICT competence	Teachers' ICT skills and technological pedagogical knowledge (TPACK).
		Extent of positive experiences using ICT	Previous successful ICT encounters, which motivate teachers to use computers for teaching.
		Difficulty integrating ICT into instruction	Levels of problems experienced by teachers in using computers in teaching.
Learner-level	Access to ICT resources at home	Access to computer hardware	The extent to which learners have technological resources (e.g. machines, printers, speakers) to use at home.
	Attitudes to ICT use for learning	Level of interest	Learners' motivation to use ICT, at school and at home.
	ICT profile	ICT competence	Level of learners' technology skills.

Having presented the relationships between the different factors in the concept map (see Figure 5 on page 29) and the factor definitions that will be used in this study (see Table 3 on pages 30 and 31), the rest of the chapter is devoted to a summary of the findings on the relative importance of the factors, according to the frequency counts from the 48 papers. Krippendorf (2013) believes that it is important that researchers are able to justify the inferences made from content analyses. I will discuss each factor derived from the content analysis of the 48 papers to provide evidence for its inclusion in the conceptual framework guiding the study.

Adding the frequencies of each of the 43 factors revealed 546 cases in total (see Appendix E, which gives the frequency counts for the factors identified from the 48 papers reviewed). Figure 6 shows the proportions of the 546 cases identified at three different levels (institutional-, teacher- and learner-level). The highest percentage of cases occurred at the institutional level (55%), suggesting that most of the cases reported in the literature as impacting on teachers' use of ICT are embedded in institutions. The literature review also revealed 225 cases of 19 factors at the teacher level (41%). Only 23 cases of three factors identified in the papers operate at the learner level (4%).

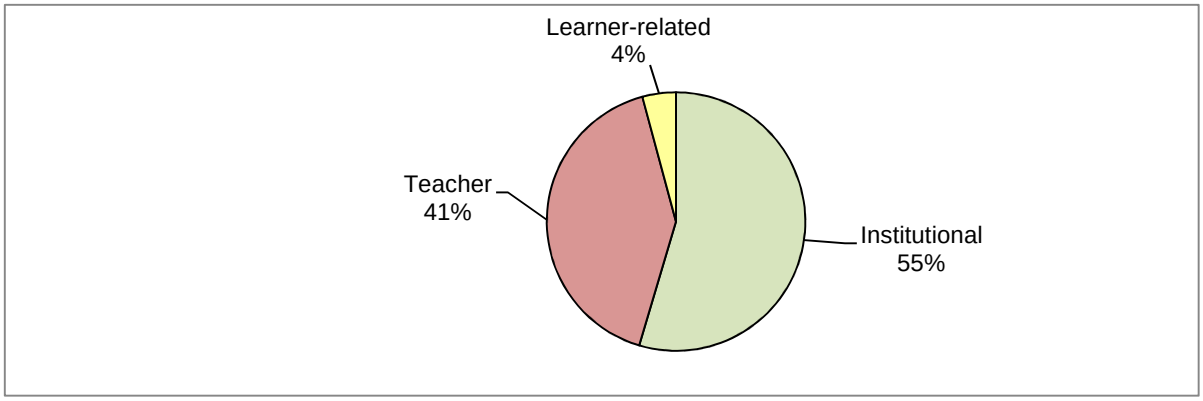

Figure 6. Proportion of factors affecting teachers' use of computers, operating at different levels, identified in the review of 48 papers

Figure 7 (see next page) shows the categories that emerged when the 43 factors were clustered together based on common themes (as described on page 27). Six categories emerged at the institutional level, five at the teacher level and three at the learner level. Calculating the percentage of cases of factors in each category out of the total of 546 cases of the 43 factors revealed that the category most frequently identified in the papers related to the extent of institutional support for teachers wanting to use ICT (20.5%). Three of the 14 categories – support-related factors (20.5%), factors relating to teachers' ICT profile (15.2%) and factors relating to teachers' attitudes towards ICT – accounted for roughly half (49.1%) of the cases of factors identified from the 48 papers.

Figure 8 provides an overview of the relative frequencies of each of the 43 factors calculated as a percentage of the total of 546 cases identified from the 48 papers reviewed. No single factor stands out hugely, suggesting that a combination of variables affects teachers' use of ICT. The four most frequent factors in Figure 8 together account for only about one-fifth (21.5%) of the total number of cases. Each of the 43 factors is discussed individually after Figure 8 to better understand their relative importance in the frequency of factors at each level.

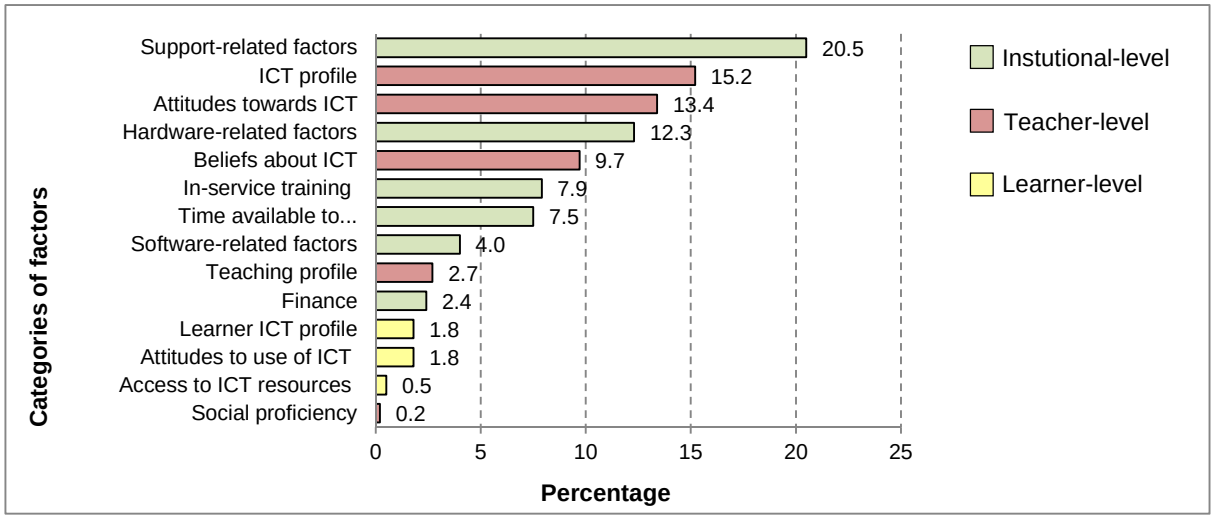

Figure 7. Relative frequencies of 14 categories of factors identified from 48 papers reviewed

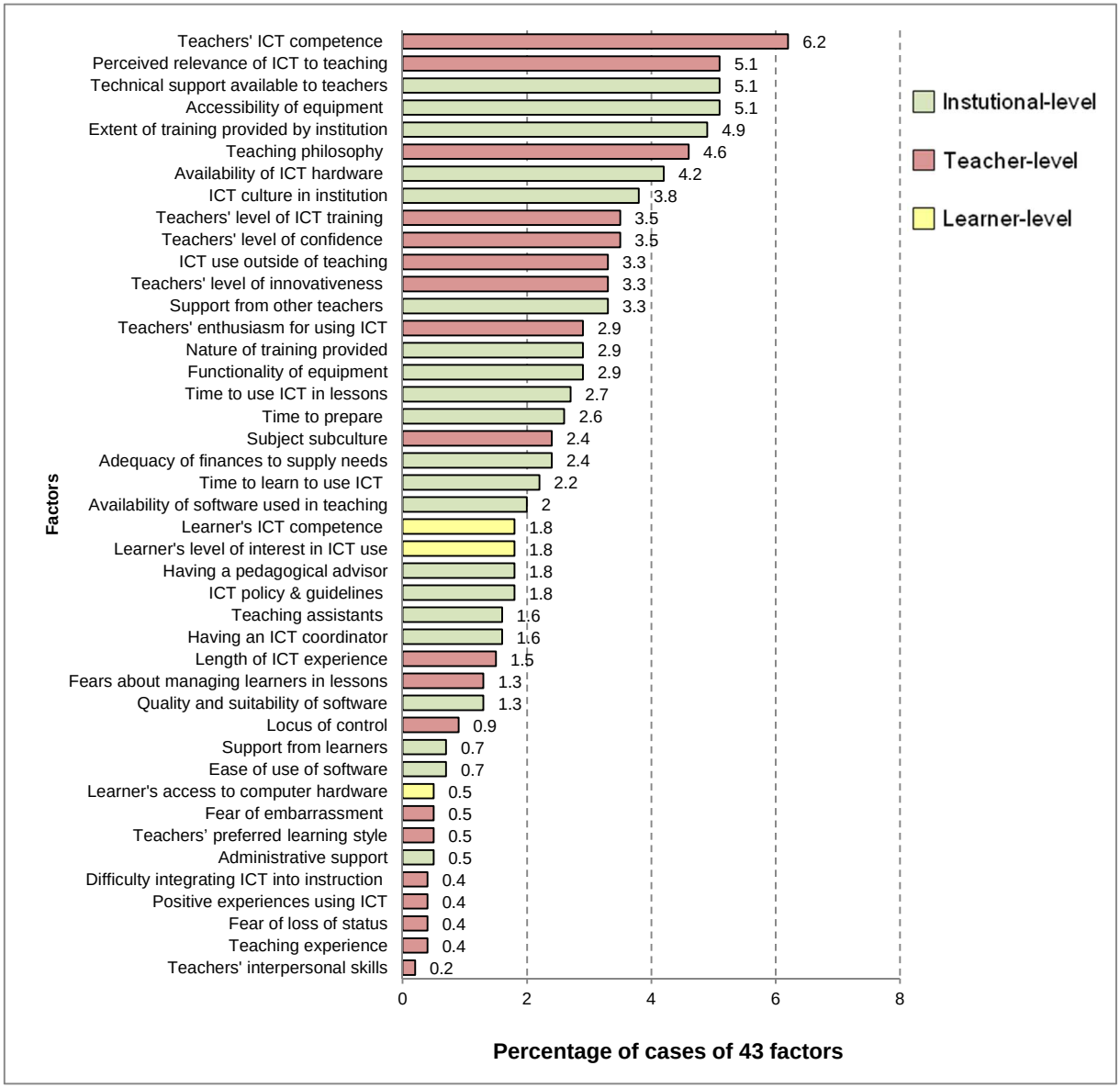

Figure 8. Relative frequencies of the cases of the 43 factors affecting teachers' use of ICT, as identified from 48 papers

2.4.1 Institution-level factors

Institution-level factors relate to issues surrounding the provision of resources at the organisation- or school-level (Ertmer, 1999; Tondeür, van Keer, van Braak & Valcke, 2008). Because institution-level factors exist in the teachers' external milieu they are independent of the characteristics of individual teachers (Ertmer, 1999). Ertmer refers to institution-level factors as *first-order* or *external barriers* to ICT integration.

In the 48 papers reviewed, 298 cases of the 21 **institutional-level** factors were reported. A summary of the 298 cases of institutional-level factors affecting teachers' use of computers is included as Appendix F. Figure 9 shows the relative frequencies of the six **categories** of institutional-level factors identified from the 48 studies, with support-related issues (38%) accounting for the bulk of institutional-level factors, followed by factors dealing with ICT hardware (23%). Together these two factors account for well over half (61%) of institutional-level factors. Figure 10 shows the 21 institution-level factors which make up the six categories. Each of these 21 factors is discussed after Figure 10.

