Development and validation of a model of ICT integration in primary education

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Voorwoord

"The presence of change knowledge does not guarantee success,
but its absence ensures failure".

Fullan, Cuttress, & Kilcher (2005, p. 54)

Het lezen van dit citaat bracht me terug naar de periode waarin ik als leerkracht aan de slag ging. Het was midden jaren negentig en computers deden hun intrede in het onderwijs. Iedere "Vlaamse" school in Brussel kreeg een aantal computers met als doel die te gebruiken in de dagdagelijkse klaspraktijk. De twee computers die onze school toen kreeg, bleven een aantal maanden ongeopend in de leraarskamer staan tot een collega ze besloot te installeren. Ik leerde er mijn eerste mails mee versturen, maar van ICT-integratie in het onderwijs kwam niet veel in huis. Nu, twaalf jaar later, staan we heel wat verder. Hoewel, de hoge verwachtingen van visionairs die via technologie een revolutie in het onderwijs voorspelden, zijn nog lang niet ingelost.

Dat ICT-integratie in het onderwijs heel wat complexer is dan het voorzien van infrastructuur wist ik bij aanvang van het doctoraat. Dat ik zo'n kluif zou hebben aan dit onderwerp had ik echter niet vermoed. Het citaat is dan ook niet toevallig gekozen. Het is afkomstig van de Canadese onderwijsgoeroe Michael Fullan die wereldwijd gezien wordt als een autoriteit op het gebied van veranderingsprocessen in scholen. Fullan roept op om door middel van dialoog gezamenlijke doelen te formuleren en resultaten na te streven. Hij pleit voor een open leergemeenschap gebaseerd op verbondenheid en gedeelde verantwoordelijkheid om het gewenste resultaat te bekomen. Dit is evenzeer van toepassing bij de totstandkoming van dit proefschrift. Ik wil dan ook mijn dank uitspreken aan alle personen die hebben bijgedragen tot de realisatie ervan.

In de eerste plaats dank ik mijn promotoren Martin Valcke en Johan van Braak. Ik herinner me nog, Martin, dat je een affiche van de muur nam en ermee voor mij kwam staan. Het was een affiche van het FWO met daarop alle informatie voor het indienen van een doctoraatsvoorstel. Als geen ander zie je nieuwe mogelijkheden en dat merk je wanneer je door de gangen van onze vakgroep loopt. Jouw ongelofelijke enthousiasme en gedrevenheid hebben veel betekend voor mij. Johan, jij kwam als een geschenk uit de hemel. Bij aanvang van mijn doctoraatsproject arriveerde jij aan onze vakgroep en nam me onmiddellijk onder de vleugels. Jij maakte me wegwijs in ons onderzoeksdomein en gaf me de nodige houvast bij mijn eerste studies. Martin en Johan, jullie waren een uitstekende tandem: altijd bereid om mee te denken over het onderzoek, steeds paraat met concrete feedback, en ook nog op korte termijn. Samen zorgden jullie ervoor dat dit project steeds op de rails bleef. Bedankt voor zoveel betrokkenheid!

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Er zijn ook heel wat mensen die me indirect gesteund hebben. In de eerste plaats mijn (schoon)ouders die er altijd zijn en iedere maandag de kinderen een zalige grootouderdag bezorgen; mijn vader door de vragenlijsten uit te testen in zijn school; Stijn door de bevoorrading van leuke muziek bij het schrijven; Anna, Sara en Sam door te babysitten zodat wij met z’n tweeën weg konden; en alle vrienden die zorgden voor de nodige ontspanning.

Hoe moet ik tenslotte jou bedanken Roosje? Zonder jouw aanmoedigingen was ik misschien niet opnieuw gaan studeren. Dat ik vervolgens heel ontspannen dit proefschrift tot een goed einde kon brengen heeft alles met jou te maken! En onze zoontjes Ode en Egon, bedankt om me steeds te laten inzien hoe relatief dit werk is. Jullie zorgden er als geen ander voor om het doctoraat even te vergeten: “papa pelen!” [Egon, 2jaar].

Ik eindig met wat Ode [4 jaar] onlangs vertelde: “Er is een piloot naar onze klas gekomen en hij heeft zijn vliegtuig getoond!”; “En heb je echt zijn vliegtuig gezien?” “Niet echt natuurlijk, op de computer…”.