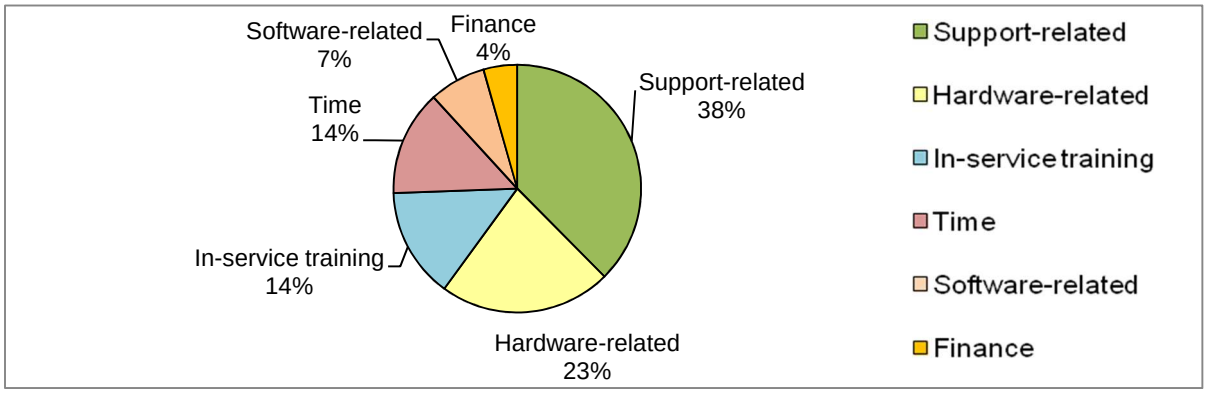

Figure 9. Proportions of six institutional-level categories across the 48 papers reviewed

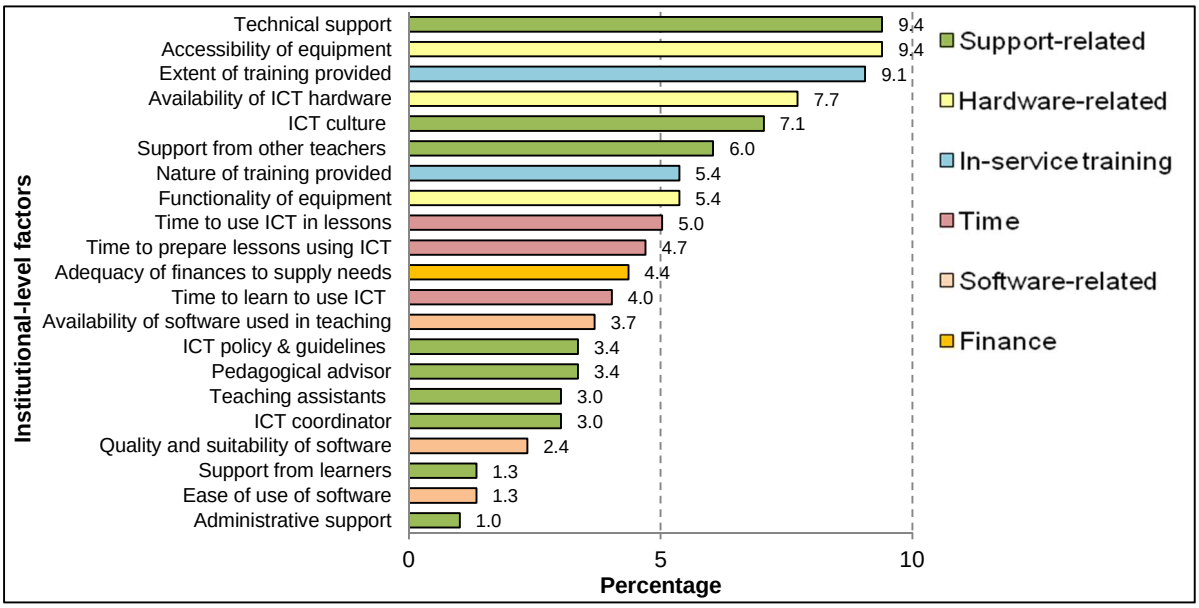

Figure 10. Twenty-one institution-level factors affecting teachers' use of ICT, identified from 48 studies reviewed

Finance

Even though the adequacy of finances to supply ICT needs only makes up 4.4% of the 298 cases of institutional-level factors affecting teachers' use of computers (see Figure 10), the availability of funds to purchase ICT equipment is fundamental to technology use. Without funding for adequate resources, teachers will not be able to integrate ICT into their teaching. After reviewing the literature, Fabry and Higgs (1997) point out three main areas of costs: firstly, costs associated with the initial outlay for software and hardware; secondly, ongoing costs for maintaining and repairing equipment, and, thirdly, funding for initial and ongoing training and technical staffing. These costs presented a "*significant barrier to technology integration*" at the time of their study, more than 15 years ago (Fabry & Higgs, 1997, p. 392), and are likely to still be a major problem. Two of the 48 studies reviewed (Lai & Pratt, 2004; van Braak, 2001) identified the lack of funds as the **major factor** affecting teachers' use of computers.

Hardware-related factors

After financial considerations, issues relating to ICT hardware in educational institutions are the next most fundamental to promoting or inhibiting ICT usage. Twenty-three percent of the institution-level cases involved hardware-related factors, making this the second most significant institution-level factor affecting the use of computers for teaching (see Figure 9 on the previous page), in the papers reviewed. Three hardware-related factors appear to impact on teachers' use of ICT for teaching purposes:

- **Availability of ICT hardware.** At the most fundamental level, organisations need to provide the computer hardware for teachers to use in their teaching. According to Williams, Coles, Wilson, Richardson, and Tuson (2000, p. 313) the availability of hardware "*tends to override all other factors in determining use*". This factor was raised in 23 out of 298 cases (7.7%) of institution-level factors affecting teachers' use of computers (see Figure 10 on the previous page). Although a number of studies suggest that the number of computers in institutions has increased over the last twenty years – as suggested by the decreasing learner-to-computer ratios in countries like the United States (Cuban et al., 2001), New Zealand (Lai & Pratt, 2004; Russell, Bebell, O'Dwyer & O'Connor, 2003), Israel (Dori et al., 2002) and Chile (Blignaut et al., 2010) – recent findings suggest the lack of availability of sufficient hardware remains a barrier to ICT integration (e.g. Chigona & Chigona, 2010; Ertmer et al., 2012; Vanderlinde, van Braak & Dexter, 2012; Ward & Parr, 2010). Russell et al. (2003) found that teachers who HAVE computers are more favourably inclined to using ICT, possibly because having computers available means they can use ICT more and learn how to use computers better than teachers who don't have computers to use. In the study by Vanderlinde et al. (2012), two schools, both of which displayed high levels of ICT usage for teaching and learning, were ranked fourth and fifth out of 62 schools for their ICT infrastructure. A lack of computers was identified as **the most important factor** hindering teachers' use of computers in the studies by Blignaut et al. (2010), Pelgrum (2001), Wellington (1999), Williams et al. (2000), and Wood et al. (2005). This factor emerged as the **second most important** barrier to ICT integration in the studies by Zammit (1992) and Russell et al. (2003).
- **Accessibility of equipment.** Providing hardware involves more than merely having equipment available. It encompasses how accessible the equipment is for both teacher and learner use,

since the ease with which computers can be accessed during lessons affects their use (Ward & Parr, 2010). Cuban et al. (2001) suggest that one way of measuring the accessibility of computers in schools is to see where the computers are placed, i.e. whether they are in an IT lab, a media centre, or in classrooms. The location of hardware in a central location such as a computer lab or an IT classroom tends to create problems with accessing the computers (Ng & Gunstone, 2003; Selwyn, 1999). These authors point out that a computer lab may only be available for wider use when not in use for information technology classes. Any timetable slots remaining will then have to be booked by subject teachers. Problems with scheduling time in the computer lab and issues surrounding the need to book the computer lab were mentioned in seven studies (Bauer & Kenton, 2005; Butler & Sellbom, 2002; Castro & Alves, 2007; Chigona & Chigona, 2010; Pelgrum, 2001; Selwyn, 1999; Wellington, 1999). Three of these seven studies claimed that is was difficult for **certain** subject-areas to gain access to the computer lab, although different subjects were identified in different cases (Castro & Alves, 2007; Chigona & Chigona, 2010; Selwyn, 1999). For example, Selwyn (1999) referred to the difficulty of 'non-IT' subjects, i.e. subjects other than Information Technology, while in the study by Chigona and Chigona (2010), mathematics and English were the only subjects allowed to use the computer labs sponsored by the Khanya project in Western Cape (South Africa) schools. A number of studies found that teachers used computers more if the computers were located in classrooms and not in central locations that need to be booked (Becker, 2000; Nisan-Nelson, 2001; Priest et al., 2004; Zhao & Frank, 2003). In three studies teachers indicated that they would make more use of computers if they had them available in their classrooms (Cox et al., 1999; Russell et al., 2003; Selwyn, 1999). At the institutional level, the accessibility of equipment accounted for 28 out 298 cases (9.4%) (see Figure 10 on page 34), making this the joint second most frequent factor mentioned, after the level of technical support available for teachers. Limited access to equipment was described as the **most important factor** affecting teachers' use of computers in the 22-year old study by Zammit (1992). However, accessing ICT equipment still remains a major factor impacting on teachers' use of ICT. Wood et al. (2005) reported the lack of computers in classrooms as the **third most important factor** affecting primary school teachers' use of computers for teachers in their study and the **fourth most significant factor** affecting secondary school teachers' computer use in lessons.

- **Functionality of equipment.** The hardware resources supplied to teachers by organisations must be reliable, must be compatible with other resources, and should not be outdated. Gülbahar (2007) stresses the importance of supplying teachers with up-to-date hardware to promote the use of recent technology by teachers. Issues related to the functionality of equipment (such as poor state of repair or incompatibility of equipment) comprised 2.9% of the 546 total cases (see Figure 8 on page 33) and 5.4% of the cases of institution-level factors (see Figure 10 on page 34). Butler and Sellbom (2002) identified the state of equipment as the **most significant factor** affecting the use of computers by the teachers in their study, while Wood et al. (2005, p. 196) reported a lack of functionality of equipment as "*a huge barrier*". Outdated equipment was mentioned in half of the 16 cases relating to the functionality of equipment (Bauer & Kenton, 2005; Chiero, 1997; Cuban et al., 2001; Pelgrum, 2001; Quick & Davies, 1999; Russell & Bradley, 1997; Wellington, 1999; Wood et al., 2005). This implies that supplying hardware is not a one-off expense, but an ongoing demand on funding.

Nine of the 48 studies identified all three hardware-related factors as impacting on teachers' use of computers (Bauer & Kenton, 2005; Cuban et al., 2001; Hossain & Brooks, 2008; Ng & Gunstone, 2003; Pelgrum, 2001; Russell & Bradley, 1997; Wellington, 1999; Wood et al., 2005; Zhao et al., 2002) while 14 of the studies (e.g. Chiero, 1997; Sahin & Thompson, 2006; van Braak, 2001; Ward & Parr, 2010; Zammit, 1992) mentioned two of the three hardware-related sub-factors as problematic.

Software-related factors

Software is the next vital requirement after hardware. Software for teachers to use when integrating computers was the fifth most frequent of the six institution-level factors identified from 48 papers (see Figure 9 on page 34), totaling 7% of 298 cases of institution-level factors. Three software-related factors emerged from the review of the 48 studies, as shown in Figure 10 on page 34.

- **The availability of instructional software.** The availability of instructional software refers to the range and number of copies of instructional software available for use by teachers. This factor was the **most frequently mentioned** of the three software-related factors (3.7% of 298 cases). In addition to indicating a need for more software to be available for use in their teaching, teachers specified a need for the *latest* software (e.g. Quick & Davies, 1999; Wood et al., 2005).
- **The quality of the software available.** The quality and suitability of the software available was the next most significant of the three software-related factors (2.4% of 298 institutional-level cases). Draper (1997, p. 5) stresses the idea of the most successful software being software that closely fits "*its situation of use"*. Where software is judged unsuitable, teachers might be less inclined to use it. Teachers may find software unsuitable for a variety of reasons, including software not matching the curriculum, or being culturally incompatible.
- **The ease of use of the software.** The least frequently mentioned category of software-related factors was ease of use of software (1.3% of 298 institutional-level cases) (see Figure 10 on page 34). Teachers in the four studies which mentioned this factor were discouraged when using software they found too complicated.

One study (Pelgrum, 2001) cited all three factors relating to the provision of software resources as impacting on teachers' use of computers for teaching. Four studies (Zammit, 1992; van Braak, 2001; Butler & Sellblom, 2002; Ng & Gunstone, 2003) mentioned two of the three categories.

In-service training

Once hardware and software are available, providing suitable in-service training is one way that institutions can attempt to equip teachers with the necessary knowledge and skills to confidently and effectively use technology in their lessons. Reviewing the 48 studies revealed in-service training as the third most frequently identified of the five institution-level categories (14.4% of the 298 cases) impacting on teachers' use of computers (see Figure 9, page 34). Two factors relating to in-service training emerged from my review of the 48 papers. The most frequently identified of the two training-related factors is the extent of the provision of training for teachers (9.1% of the 298 occurrences), while the nature of the training offered to teachers was mentioned in 16 (5.4%) of the 298 occurrences, as shown in Figure 10 on page 34.

- **Provision of training.** The extent to which training has been provided for teachers wanting to integrate ICT was the **third most frequently mentioned** of the 21 institution-level factors (see Figure 10, page 34). Two of the 48 papers (Chiero, 1997; Sahin & Thompson, 2006) mentioned a lack of training on how to use technology emerged as the **second major factor** affecting discouraging teachers' use of computers for instruction in their studies.
- **Nature of training**. The nature of the training provided to teachers was the **seventh most frequently mentioned** of the 21 institution-level factors (5.4% of 298) (see Figure 10 on page 34). Some teachers may require training in basic ICT skills, as indicated by teachers in the studies by Drenoyianni (1998) and Chigona and Chigona (2010). Some of the studies reviewed suggest that teachers require training that is based on their specific needs (Baylor & Ritchie, 2002; Dori et al., 2002; Quick & Davies, 1999). Training that focuses on the technical aspects of technology use might not be as beneficial to teachers as training that prepares teachers to use technology in their teaching (Cox et al., 1999; Kanaya, Light, & Mcmillan Culp, 2005; Sandholtz & Reilly, 2004). In a number of studies, teachers indicated a need for training focused on equipping them with the pedagogical skills to effectively integrate technology (e.g. Kanaya et al., 2005; Lai & Pratt, 2004; McCarney, 2004). The Scottish study by McCarney (2004) suggested that teachers perceive in-service training that does not infringe on teachers' own time, and that is based outside the school, as the most effective type of training.

Support for teachers

Once ICT resources have been supplied, teachers need ongoing support to ensure the smooth integration of technology into teaching and learning. When reviewing the 48 papers in this study, factors relating to support for teachers wanting to use ICT for teaching were mentioned more frequently (20.5%) than any other category of factors (see Figure 9, page 34). In addition to being the most frequently mentioned category of factors, the support-related factors category was also the most *complex* of any of the 14 categories of factors across institution-, teacher- and learner-level factors (see Figure 8, page 33), consisting of nine separate factors. Figure 11, on the next page, shows the proportions the nine support-related factors making up the total of 112 cases of support-related factors and is intended to give the reader a better overview of the complexity of factors in this category, as well as their extent.

The main reason for the complexity of factors in the support category is that comprehensive ICT support for teachers involves a combination of technical, instructional and collegial support (Dwyer, Ringstaff, & Sandholtz, 1991). Strudler and Hearrington proffer the following explanation for the number of different people needed to provide different types of support for teachers integrating ICT:

> *Technical systems are complex and require people with a variety of technical and social skills to function. In this way of thinking, social organizations, such as schools, require people who can translate and facilitate communication with the technical system. Because technical systems and social systems are complex, many people are needed to serve as translators.* (Strudler & Hearrington, 2008, p. 591)

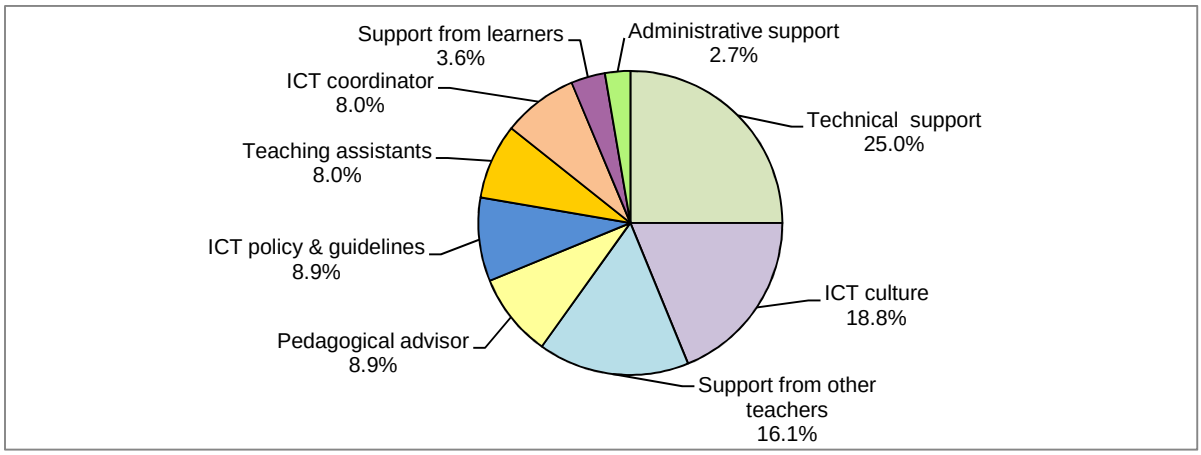

Figure 11. Support-related factors identified from 48 papers

- **Technical support.** Technical support for teachers is essential to maintain hardware and solve technical problems as they arise. Teachers often find that they spend huge amounts of time dealing with technical issues when they should rather be focusing on using technology to enhance learning (Butler & Sellbom, 2002; Sandholtz & Reilly, 2004). The level of technical support available to teachers was the most frequently mentioned support-related factor, making up 25% of the cases in the support category (see Figure 11). Further emphasizing its impact, technical support had the joint highest frequency of the 21 institution-level factors (see Figure 10 on page 34). Technical support could come from an ICT coordinator, but because of the wide range of tasks ICT coordinators may be expected to carry out (which will be discussed in greater depth under the sub-heading 'ICT coordinator'), these individuals may not cope with all the demands made on them. Where finances permit, it may be useful to have a team of technicians to provide technical support. Some authors believe that where schools can afford to employ technicians they would have to, firstly, be suitably qualified; secondly, they should be able to explain clearly to teachers how to use technologies (Davidson & Olson, 2003; Zhao et al., 2002) and understand that problems should be resolved as soon as possible to minimise the impact of down-time on teaching time (Butler & Sellbom, 2002). Technical support was rated as the **most important factor** affecting teacher's use of computers in the study by Drenoyianni and Selwood (1998), as the **second most important obstacle** to computer use in the studies by Wellington (1999) and Ertmer et al. (2012), and as the **third most significant factor** in the studies by Chiero (1997) and Sahin and Thompson (2006).
- **ICT culture in the school.** This factor, which accounted for 21 (19%) out of 112 cases of support-related factors (see Figure 11), refers to the level of ICT usage considered the norm in an educational institution. An important component of the ICT culture in any institution is the extent to which a leader motivates and encourages teachers to integrate ICT, either by example or by setting definite standards for performance. Dori et al. (2002, p. 535) define leadership as "*the ability to empower others with the purpose of bringing about a major change in form, nature or function of some phenomenon*". Five of the 48 studies reviewed (including recent ones) emphasize the importance of having a leader to model the use of technology and to motivate teachers to use ICT in their teaching (Baylor & Ritchie, 2002; Blignaut et al., 2010; Dori et al., 2002; Selwyn, 1999; Vanderlinde et al., 2012). Tondeür et al. (2008) refer to a

number of studies which highlight the role of the school principal in providing strong leadership in the change process and promoting the use of technology. However, the leadership role could be filled by an ICT coordinator (Vanderlinde et al., 2012) while department heads could contribute to the prevailing ICT culture by promoting technology integration for their subjects (Ertmer et al., 2012; Selwyn, 1999).

- **Support from other teachers.** According to Vanderlinde et al. (2012, p. 1342) this factor relates to "*the level of communication and cooperation between teachers*". Fabry and Higgs (1997), after reviewing the literature 17 years ago, claimed that collegial support is required to promote technology integration. Eighteen (16%) of the 112 cases of support-related issues across the 48 papers dealt with support from other teachers (see Figure 11 on page 39), either indicating a need for support in the form of sharing resources (Donnelly et al., 2011) or for other teachers to model the use of ICT (Russell & Bradley, 1997; Tondeür et al., 2008).

- **Pedagogical advisor**. Castro and Alves (2007) believe that for computers to be successfully integrated into education, they must be used in ways that enhance teaching and learning. These researchers, elaborating on statements made in a Spanish-medium paper by Almeida (2000), point out that

  > *… computers can be used for programmed instruction, or still further as a way of brutally transmitting information without an adequate appreciation of the learning process and the meaning of teaching in the structured acquisition of knowledge. As a result, from such a narrow perspective, the only change possible is the way information is transmitted, without any change in the pedagogical practice related to learning.* (Castro & Alves, 2007, p. 1384)

  To avoid computers being used merely to transmit knowledge, teachers need to be shown how to integrate computers in their subjects in ways that promote meaningful learning. Zhao et al. (2002, p. 502) refer to a need for translators "*who can help the teacher understand and use technologies for his or her own classroom needs*". Ten of the 112 cases (9%) of support-related factors pertained to teachers' need for assistance with integrating ICT into their specific subject area, i.e. a pedagogical advisor (see Figure 11 on page 39).

- **ICT policy and guidelines.** Educational institutions should support teachers in the process of including ICT in their lessons by having a clear plan for ICT integration (Tondeür et al., 2008; Vanderlinde et al., 2012). Ten (9%) of the 112 institutional-level cases identified from the 48 papers reviewed related to the need for a clear strategy for ICT integration (see Figure 11 on page 39). Vanderlinde et al. (2012) believe that an ICT policy is a way of operationalising leadership practice. Such a plan should not revolve solely around "*technical and infrastructural specifications*" (Vanderlinde et al., 2012, p. 1340). Rather, these authors argue, an ICT plan should be based on the philosophy underpinning technology integration, outline what the institution hopes to achieve by integrating technology into instruction, and detail the strategies (including staff ICT training) that will be used. In addition, the most effective policy plans are those which make provision for ongoing evaluation of teachers' ICT needs, resulting in an iterative approach to ICT planning (Lim, Chai, & Churchill, 2011; Tondeür et al., 2008). In the absence of a clear purpose for integrating technology and a set of guidelines governing how this will be achieved, schools run the risk of succumbing to "*technology push*" (ten Brummelhuis & Kuiper, 2008, p. 99). This concept, which is similar to "*technological determinism*" (Fisher, 2006, p. 296) suggests that ICT integration is driven by "*the acquisition of ICT materials and then appropriate applications are sought that fit into a learning process*" (ten Brummelhuis &

Kuiper, 2008, p. 99). In the study by Vanderlinde et al. (2012), having an ICT policy emerged as **the major factor** affecting ICT integration, irrespective of whether the policy was formalised or not. These researchers found differences in the ICT policies of the top three ICT-integrating schools in Flanders:

> *… these schools have a clear vision and policy on ICT integration, yet, ICT policy planning in these schools still appeared as three very different configurations in terms of who interacts with who; the frequency, nature, and duration of their interactions; and the tools, routines and structures that shape those interactions.* (Vanderlinde et al., 2012, p. 1347)

Baylor and Ritchie (2002) point out that schools where ICT has been effectively integrated often have ICT plans. Tondeür et al. (2008) reported that only 12 of the 53 Flemish primary schools in their study had a comprehensive ICT plan outlining how they would achieve clearly defined aims. Of the remaining schools, half (21) had plans without details of how they were going to operationalise their goals, while the other half lacked ICT plans. These authors reported that schools with an ICT policy focusing on "*shared goals are using ICT more regularly in the classroom*" (Tondeür et al., 2008, p. 220).

- **Teaching assistants**. Nine of the 112 cases (8%) of support-related factors indicated that teachers need support with managing lessons involving ICT (see Figure 11 on page 39). The elementary teachers in the study by Wood et al. (2005) emphasized the difficulties involved when a single teacher monitors a class of 27 pupils in a computer lab and indicated the need for support with managing their classes whilst they were using computers. Management problems are exacerbated when learners are working in groups at computers. One teacher in the study by Nisan-Nelson (2001) avoided taking her pupils to the computer lab because they were going to have to work four to a computer. The positive effect of providing assistance for teachers when using computers in lessons is illustrated by the small-scale Welsh study on the impact of interactive whiteboards on learning, carried out by Kennewell and Beauchamp (2007, p. 228), where "*groups were supervised and assisted by learning support assistants or other adult helpers*", allowing the teacher to focus on one group at a time.
- **ICT coordinators.** When computers were first introduced into schools in the 1980s, and for much of the intervening time, the job of understanding and interpreting technical systems for administrators and teachers traditionally fell to the ICT coordinator. These individuals, often teachers themselves, have largely been responsible for fulfilling most ICT-related duties in schools, even though the exact nature of their roles has differed from setting to setting (Rodríguez-Miranda, Pozuelos-Estrada, & León-Jariego, 2014). These duties could include providing technical assistance to teachers and administrative staff; training teachers to use ICT; helping teachers develop curriculum materials; maintaining hardware; buying software; managing networks; managing budgets and developing and implementing ICT policies (Devolder, Vanderlinde, van Braak & Tondeür, 2010; Lai & Pratt, 2004; Marcovitz, 2000). Nine of the 112 cases (8%) of support-related factors identified from the 48 papers I reviewed dealt with the need for an ICT coordinator (see Figure 11 on page 39). This percentage is low considering the important roles ICT coordinators can play in schools, but may indicate schools where there is *no* technical support available. For example, the teachers in the study by Bauer and Kenton did not have technical assistance available and had to rely on "*that person on the staff with the most technical knowledge*" to resolve technical hiccups (Bauer & Kenton, 2005, p. 536).

- **Support from learners.** Four out of the 112 cases (3.6%) of support-related issues concerned learners providing support for teachers (see Figure 11 on page 39). Appropriate assistance from learners with good ICT skills could alleviate pressure on technical teams and simultaneously resolve technical problems that could potentially disrupt lessons. Cuban et al. (2001) reported on five students per school who provided technical assistance to teachers at each of the United States high schools in their study. These students had been chosen for their technical prowess and were 'cultivated' by the ICT coordinators to assist teachers with ICT-related problems. These students were simultaneously easing the load of the ICT coordinators while assisting teachers who could not resolve the technical hitches by themselves. Ertmer and Hruskocy (1999) reported in their study that four of the 12 teachers had used students to help them resolve a technical problem or learn how to use a new software programme. However, some teachers in this study were reluctant to ask learners for help. Another potential problem with using learners to provide support is that learners may have to be called out of lessons to help teachers resolve problems, as occurred in the Ertmer and Hruskocy study, thus distracting them from their own studies.
- **Administrative support.** This factor deals with support for the administrative tasks relating to teachers' use of computers and includes managing databases (e.g. issuing passwords) and computer directories (e.g. associating names with computer addresses); implementing email policies (e.g. mailbox storage sizes) and issuing new ICT equipment (e.g. laptops or iPads) to teachers. Three of the 112 cases of support-related factors dealt with the impact of such support on teachers' use of computers for instruction.