Jo Tondeur, 1 oktober 2007

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Chapter 1*
General introduction

Abstract

The first chapter serves as a general introduction to the studies reported in this dissertation. We first focus on the context in which the research was organised. This is followed by an overview of critical points that can be raised about earlier research approaches in the area of educational ICT use. With consideration given to specific limitations, this dissertation defines four research objectives, which form the basis for the main research questions. Before describing the research questions, the theoretical framework will be discussed followed by the conceptual framework. Consequently, research questions are listed, and the overall research design is described. We conclude with an outline of the structure of the dissertation and an overview of the content of the subsequent chapters.

Research context

The dynamics of ICT in society

The speed with which the revolution of Information and Communication Technology (ICT) has taken place is phenomenal. Today, primary school teachers in many countries of the world are working with "digital natives" who are growing up with ICT as a non-remarkable feature of their world, in the same way as an earlier generation took television for granted. The changes have been faster and more sweeping than anyone imagined as recently as two or three decades ago (Facer, Furlong, Furlong, & Sutherland, 2003; Haddad & Draxler, 2002). ICT allows us to create, collect, store and use knowledge and information; it enables us to connect with people and resources all over the world, to collaborate in the creation of knowledge and to distribute and benefit from knowledge products (Alberta Learning, 2000; Kearns & Grant, 2002; Loveless & Dore, 2002; Plomp, Anderson, Law, & Quale, 2003). Nevertheless, many would argue that, as remarkable as technological innovations are, they are no more than a beginning.

Until recently, ICT was known only as "Information Technology" (IT). The term "Information Technology" came about in the 1970s (Loveless & Dore, 2002) to describe technology that gives the user direct access to a wide range of diverse information types (Ertmer, Addison, Lane, Ross, & Woods, 1999). IT has being superseded by the term "Information and Communication Technology" to explicitly include the field of electronic communication (Kennewell, Parkinson, & Tanner, 2000; Plomp, Anderson, Law, & Quale, 2003). Today, ICT has ballooned to encompass many aspects of computers and technology,

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Tondeur, J., Valcke, M., & van Braak, J. (2005). ICT-competenties in het lager onderwijs: een nieuwe fase van ICT-integratie. *ICT en onderwijsvernieuwing, 9*, 15-34.

and the term is more recognisable than ever before. The term ICT is generally used in this dissertation in combination with perhaps the most important development in this context, the computer. “ICT integration” and “adoption of computer use” will be used as interchangeable concepts.

This work is concerned with the integration of ICT in education, but the introduction of ICT is not limited to one sector. The fast development of ICT has brought about profound changes in our ways of living and working, a phenomenon referred to as the “information society”, a society in which ICT is regularly in use, or “knowledge society”, to stress that the most valuable aspects are intangible – human and social capital – and that the keystones are knowledge and creativity (Commission of the European Communities, 2000; Kozma, 2003; OECD, 2001; Plomp, Anderson, Law, & Quale, 2003). ICT provides the tools needed by the information or knowledge society. In this context, primary teachers are almost inevitably presented with the demand to integrate ICT. However, integrating ICT is a complex process of educational change, and the extent of ICT applications in schools is still extremely varied and, in many instances, very limited (Kirschner & Selinger, 2003; Loveless & Dore, 2002; Scrimshaw, 2004).

ICT integration in primary education: a complex process of change

Education has always lived in tension between two functions: education as a matter of assuring continuity and as a matter of fostering creativity and change (Haddad & Draxler, 2002). Within these developments, ICT brings a new set of challenges and pressures for educational institutions. At the time of writing this introduction, many teachers, schools, educational authorities and researchers are considering a range of questions about how to use ICT with young children, such as: What educational goals and learning objectives will be accomplished by using ICT in schools? Is there a need for a specific course in computer literacy? How can ICT be implemented effectively in existing subjects? Many of the questions related to ICT integration are still unanswered, and attempts to address them have generated widespread debates.

Effectively integrating ICT into learning systems is much more complicated than providing computers and securing a connection to the Internet. Computers are only a tool; no technology can fix an undeveloped educational philosophy or compensate for inadequate practices (Ertmer, 2005; Niederhauser & Stoddart, 2001). Therefore, choices have to be made in terms of educational objectives (Sugar, Crawley, & Fine, 2004). In this respect, the process of ICT integration is a dynamic one involving interacting factors over time (ten Brummelhuis, 1995). Moreover, no single solution exists to address the immense challenges of ICT integration because different perspectives of integrating ICT can be chosen (Becker, 2001; 2003; Niederhauser & Stoddart, 2001; Janssen Reinen, 1996).