One of the 48 studies (Zhao et al., 2002) mentioned seven of the nine support-related factors discussed here. Four studies (Lai & Pratt, 2004; Sahin & Thompson, 2006; Tondeür et al., 2008; Wood et al., 2005) mentioned six of the nine support-related factors, while another four studies (Zammitt, 1992; Wellington, 1999; Pelgrum, 2001; Vanderlinde et al., 2012) discussed five of the factors.

Time

Time has been described as "*a major factor… possibly the most influential factor*" affecting teachers' work (Chiero, 1997, p. 135). In the papers reviewed, time available to teachers was the **seventh most frequently mentioned category** of the total number of categories (14) at all three levels (see Figure 7 on page 33), but the **fourth most frequently mentioned** category of the six **institution**-level categories of factors, after in-service training (see Figure 9 on page 34). Karasavvidis (2009) recognizes two interrelated dimensions in the time concerns expressed by teachers. The first dimension relates to the time needed to learn the technology, i.e. to find out about new technologies and related resources, and to plan and try out new approaches using the technology. The second dimension relates to the "*feasibility of ICT introduction*", which refers to the time required to use computers in lessons, limited lesson time, and scheduling issues. Although Karasavvides recognizes two interrelated dimensions, three distinct time-related factors emerged from reviewing the 48 papers, which I discuss in order of decreasing frequency.

- **Time available to use ICT in lessons** was the **ninth most frequently mentioned** factor out of 21 institutional-level factors, with 15 cases (5%) out of 298 at the institutional level (see Figure

10 on page 34). Teachers reported problems with using ICT equipment as one of the reasons why they have limited time for computer use in lessons (Al-Fudail & Mellar, 2008; Bauer & Kenton, 2005; Butler & Sellbom, 2002; Cox et al., 1999). Teachers in the study by Bauer and Kenton stressed the problems of having a lesson in a computer lab and how this reduced their teaching time in a lesson:

> *…many students came late since it was not their regular class. They had to find seats at computers that were operating, switch on, load disks and/or log into the schools server, listen to directions, and read handouts. Then they would negotiate keyboards and menu bars to get to desired location. This would often take up to 10 minutes of class time. Subtract also from class time [the time] it took to close up the station, and a good CT class might get 25-30 minutes of quality instruction.* (Bauer & Kenton, 2005, p. 537)

Another reason given for having limited time to integrate ICT into lessons was curriculum and assessment pressures (Ertmer et al., 2012; Wood et al., 2005). Some researchers (e.g. Karasavvidis, 2009; Olson, James & Lang, 1999) believe that some teachers may use 'time' as a "c*ode word*" (Olson et al., 1999, p. 73) for other time-related concerns they may have, such as a vast syllabus they have to complete. Van Braak (2001) reported insufficient time during lessons for computer use as the **second major obstacle** in his study.

- **Time available to prepare lessons using ICT.** Some researchers believe that the effective use of ICT can reduce teachers' workload through "*finding, sharing and preparing resources electronically*" (Selwood & Pilkington, 2005, p. 165). However, when data from a project that investigated whether using technology reduced teachers' workload was analysed, some teachers said they found "*the time involved in ICT take-up and systems conversion from paper to e-media as a cause of excessive workload*" (Selwood & Pilkington, 2005, p. 165). Teachers in three other studies also felt that using ICT increased their workload (Priest et al*.,* 2004*;* Bauer & Kenton, 2005; Ward & Parr, 2010) This factor was the **tenth most frequently mentioned factor** of the 21 institution-level factors, with 14 out of 298 institutional-level cases (4.7%) (see Figure 10, page 34).

- **Time available to learn how to use ICT.** According to Vannatta and Fordham (2004, p. 261) "*the process of learning to use technology requires time – time spent in training, but also time spent playing with and exploring technology*". Where teachers do not have free time to learn to use ICT, this could be due to the demands made on their time by carrying out their normal duties. Gunter et al. (2005) analysed the results of a project run in 32 English schools aimed at reducing teachers' workload by providing funding for, among other things, ICT. The project was called the 'Transforming the School Workforce (TSW) Pathfinder'. Teachers completed a questionnaire at the beginning and end of the year-long project. Gunter et al. analysed data from the questionnaires on how 282 secondary school teachers who participated used their time for work. The teachers reported spending 48% of their time teaching, 11% on other forms of pupil contact, 20% of their time on lesson and test preparation and marking, 6% on school/staff administration, 6% on general administration, and 13% on other school-related duties. In addition, Gunter et al*.* reported that 95% of the participating teachers worked in the evenings and over weekends. Such demands on teachers' time leave little time available for teachers to carry out the activities required to integrate ICT into their teaching. Teachers in two studies (Russell & Bradley, 1997; Ward & Parr, 2010) expressed a need for "*time-release*" (Russell & Bradley, p. 26) to spend learning how to use computers. A lack of time to learn how

to use ICT was the **twelfth most frequently mentioned factor** out of 21 institution-level factors, with 12 mentions out of 298 institution-level cases (4%) (see Figure 10 on page 34).

2.4.2 Teacher-level factors

The role of teachers in ICT use is "*key to the change process*" (Ertmer, 1999, p. 48), since it is teachers who will ultimately choose whether or not to use technology. Teacher-level factors arise from teachers' individual characteristics and reflect teachers' personal variables (Ertmer, 1999; Tondeür et al., 2008). Ertmer refers to factors at this level as "*second-order*" or "*internal barriers*" to ICT integration. Five categories of teacher-level factors were identified from the 48 studies reviewed, as shown in Figure 12. The most frequently mentioned category of factors dealt with teachers' ICT profile, which accounted for 83 (36.9%) of the total of 225 teacher-related cases (number of papers in which a factor was identified), followed by teachers' attitudes (30.2%) and their beliefs (25.8%) about using ICT for teaching and learning. These three categories – teachers' ICT profile, their attitudes, and their beliefs about using ICT in their teaching – together accounted for just below 93% of the 225 cases of teacher-level factors (see Figure 12).

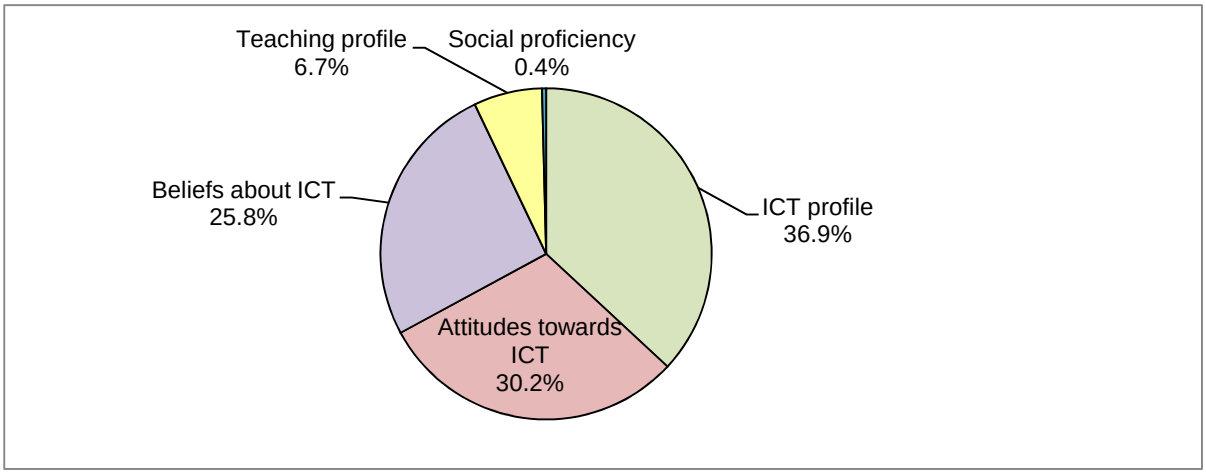

Figure 12. Five categories of factors at the teacher level identified from 48 papers reviewed

The five categories of teacher-level factors shown in Figure 12 contain 19 factors, as shown in Figure 13. Each category of factors is discussed after Figure 13, starting with teachers' beliefs about ICT, since these affect their attitudes towards ICT, which is discussed next. The next category of teacher-level factors which will be discussed is teachers' ICT profile. Finally 'teaching profile' and 'social proficiency' are discussed.

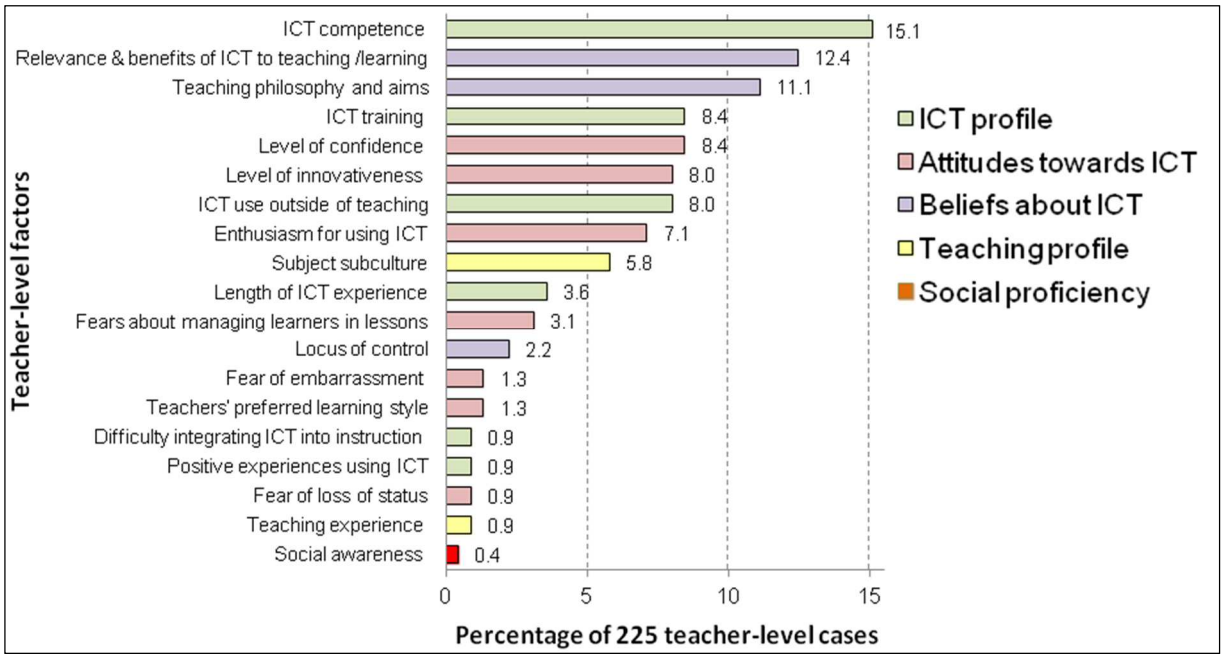

Figure 13. Proportion of 19 teacher-level factors identified from 48 papers reviewed

Teachers' beliefs about ICT

Ertmer (1999, p. 6) points out that factors operating at the teacher-level arise from "*teachers' underlying beliefs about teaching and learning*". Figure 12 (see previous page) shows that, of the five categories of teacher-level factors, teachers' beliefs about ICT had a lower frequency (25.8%) than teachers' attitudes towards ICT (30.2%). However, I will discuss teachers' beliefs about ICT before reviewing the impact of teachers' attitudes towards using ICT, because, as discussed below, beliefs underlie attitudes.

Using computers in teaching requires teachers to make behavioural changes. Teachers must learn how to use technology and how to adapt the way they teach to accommodate the use of technology. The theory of planned behaviour, which was "*designed to predict and explain human behaviour in specific contexts*" (Ajzen, 1991, p. 181), can be applied to teachers' use of computers in the classroom. According to the theory of planned behaviour an individual's behaviour depends on their intention to perform that behaviour (Ajzen & Madden, 1986). The theory states that the intention to carry out a behaviour is influenced by three factors. The first factor is the person's attitude towards the particular behaviour, as reflected in their positive or negative feelings about carrying out an action. The second factor relates to the person's perceptions about the social pressures they are under to perform that behaviour, i.e. the subjective norm. The third factor, perceived behavioural control, is based on "*the person's belief about how easy or difficult performance of the behaviour is likely to be*" (Ajzen, 1991, p. 457). Each of the three determinants of behaviour in the theory is influenced by the salient beliefs the individual holds about performing a particular behaviour. Thus, for example, the person's normative beliefs determine their subjective norms. Ajzen (1991, p. 189) described salient beliefs as "*the prevailing determinants of a person's intentions and actions*". Ajzen's model of the theory of planned behaviour is shown in Figure 14 (on the next page). The model shows the importance of the underlying beliefs in influencing attitudes, and indirectly determining individuals' intentions. Applying the model shown in Figure 14 to teachers' use of computers highlights the role

played by teachers' beliefs and attitudes about computers in determining whether or not they will use technology in the classroom. Other authors have applied the theory of planned behaviour to teachers' use of computers (e.g. Roca, Chiu, & Martinez, 2006; Sadaf, Newby, & Ertmer, 2012), as has been done in this study.

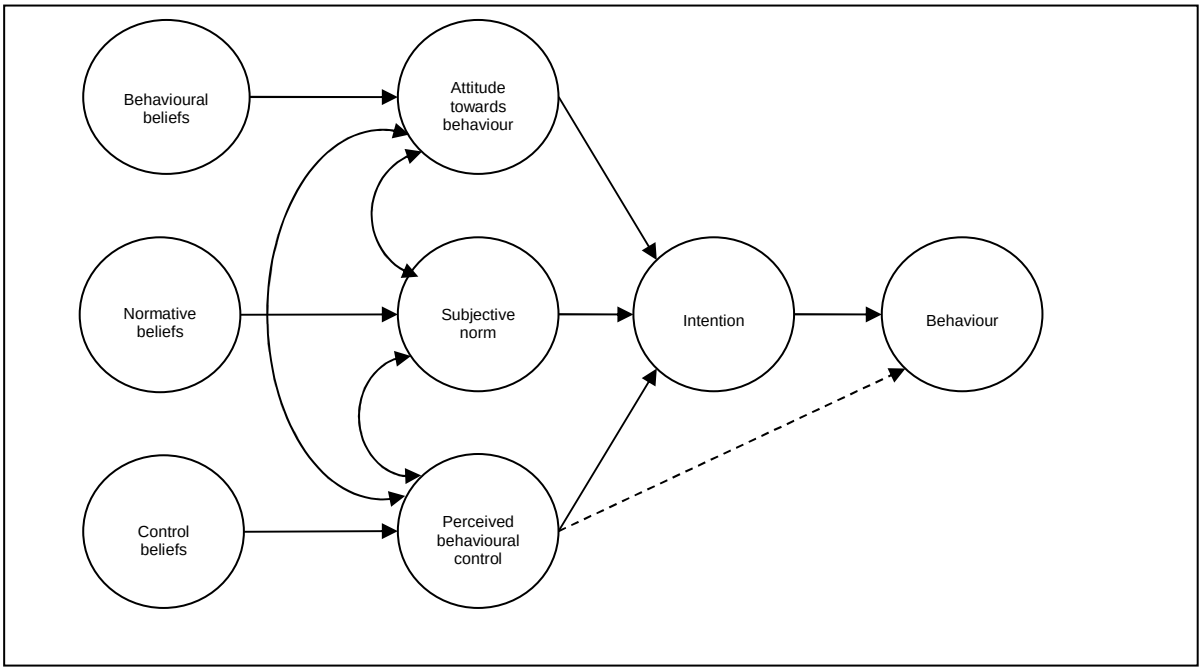

Figure 14. Theory of planned behaviour (Ajzen, 1991)

The theory of planned behaviour has the individuals' level of perceived behavioural control as an important predictor of behaviour. Perceived behavioural control can influence behaviour indirectly, via the persons' intentions (as shown by the solid line between perceived behavioural control and intention in Figure 14) or act directly on the behaviour (as shown by the broken line between perceived behavioural control and behaviour in Figure 14) (Ajzen & Madden, 1986). The perceived behavioural control has an influence on behaviour irrespective of whether the individuals' perceptions are accurate or not (Ajzen & Madden, 1986).

Ajzen's theory of planned behaviour is useful in considering the following factors which make up teachers' beliefs and attitudes towards using technology in teaching.

- **Perceived relevance of ICT to teaching.** This factor is the **second most frequent** of the 43 factors identified in the 48 papers reviewed, after teachers' ICT competence (as shown in Figure 8 on page 33). This belief is also the **second most frequently mentioned** factor affecting teachers' use of computers. Marcinkiewicz (1994) related teachers' attitudes towards technology to their perceptions (beliefs) of whether technology can improve teaching and learning. According to Ajzen's model, teachers' perceptions of whether technology can improve teaching and learning would be based on the teachers' beliefs about ICT, whether or not those underlying beliefs are true. Rogers (1962) claimed that the relative advantage of an innovation affects its rate of adoption. However, Rogers also stated that "*It matters little whether or not an innovation has a great degree of advantage over the idea it is replacing. What does matter is*

whether the individual perceives the relative advantage of the innovation" (Rogers, 1962, p. 124). This suggests that an important predictor of teachers' use of technology is individual teachers' beliefs about whether using technology will improve teaching and learning. According to Marcinkiewicz (1994) individuals are more likely to adopt behaviours that they perceive as being worthwhile. Kanaya et al. (2005) found that teachers' perceptions of the relevance of a new software programme had a significant effect on whether they would use it in their teaching. Studies suggest that many teachers are reluctant to adopt new practices unless they are convinced of the merits of changing their current practices and that ICT can enhance learning (Cox et al., 1999; Kanaya et al., 2005). Zhao et al. (2002) found that successful implementation of classroom technology was more likely to occur when teachers viewed technology as a means to an end, rather than an end in itself, and when they saw an intimate connection between technology and the curriculum. When the value of technology was limited to peripheral functions, such as adding novelty to teaching, the likelihood of success was greatly reduced. Teachers' views on the relevance of computers was the **major factor** affecting their use of computers in two studies (Russell et al., 2003; Shannon & Doube, 2003) and the **third most important factor** in one study (van Braak, 2001).

- **Teachers' locus of control.** Five out of 225 teacher-level cases (2.2%) identified teachers' locus of control as impacting on their computer use. This factor refers to the extent to which teachers believe they have control over events:

  > *Perceived control refers to general expectancies about whether outcomes are controlled by one's behavior or by external forces, and it is theorized that an internal locus of control should support self-directed courses of action, whereas an external locus of control should discourage them.* (Zimmerman, 2000, p. 85)

  Although 'locus of control' and 'perceived behavioural control' both relate to control beliefs, an important predictor of behaviour according to the theory of planned behaviour, there is a subtle difference between the two concepts. Ajzen (1991) clarified the relationship between the two as follows:

  > *… perceived behavioural control refers to people's perception of the ease or difficulty of performing the behaviour of interest. Whereas locus of control is a generalised expectancy that remains stable across situations and forms of action, perceived behavioural control can, and usually does, vary across situations and actions. Thus, a person may believe that, in general, her outcomes are determined by her own behaviour (internal locus of control), yet at the same time she may also believe that her chances of becoming a commercial airplane pilot are very slim (low perceived behavioural control).* (Ajzen, 1991, p. 183)

- **Teaching philosophy** is the **sixth most frequent** of the 43 factors identified in the 48 papers reviewed (see Figure 8 on page 33). According to Zhao et al. (2002) research suggests that teachers who are aware of their pedagogical beliefs are more likely to adapt to new situations. An awareness of their own teaching practices and goals could allow teachers to choose technologies which better suit their teaching styles**.** Some researchers (e.g. Koehler & Mishra, 2009; Zhao et al., 2002) believe that digital technologies are not *"functionally neutral***"** (Zhao et al., 2002, p. 492)**.** That is, different technologies offer different affordances and impose different constraints which impact on teachers actions in the classroom (Koehler & Mishra, 2009)**.** Zhao et al. suggest that teachers who are aware of their own teaching practices and goals are more likely to successfully integrate technology into their teaching "*in the sense that they consciously use technology in a manner consistent with their pedagogical beliefs*" (Zhao et al., 2002, p. 492).

As discussed in Chapter 1 (see *The potential of ICT use to promote meaningful learning* on page 8 and *The failure of computers to fulfil the potential to improve learning,* starting on page 12), some researchers believe that the use of technology for teaching is consistent with a constructivist view of learning. The central idea in constructivist technology-embedded learning is to enable learners "*to learn by experiencing and doing*" (Dori et al., 2002, p. 512). Early research on how teachers were integrating technology found that teachers were initially using computers in ways that fitted relatively easily into their existing practice and matched their current beliefs about teaching (see Cuban et al*.,* 2001; Nisan-Nelson, 2001; Dori et al., 2002). This was in keeping with the belief held by some authors (e.g. Levin & Wadmany, 2005; Andrew, 2007) that constructivist teaching requires teachers to make a significant paradigm shift as they move away from a teacher-directed, transmissive mode of teaching to a more learner-centred one. The recent study by Ward and Parr (2010) suggested that even though some teachers may be making more use of ICT to enhance learning (e.g. through learners searching for information on the internet and creating multimedia presentations), most teachers are not using ICT in constructivist ways. Constructivist approaches would allow learners to use technology for higher-order cognitive tasks such as problem-based or discovery learning to promote meaningful learning (construction or modification of mental schemata). However, learner use of computers will not automatically lead to construction of knowledge – it depends on whether the design of the task or the educational software application promotes reflection and construction of ideas.

Drenoyianni and Selwood (1998) found that teachers' use of computers was related to their educational goals. The majority of teachers in their study (89.1%) cited computer awareness as a goal, while other teachers mentioned goals that better exploited the potential benefits of using computers, such as self-paced learning (59.4%) and collaborative learning (72.9%). Ertmer and Hruskocy (1999) found that although the teachers in their study used computers more, and used a wider variety of applications in their teaching as a result of a collaborative programme offering professional, technical and instructional support, there was little change in the way teachers' taught, suggesting little change in their underlying teaching philosophies.

Teachers' attitudes towards ICT

Seven factors relating to teachers' attitudes, together comprising 30.2% of the 225 cases of teacher-level factors affecting teachers' use of computers (see Figure 12 on page 44), were identified from the 48 papers reviewed. Because of the large number of factors in this category, the seven individual attitudinal factors are shown in Figure 15 (on the next page). Three factors together make up 79% of the 68 cases mentioned in the 48 papers relating to the impact of teachers' attitudes on their computer use (see Figure 15): teachers' level of confidence using ICT (28%), their level of innovativeness (26%), and their enthusiasm for using ICT (24%). The seven factors shown in Figure 15 are discussed in the following order: Teachers' level of confidence is discussed first and then teachers' level of innovativeness, because a person's level of confidence in their abilities may influence their level of innovativeness. Next teachers' enthusiasm for using ICT for instruction is discussed, followed by the remaining four factors shown in Figure 15, in order of decreasing frequency.

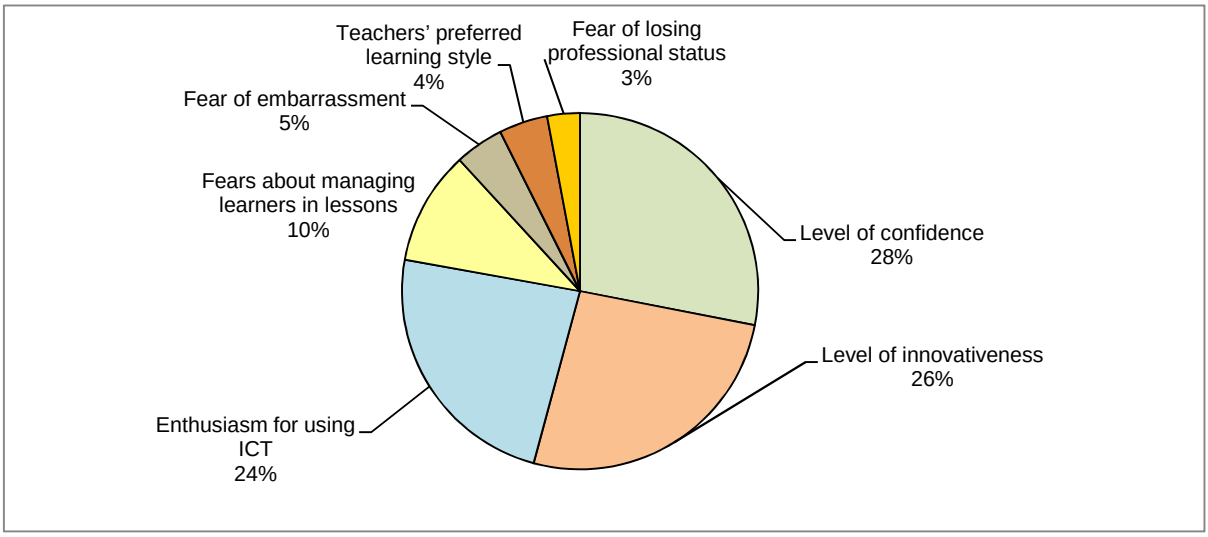

Figure 15. The seven factors comprising teachers' attitudes towards ICT, calculated as proportions of the 68 cases in this category

- **Level of ICT confidence.** This factor refers to how confident teachers feel about using computers in their classes. An individual's confidence in their ability to carry out a particular behaviour is widely referred to in the literature as 'self-efficacy' (e.g. Chen, 2010; Yusuf, 2011). Zimmerman (2000) points out that 'self-efficacy' provides an easier "*performance-based measure of perceived capability"* than the related motivational construct of 'locus of control' (Zimmerman, 2000, p. 82). Teacher confidence was reported as a factor affecting teachers' use of computers in 19 of the 225 cases (8.4%) of teacher-level factors (see Appendix G for a summary of the teacher-level factors affecting teachers' use of computers, from the 48 studies). In two studies (one old and one recent), lack of self-confidence was ranked as the **most significant factor** preventing teachers from using computers (Zammit, 1992; Ward & Parr, 2010). In the study by Cox et al. (1999), most of the 82 experienced ICT teachers felt confident about their ability to use computers effectively and to manage lessons using computers, which might have contributed to their extensive ICT use in their teaching.

- **Level of innovativeness.** According to Rogers (1962) an individual's natural disposition determines their motivation to become competent in a particular area. Such motivation is related to the individual's level of innovativeness, where innovativeness refers to the speed with which an individual adopts a new idea. Although Rogers defines innovativeness as "rate of adoption", some authors see innovativeness as a personality trait indicating a willingness to change. For example, van Braak (2001, p. 44) describes it as "*a positive attitude towards change*". Still other authors refer to innovativeness in terms of "*actual behaviour in terms of implementation of innovations*" (Loogma et al., 2012, p. 810). In my review of 48 papers, I looked for any mention of the term "innovativeness", whether this referred to an attitude or an innovative behaviour, which is likely to be underpinned by a positive attitude to change.

  Eighteen of the 225 cases (8%) at the teacher-level in the 48 papers reviewed (see Figure 13 on page 45) related to the influence of level of innovativeness on teachers' use of computers for teaching. One study identified teachers' level of innovativeness as the **most important factor** affecting teachers' use of computers for learner-centred teaching (Drent & Meelissen,

2008), while another study reported innovativeness as the **second most important factor** (van Braak, 2001). Three studies identified teacher innovativeness as an **important predictor** of the use of computers for teaching purposes (Baylor & Ritchie, 2002; Marcinkiewicz, 1993; Tondeür et al., 2008). Some researchers claim that teachers' level of innovativeness influences their ability to overcome first-order barriers (external barriers to ICT integration), such as a lack of resources or a lack of support (Donnelly et al., 2011; Drent & Meelissen, 2008; Ertmer et al., 2012). Drent and Meelissen believe that "*the innovative use of computers is partly the result of teachers' conscious choice to integrate ICT into their (more student-oriented) education*" (p. 195) and that highly-motivated teachers will develop their competence to be able to achieve their educational goals.

Rogers (1962) identified five adopter categories of individuals based on the rate at which they adopt innovations. In his 2003 book Rogers explains the five adopter groups using an innovation adoption curve to show the expected distribution of the individuals in a population, based on *"the mean of the individuals in the system, and the standard deviation*" (Rogers, 2003, p. 280). His innovation adoption curve is shown in Figure 16. The adoption curve in Figure 16 is a normal distribution. As explained by Sahin (2006) each category in the curve is

> *… defined using a standardized percentage of respondents. For instance, the area lying under the left side of the curve and two standard deviations below the mean includes innovators who adopt an innovation as the first 2.5% of the individuals in a system.* (Sahin, 2006, p. 19)

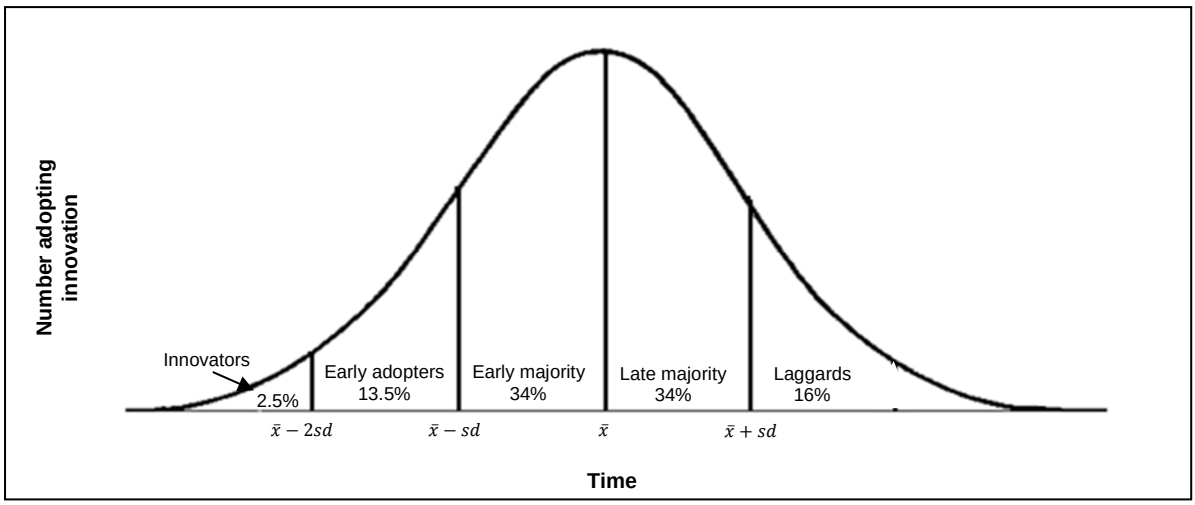

Figure 16. Categories of adopters based on innovativeness (Rogers, 2003)

Five categories of innovation adopters are shown in Figure 16:

- **Innovators**. These individuals form approximately the first 2.5% of the individuals to adopt an innovation (Rogers, 2003). Rogers (1962, p. 169) characterises innovators as "*venturesome*", i.e. individuals who "*are eager to try out new ideas*" and who are not afraid to take risks. Innovators are not afraid to make mistakes in the process of adopting an innovation (Rogers, 1962).
- **Early adopters**. Rogers (1962) says these individuals represent roughly the next 13.5% to adopt innovations. Roger believes early adopters are less maverick than innovators and more integrated into their social system, and that they are generally respected by their peers and often serve as role models for the implementation of an innovation.

- **Early majority**. Approximately the next 34% of individuals form the early majority who tend to "*adopt new ideas just before the average member of a social system*" (Rogers, 1962, p. 169). They are the individuals who may deliberate before adopting an innovation, so that they take longer to adopt the innovation than the innovators and early adopters (Rogers, 1962). Teachers in this group may be more likely to use computers for teaching purposes when sufficient technological equipment is available and adequate support is available.
- **Late majority**. About 34% of the individuals in a social system adopt innovations only after the majority of the individuals in that system have done so and they feel some social pressure to adopt the new idea (Rogers, 1962). They are characterised by their cautious approach to adopting innovations (Rogers, 1962). The teachers in the study conducted by Zhao et al. (2002) could possibly be placed in this group. The teachers in that study were found to be less resistant to using computers for teaching purposes where the technological innovation they were trying to implement was not too different from their current teaching practices.
- **Laggards**. This group (about 16%) is the "*last to adopt an innovation*" (Rogers, 1962, p. 169). Laggards are wary of change and tend to be focused on following traditions rather than trying out new ideas. Pelgrum (2001) identified a lack of teacher interest in using computers by 27% of the respondents in his survey as an obstacle to using computers in the classroom.

Rogers' concept of adopter categories, which supports the idea of individual differences between teachers accounting for the varying rates at which teachers adopt the use of computers for teaching, was used in this study to develop a method for classifying teachers into these categories (see Chapter 7) and to classify teachers into adopter categories (in Chapters 4 and 7).

- **Teachers' enthusiasm for using ICT.** Where teachers have a positive attitude towards information and communication technologies, they are more likely to use them, but a positive attitude alone is not sufficient to ensure computer use for teaching. For example, in the study by Ng and Gunstone (2003) 95% of the teachers displayed positive attitudes towards using computers, but only 43% actually used computers in their teaching.
- **Fears about managing learners in lessons**. Using ICT in lessons changes the nature of classroom management. Teachers have to manage their classrooms and operate expensive equipment while teaching. Seven cases out of a total of 225 (3.1%) teacher-related cases mentioned teachers being discouraged from using ICT in lessons because they were afraid of not being able to manage the classes adequately while dealing with issues related to technology use. In one study (Wood et al., 2005) teachers cited three types of problems they had when managing classes where learners were going to be using computers: the difficulties associated with moving a class of young children to a computer lab; the difficulties managing groups of learners with different skill levels; and their fears about possible sabotage of computers and hacking or vandalism. In some cases classroom management problems could be exacerbated by limited availability of computers, as was the case in the study by Nisan-Nelson (2001). In this study insufficient computers in the computer lab meant that between three and six learners had to be grouped at each computer, which made for a cramped and noisy environment that the teacher felt unable to cope with.

- **Fear of embarrassment.** A small percentage (4%) of the 68 attitude-related cases (number of times a factor was mentioned) relating to the impact of teachers' attitudes towards using computers (see Figure 15 on page 49) concerned teachers' fear that their lack of computer skills might embarrass them in front of their classes, especially where learners were more computer-literate than teachers were. In one study (Al-Fudail & Mellar, 2008) teachers reported fears of not being able to meet students' expectations, or not being able to use software effectively.
- **Teachers' preferred learning style.** Another small percentage of the 68 attitude-related cases (4%) related to the teacher's learning style (see Figure 15 on page 49). The study by Nisan-Nelson (2001) suggested that the type of instructional activities teachers design using computers reflects their preferred learning style. In another study (Drenoyianni & Selwood, 1998) some teachers were interested in learning how to use new software and how to integrate it into their teaching, while a few displayed a more research-oriented attitude by requesting training about the "educational aspects" of integrating ICT (Drenoyianni & Selwood, p. 96). The latter perspective suggests a reflective learning style which could greatly enhance the value of the teachers' use of computers for teaching and learning.
- **Teachers' fear of losing professional status.** After reviewing the literature, Fabry and Higgs (1997) identified the fear of losing status as a factor that discouraged teachers from using computers. Teachers feared that their work might be undermined by using computers or that they could be replaced by computers (Fabry & Higgs, 1997).

Teachers' ICT profile

Six factors made up this category, as shown in Figure 17. Teachers' ICT training, their ICT use outside of teaching and their length of ICT experience will be discussed first, as each of these factors contributes to teachers' level of ICT competence – the most frequent of the factors making up teachers' ICT profile (as shown in Figure 17). Finally, evidence for the impact of teachers' difficulties with integrating ICT and their positive experiences with ICT on teachers' ICT profile will be provided.

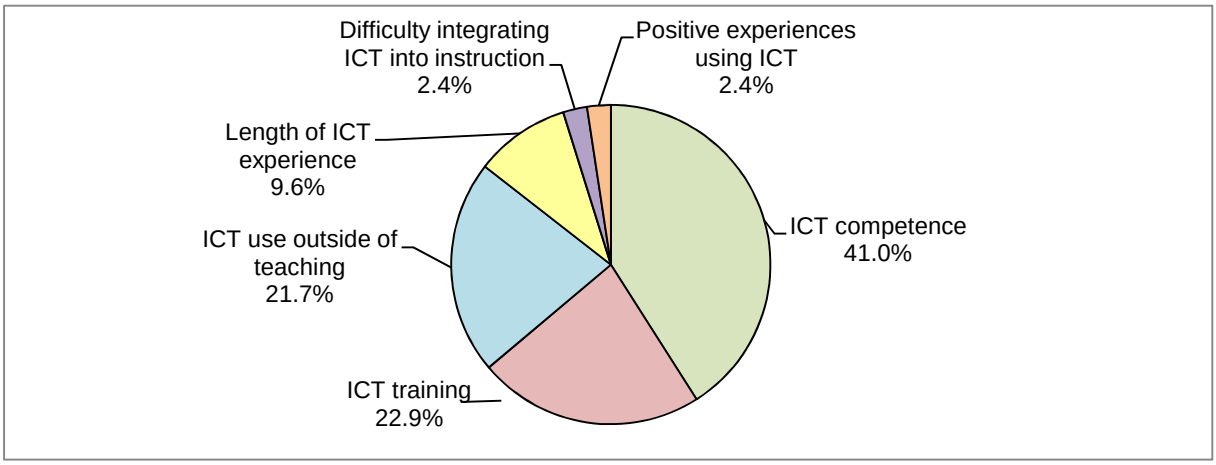

Figure 17. Relative frequencies of the six factors making up teachers' ICT profile, out of 83 cases

- **Extent of ICT training.** This factor was the ninth most frequent factor out of 43 factors identified from 48 papers reviewed (see Figure 8, page 33). Nineteen of the 225 teacher-level cases (8.4%) (see Figure 13 on page 45) mentioned a lack of training and experience as a factor which could hinder teachers' use of computers in the classroom (e.g. Ng & Gunstone, 2003; Tondeür, van Keer, van Braak & Valcke, 2008; Zhao et al., 2002). Where teachers lack the necessary technological knowledge and skills they are less likely to implement technology successfully. Teachers who have received the necessary training and/or are experienced in using computers can be expected to be more inclined to use computers than those who lack training and/or experience. Ertmer and Hruskocy (1999) found that when the 13 teachers from the single elementary school in their study were provided with training on how to use software for teaching, teachers not only reported increased levels of comfort in the use of software applications, they also started using computers more for instructional purposes
- **ICT use outside of teaching.** Teacher computer use at home and having Internet access at home are believed to be powerful indicators for technology adoption (Knezek & Christensen, 1999). Eighteen of the 83 cases comprising teachers' ICT profile (21.7%) related to the impact of using computers outside the classroom (see Figure 17 on previous page). Baylor and Ritchie (2002) posit that computer use outside of school suggests that the teacher is more comfortable with technology and is able to focus on how to integrate computers into their teaching rather than on how to use the technology.
- **Length of ICT experience.** The length of time teachers' have been using computers impacts on their use of computers for teaching. Teachers who have not grown up with computers tend to be less likely to use computers in their teaching (Donnelly et al., 2011) while teachers who have used computers for longer tend to be more inclined towards the innovative use of ICT (Drent & Meelissen, 2008).
- **Teachers' level of ICT competence.** Teachers' level of ICT competence refers to whether teachers know how to operate computer hardware and/or use a software application (Zhao et al., 2002). However, far from being an all-or-nothing phenomenon, ICT competency ranges from having no ICT skills to being able to use ICT pedagogically in the classroom in ways that take advantage of the potential benefits of computers, e.g. self-paced learning or using interactive features of software programmes. Although Rogers (1962, p. 108) believes that "*there is little evidence that lack of knowledge about innovations actually delays their adoption*", research into the use of computers for teaching highlights teachers' level of skill in using computers as an important factor influencing their use of computers for teaching. The significance of this factor warrants a more detailed look at the knowledge teachers need in order to be able to teach effectively using technology.

  Teachers' ICT competence can be interpreted as teachers' knowledge of how to use technology. Before teachers can include technology in their teaching, they must know how to use the technology, and they must know how to use technology to teach a particular section of content. Mishra and Koehler (2006) developed the concept of technological pedagogical content knowledge to address the knowledge teachers must have to use technology in teaching, based on Shulman's idea of pedagogical content knowledge, applied to the use of computers in teaching.

Since Shulman first published his idea of pedagogical content knowledge in 1986, knowledge has been recognised as the absolute basis for good teaching. According to the concept of pedagogical content knowledge, teachers' subject matter knowledge and their pedagogical knowledge (knowledge of appropriate general pedagogical strategies) should not be regarded as two separate domains. To teach a particular topic, Shulman (1986) proposed the idea of 'pedagogical content knowledge' as the subject matter knowledge and pedagogical knowledge teachers need to have in order to teach that topic effectively. Figure 18, is a diagrammatic representation of pedagogical content knowledge showing its components.

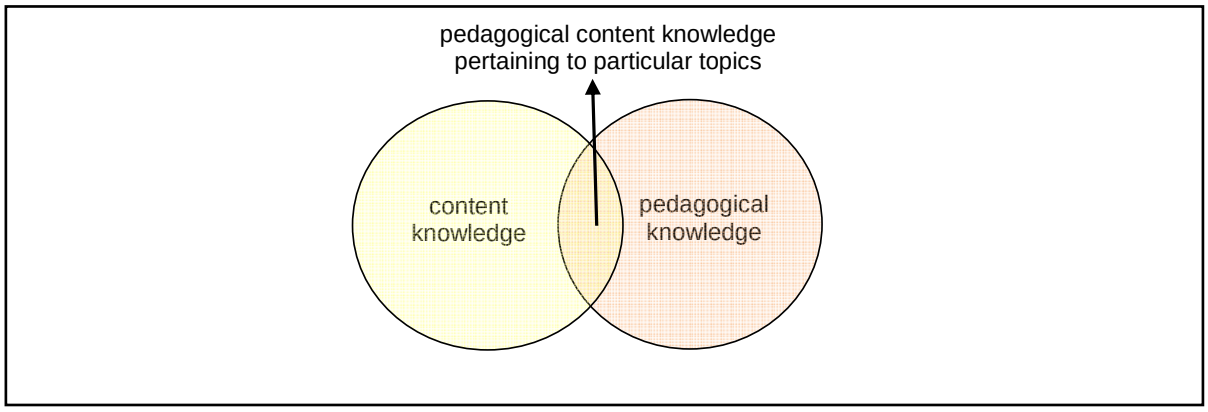

Figure 18. Diagrammatic representation showing the pedagogical knowledge and content knowledge components of pedagogical content knowledge (Mishra and Koehler, 2006)

Although Angeli and Valanides (2009, p. 156) point out that "*there is no universally accepted conceptualization of PCK*" these authors go on to say that in spite of various researchers having different ideas about the nature of the elements included in pedagogical content knowledge, they all agree that the construct includes

> *… both teachers' knowledge of representations of subject matter, and their knowledge of learners' conceptions and content-related difficulties. They also agree that PCK is specifically concerned with the teaching of particular topics, and is distinguished from general knowledge of pedagogy, knowledge of educational purposes, and learner characteristics.* (Angeli & Valanides, 2009, p. 156)

Mishra and Koehler (2006) recognise a further type of knowledge, called technological knowledge, which must be used in conjunction with pedagogical knowledge and content knowledge when teaching a particular topic using digital technologies. When teaching a topic of work using older, familiar technologies like blackboards and overhead projectors, teachers do not necessarily need to have special knowledge beyond what they were taught as student teachers, or to adapt their current teaching styles. Koehler and Mishra (2009) ascribe this to the specificity (singular function), the stability (function remaining unchanged over time) and transparency (simplicity to understand and use) of the more commonplace technologies. The use of any of the newer digital technologies to teach a topic, however, requires teachers to rethink their use of technology in teaching and to adapt both the way they represent content and the pedagogical strategies they employ to accommodate the digital technologies (Fabry & Higgs, 1997; Koehler & Mishra, 2009; Mishra & Koehler, 2006). According to the concept of technological pedagogical content knowledge (initially called TCPK, but now being referred to

as TPACK), the acquisition of technological knowledge cannot be considered separately from other types of knowledge teachers require when applied in a pedagogical setting. Technological knowledge must be used in conjunction with other types of knowledge for a teacher to display technological pedagogical content knowledge (Mishra & Koehler, 2006). Koehler, Mishra, and Yahya (2007) claim that

> *At the heart of TPCK is the dynamic, transactional relationship between content, pedagogy, and technology. Good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate, context-specific, strategies and representations.* (Koehler et al., 2007, p.741)

The concept of technological pedagogical content knowledge is represented in Figure 19. The types of teacher knowledge represented in Figure 19 are described in Table 4 (on the next page).

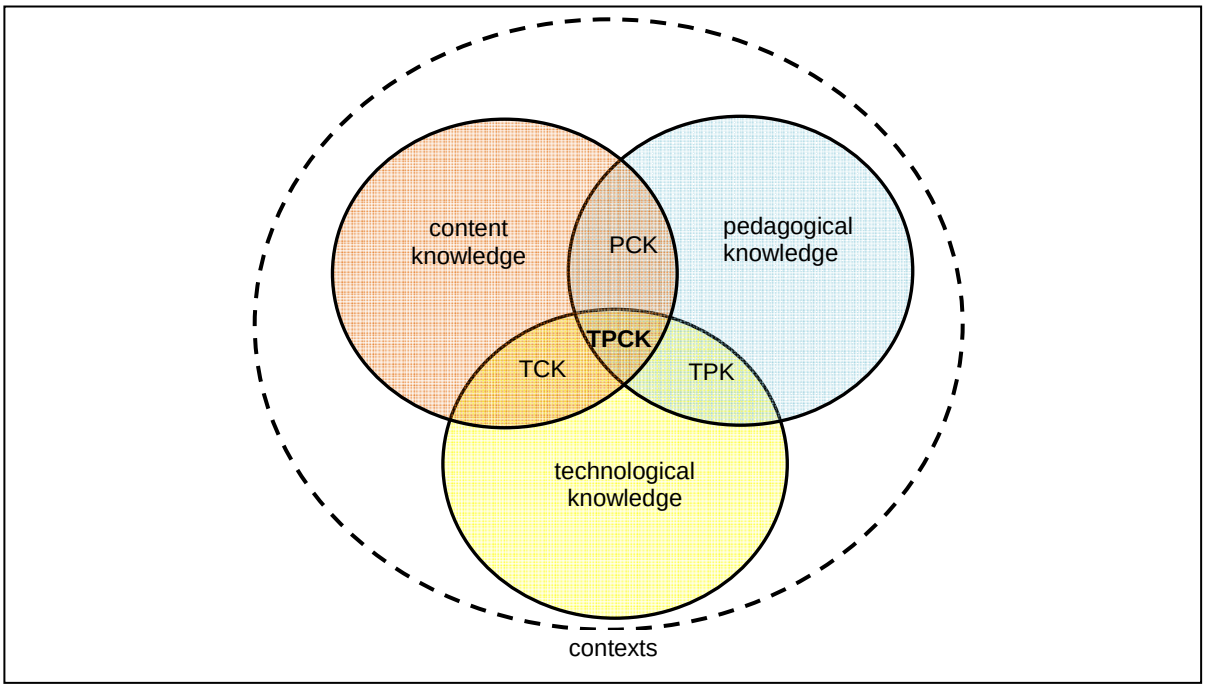

Figure 19. Diagrammatic representation showing the pedagogical knowledge, content knowledge, and technological knowledge components of technological pedagogical content knowledge (Mishra & Koehler, 2006)

The value of technological pedagogical content knowledge lies in its use as a theoretical framework "*to inform and guide research in the area of teaching with technology*" (Angeli & Valanides, 2009, p. 155). However, some researchers have raised concerns about the value of technological pedagogical content knowledge as a theoretical framework. Graham (2011) points out that some researchers have difficulty with defining the original construct of PCK, making it difficult to measure. Other researchers appear to be having similar problems with defining and measuring technological pedagogical content knowledge, which is based on PCK (e.g. Archambault & Barnett, 2010).

Table 4. Descriptions of the types of knowledge in the TPCK (now TPACK) framework (Mishra & Koehler, 2006)

Type of knowledge	Description
Pedagogical knowledge	Generic knowledge about methods of teaching and learning, including knowledge about techniques to be used in the classroom and ways of assessing learner understanding.
Content knowledge	Knowledge of the subject matter to be covered, "*including knowledge of central facts, concepts, theories, and procedures within a given field; knowledge of explanatory frameworks that organize and connect ideas; and knowledge of the rules of evidence and proof*" (Mishra & Koehler, 2006, p. 1026).
Technological knowledge	This type of knowledge includes knowledge of the different types of digital technologies available and how to use them, knowledge of computer hardware and operating systems, knowledge of software tools (e.g. spreadsheets and word processors), knowledge of how to install and remove software, and knowledge of how to install and remove peripheral devices like printers and scanners.
Pedagogical content knowledge (PCK)	Knowledge relating to the teaching of particular topics, including how the content knowledge is organised, and the best ways of teaching that topic.
Technological content knowledge (TCK)	TCK is knowledge about the affordances offered by using particular technologies and the possible constraints technologies could place on teaching certain content.
Technological pedagogical knowledge (TPK)	TPK is teachers' knowledge about how they can use various technologies to teach and "*knowing how teaching might change as the result of using particular technologies*" (Mishra & Koehler, 2006, p. 1028).
Technological pedagogical content knowledge (TPACK)	Knowledge of the subject matter for that topic, combined firstly with knowledge of the most appropriate pedagogical strategies for addressing any difficulties and misconceptions that might be associated with the topic and secondly with knowledge of which type of technology to incorporate when teaching that particular topic will allow teachers to successfully incorporate the use of technology into their pedagogical strategy when teaching that content.

Some authors question whether technological pedagogical content knowledge is a unique construct formed from the contributing knowledge bases which underpin it (i.e. transforming the knowledge bases into a new form of knowledge), or whether technological pedagogical content knowledge relies on integrating knowledge from the underlying knowledge bases (Angeli & Valanides, 2009; Archambault & Barnett, 2010; Graham, 2011; Jimoyiannis, 2010). The differences between the two perspectives on technological pedagogical content knowledge have important implications for research and measuring technological pedagogical content knowledge. In the first, transformative view, technological pedagogical content knowledge can be measured as an independent construct, while in the second, integrative view, a change in the underlying constructs (e.g. content knowledge or pedagogy) is necessary to see a change in the technological pedagogical content knowledge. The real question is whether the individual constructs which make up TPACK need to be measured, as this is a positivist term and may not be applicable in all cases. Despite the problems the use of technological pedagogical content knowledge as a theoretical framework may pose for researchers, integrating the underlying knowledge domains of pedagogy, subject matter, and technology remain important for teachers using technology (Graham, 2011; McGrath et al., 2011).

In my review of 48 papers, teachers' ICT competence had the highest frequency (6.2% of 546 cases) of any of the 43 factors identified (see Figure 8, page 33). It was also the most frequent of the 225 teacher-level cases (see Figure 13 on page 45), with 34 cases (15%), and the most frequent of the factors comprising teachers' ICT profile (see Figure 17 on page 52). A number of the 48 studies reported on some teachers' inability to use technology effectively for teaching

purposes (Bauer & Kenton, 2005; Chigona & Chigona, 2010; Drenoyianni & Selwood, 1998; Wood et al., 2005; Zammit, 1992), while three studies reported on the enabling effect of a high level of ICT competence on teachers' use of computers (Becker, 2000; Ertmer et al., 2012; Vanderlinde et al., 2012). Teachers' level of ICT competence was found to be the **most important factor** affecting the uptake of computers among 117 faculty members at an Anatolian university in Turkey (Sahin & Thompson, 2006) and the **second most important factor** affecting the uptake of computers in three of the 48 studies reviewed (Butler & Sellbom, 2002; Chiero, 1997; Pelgrum, 2001). The concept of technological pedagogical content knowledge emphasises the importance of technological knowledge as a factor affecting teachers' use of computers to teach particular content. However, the knowledge requirement is only one of a number of obstacles to the use of technology for teaching purposes.

- **Difficulty integrating ICT into instruction.** This factors was ranked the **third highest obstacle** to ICT use for teaching after lack of knowledge and skills, in one study (Pelgrum, 2001). Where teachers have difficulty integrating ICT into instruction, their lack of ICT skills could be a contributing factor (Al-Fudail & Mellar, 2008).
- **Positive experiences with using computers.** Positive experiences using computers seems to increase teachers' confidence with computers and increase the likelihood of their using computers for instructional purposes (Mueller, Wood, Willoughby, Ross, & Specht, 2008). For example, Ertmer and Hruskocy (1999) found that the teachers in their study became more positive about using computers when they saw an increase in learners' level of motivation and skills.

Teaching profile

Two factors made up this category, which had a frequency of 15 of the 225 teacher-level factors (6.7%), making it the fourth most important category out of five at the teacher-level (see Figure 12 on page 44).

- **Subject taught:** This factor was the nineteenth most frequently mentioned out of 43 factors identified from the 48 papers (see Figure 8, page 33). Selwyn (1999) reported that ICT use differed across subjects, based on teachers' beliefs about the nature of the subject (subject paradigm), the way the subject content was best taught (subject pedagogy) and how closely ICT use matched the culture associated with that subject. One study (van Braak, 2001), found that teaching a language was the most important predictor of teachers' use of computers for teaching. Four other studies found that the use of computers was highest for English teachers (Becker, 2000; Cuban et al., 2001; Priest et al., 2004; Zhao & Frank, 2003). This contrasts with findings from some other studies (e.g. Ward & Parr, 2010; Williams et al., 2000) which reported lower levels of ICT use in the core academic subjects (English, mathematics, science and social science) compared to other subjects. It is difficult to make generalisations because other teacher factors and institutional factors, such as the availability and accessibility of hardware and suitable software, may influence subject teachers' use of computers. For example, in the study by Chigona and Chigona (2010) only mathematics and science teachers were allowed to use the computers available in the schools involved in the study, and had access to ICT support, so their results excluded teachers of other subjects.

- **Experience in teaching**. Although this factor had a very low frequency out of the 43 factors (see Figure 8 on page 33), Russell et al. (2003) found teaching experience to be an important predictor influencing teachers' use of technology use for learner-centred instruction. They suggested that more teaching experience might suggest a greater exposure to ICT or a higher level of self-confidence.

Social proficiency

Although there was only one factor in this category, and one paper which mentioned the impact of teachers' interpersonal skills, some researchers regard social awareness as an important factor affecting ICT uptake. A teachers' 'interpersonal skills' refers to their "*ability to negotiate the social aspects of the school culture*" (Zhao et al., 2002, p. 494). A socially savvy teacher would be aware of the social dynamics at play in the school and know who to approach for support with integrating ICT. Zhao et al. (2002) believe that ICT as an innovation requires greater social proficiency than other innovations because

- teachers need to be able to identify and to interact effectively with technicians and administrators who can help them meet their goals.
- teaching with technology could interfere with well-established patterns in classroom routines, which could alarm parents and/or administrators. Teachers would need to anticipate potential problems and to be able to negotiate compromises where necessary. Twelve years later this may no longer be a problem, as attitudes to the use of ICT have changed dramatically in recent years.
- the limited funding for technology projects in schools could contribute to disharmony among colleagues if one project is prioritised over another. Teachers would need to be aware of what resources the school has and be sensitive to the needs of their colleagues.

Teacher-level factors and adopter categories

One of the aims of my study was to look at ways to best support teachers when integrating ICT, given the importance of the effect of different teacher beliefs and attitudes on their use of technology for teaching (for the effect of teachers' beliefs and attitudes on ICT integration see discussion starting on page 42 and also Gibson et al., 2014; Lee & Lee, 2014; Mama & Hennessy, 2013; Pajares, 1992). Donnelly et al. (2011) provide a useful model (see Figure 20) which "*identifies four types of teachers in relation to ICT integration into their practice*" (Donnelly et al., 2011, p, 1477).

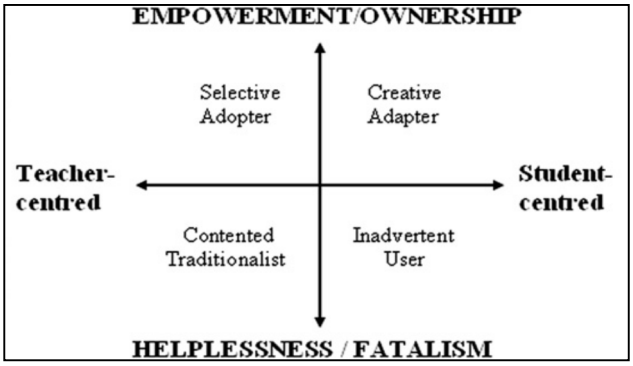

Figure 20. Teachers' ICT integration model (Donnelly et al., 2011)

The four adopter categories shown in Figure 20 are based on teachers' perceived self-efficacy and their teaching philosophy. The model is useful because it describes the different types of technology usage of teachers in different adopter categories and considers the implications therof for providing differentiated support to target the needs of different groups of teachers towards making considered decisions about the best ways to integrate ICT into their teaching in order to imporve learning. The four adopter categories from the ICT integration model of Donnelly et al. are:

- **Creative adapters**. According to Donnelly et al. this group represents the highest level of teacher technology integration because these teachers "*have no qualms about trying new techniques in their teaching*" and are able to adapt a new technology for use in their teaching (Donnelly et al., 2012. p. 1479). These researchers cite the comment by Ferdig (2006, p. 756) which they believe describes a *Creative adapter*:

  > *There are other times when a knowledgeable person can take a technology and make it pedagogically sound 'on the fly'. (*Donnelly et al., 2011, p. 1479)

  These individuals have high levels of self-efficacy and are eager to try new techniques that could lead to improved learning. Teachers in this group are unlikely to need training on how to use computers.

- **Selective adopters.** Teachers in this category are selective in the extent to which they integrate ICT, and the types of technology they are using their teaching. They will "*only adopt and continue to use an ICT resource if it helps their students to do better in the final assessment*" (Donnelly et al., 2011, p. 1478). Their strong sense of empowerment means that although they are not afraid to try new things, they will only choose to use an ICT resource if they are convinced it will benefit learning. This group, because of their selective and judicious use of computers, could serve as role models for other teachers on how to integrate technology effectively to improve learning and avoid adopting new technologies which might not benefit learning.

- **Inadvertent Users.** Donnelly et al. suggest that *Inadvertent Users* "*would not have sought out the innovation. The innovation would have come to them*" (Donnelly et al., 2011, p. 1478). These individuals are unlikely to look for ICT resources and depend on others (e.g. colleagues/ the institution) to provide resources. Donnelly et al. (2011, p. 1478) also describe this group of teachers as not having "*a particular focus per se in that they are more of an accidental user of a particular ICT in the classroom*". For example, they could be using computers to project memos and notes for learners to copy down from a screen. Although they are using computers for instruction, their incidental and unfocused technology usage is unlikely to promote constructivist learning. These individuals could be supported through training aimed at improving their knowledge of what technologies are available and how these technologies can be used in their subject to enhance learning.

- **Contented traditionalists.** These individuals are characterised by their teacher-centred approach and their lack of intrinsic motivation to adopt new teaching practices. According to Donnelly et al. (2011) teachers in this group

  > *... may only start using ICT tool if it becomes the norm in the culture of the school but even then, they will try to resist it citing they do not needed for their practice.* (Donnelly et al., 2011, p, 1478)

Hennessy, Ruthven, and Brindley (2005) emphasise "*the need to use ICT only where it enhances learning compared with other approaches*". This seems to be the rationale behind the *Contented traditionalists'* reluctance to replace their tried and trusted teaching methods with teaching with computers. They are content with their current methods of teaching and achievements, and may not be convinced that using technology can improve on these. These teachers would benefit from support aimed at improving their knowledge of what technologies are available and how these technologies can be used in their subject to enhance learning. Although not mentioned by Donnelly et al. (2011), there appear to be different subgroups in this category.

The concept of teachers moving adopter groups if provided with appropriate support based on their specific needs is an important one. Contented traditionalists would need the most support. Their sense of empowerment could be improved through training in how to use computers more effectively to enhance learning, which Donnelly et al. (2011, p. 1481) refer to as "*pedagogical professional development*". A shift to the left for these individuals, i.e. towards more learner-centred teaching, would require a change in "*environmental factors*" such as the prevailing assessment requirements, or a mandated change requiring teachers to use ICT. A change in *environmental factors* would be the way *Selective adopters* could be encouraged to make more use of ICT in their teaching, since they are already competent and confident about using ICT. Inadvertent users, on the other hand, lack the knowledge of how to apply their computer knowledge judiciously to enhance learning, and would benefit from pedagogical professional development.

This model is adapted and used in Chapter 6 when I report on the changes in teachers' ICT use after the introduction of the innovation promoting the use of ICT for instruction at the case study school.

2.4.3 Learner-level factors

Twenty-three cases of three learner-level categories of factors were identified from the 48 papers reviewed (see Appendix H). The three learner-level categories are shown in Figure 20.

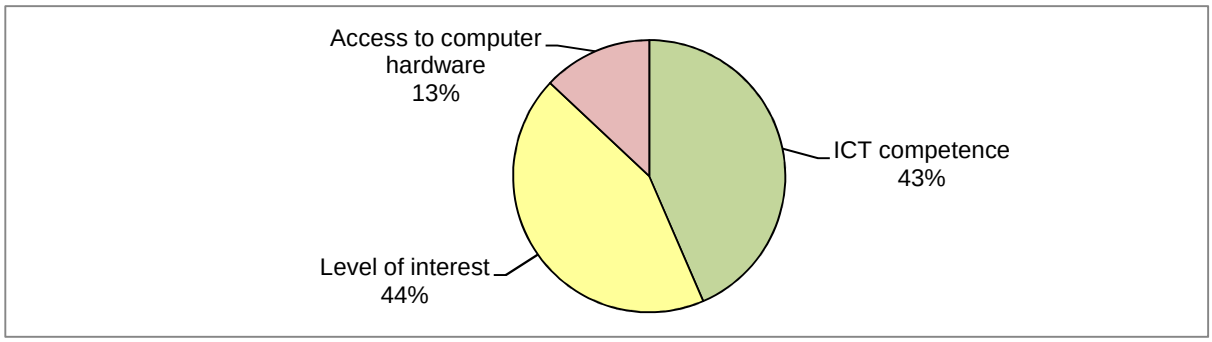

Figure 21. Proportion of learner-level categories out of a total of 23 cases, identified from 48 papers reviewed

Each category of learner-level factors only consisted of one factor. The reader is reminded that the number of papers mentioning a factor out of the 48 papers reviewed is referred to as the number of

'cases' of that factor. Two of the three learner-level factors had the same case count of 10 (43.5% of the 23 learner-level cases). These two factors are discussed first.

- **Learners' ICT competence.** This was the 23rd most frequently mentioned factor out of 43 factors (see Figure 8 on page 33). Teachers are more likely to use computers with learners who are more competent at using them without needing assistance (Ertmer et al., 2012; Selwyn, 1999; Wood et al., 2005).
- **Learners' level of interest**. Learners' response to the use of ICT for teaching and learning influences teachers' use of computers. The most common reason for this is that teachers feel encouraged where students respond positively to using computers in lessons (Donnelly et al., 2011; Ertmer et al., 2012; Ng & Gunstone, 2003; Ward & Parr, 2010; Williams et al., 2000; Wood et al., 2005). These teachers felt that "*technology motivates students and when students are motivated they will learn better and more effectively*" (Ng & Gunstone, 2003, p. 250). Some teachers, however, found that learners are less likely to respond positively if the work was not going to be examined (Donnelly et al., 2011).
- **Learners' access to computer hardware at home.** Three studies mentioned the impact of learners' access to computer hardware at home as impacting on the use of computers for instruction in schools. For example, learners who have access to better equipment at home than is available at school may become frustrated with the school equipment (Wood et al., 2005).

2.5 CONCLUDING REMARKS

In this chapter I reviewed 48 research-based papers from the literature to identify factors affecting teachers' use of ICT. My understanding gained from reviewing the papers allowed me to construct a conceptual framework which I presented as a concept map (see Figure 5, page 29). This conceptual framework, derived from two sources, the research literature and theories in the literature, represented a "*tentative theory*" (Maxwell, 2005, p. 35) about the factors affecting teachers' use of computers to support learning, and the relationships between these factors. The conceptual framework helped me to design my research and decide on the methods that could be used to investigate the factors affecting teachers' use of computers in the case study school.

The research design for the study and the methods used to investigate the factors affecting teachers' use of ICT during the first phase of the study are described in Chapter 3 with the findings from this investigation being presented in Chapter 4. Because one of the factors affecting teachers use of ICT (the software) was investigated in more depth, and required a different methodology for the software evaluation, a separate chapter is devoted to the conceptual framework for evaluations, the methods used, and results of the software evaluation (see Chapter 5). The methods used to investigate the factors affecting teachers' use of ICT during the second phase of the study are described in Chapter 6 and the findings for the second phase are presented in Chapters 7 and 8.