As early as 17 years ago, Hawkridge (1990) discerned three different reasons or rationales that drive policies related to the integration of ICT in education. Each of these represents a perspective of legitimacy to introduce ICT:

- an economic rationale: The development of ICT skills is necessary to meet future needs for a skilled work force, as learning is related to jobs and careers;
- a social rationale: All pupils should be familiar with computers in order to become responsible and well-informed citizens;
- an educational rationale: ICT is a supportive tool to improve teaching and learning.

These rationales illustrate the range of functions ICT could have in the educational process. In order to realise these potential benefits, many governments and organisations have supported ICT integration in education. Current curriculum developments often reflect an economic and social rationale. The "eEurope 2002 objectives of the Lisbon Summit", for instance, stipulate that all graduates must be digitally literate in order to be prepared for a knowledge-based economy (Commission of the European Communities, 2000). National documents such as the "School Education Action plan for the Information Economy" (EdNA, 2001) and the "National Educational Technology Plan" (U.S. Department of Education, 2004) take a similar approach. In the light of this socio-economic rationale, many countries have introduced ICT as a separate school subject to teach pupils a number of technical skills (Plomp, Anderson, Law, & Quale, 2003). National ICT curricula and frameworks, e.g., "Qualification and Curriculum Authority" (1999) and "Alberta Learning" (2000) build on the assumption that the use of ICT is beneficial for student learning, stressing an educational rationale. ICT literacy is – according to this rationale – a secondary effect of a content-related ICT use. The educational use of ICT should be embedded within subject-oriented competencies.

The question of which perspective to choose was raised in almost every situation in which this innovation was a topic of discussion: Educational authorities wanting to stimulate ICT in education have to decide on a focus of interest, but also schools have to think about the different perspectives of ICT integration (Fluck, 2003; Janssen Reinen, 1996). Despite the distinction between the three rationales discussed above, the OECD (2001) reports that there is a growing convergence between the economic, social and educational rationales. Current policies convey the idea that ICT supports economic and societal developments, but they also state that ICT-based educational practices have to take a pedagogical position as a point of departure (Bryderup & Kowalski, 2002; Kearns & Grant, 2002). This search for a more holistic approach is illustrated in the case of Flanders.

The status of ICT in Flemish primary schools

Because all young people move through compulsory education, school is, according to the Flemish government (Ministry of the Flemish Community; Department of Education, 2004), the appropriate place to develop crucial ICT competencies. But in Flanders, educational policies are characterised by a high level of local school autonomy. Schools are responsible for organising their own teaching and learning processes, although they are also accountable for instituting quality control policies that meet government-dictated standards – minimum objectives that should be achieved by a majority of pupils at the end of primary

education. Schools translate these standards into a school-based plan. In primary schools, a distinction is made between subject-specific and cross-curricular attainment targets. The latter refer to more generic goals such as ICT competencies that are relevant in all subject areas (Ministry of the Flemish Community; Department of Education, 2004). A first set of standards was conceived during the mid-1990s, and ICT competencies hardly played a role. Standards with any reference to ICT were as follows:

- Pupils are able to use information resources in a systematic way.
- Pupils recognise examples of information processing technologies.
- Pupils are able to consult information resources.

ICT integration can be seen as a bottom-up innovation where the integration of ICT in the teaching and learning process depends upon the motivation of the individual teacher and/or school principal. It has to be mentioned that, although ICT competencies were not included in the formal curriculum at the time of writing this dissertation, the Flemish government – by means of information and awareness campaigns, in-service training, subsidising of infrastructure, etc – indirectly encouraged schools to integrate ICT into education. A concrete example is the dissemination of an information brochure in primary schools that presents good practices in the integration of ICT.

In response to the lack of a formal ICT curriculum, the Flemish government has recently introduced new ICT standards (Ministry of the Flemish Community; Department of Education, 2007). The core of these standards focuses on the nature of the learning process (educational rationale). Achieving the goals of the educational rationale will, according to the Ministry of the Flemish Community's Department of Education (2004), automatically lead to the accomplishment of the goals of the economic and social rationale. These new ICT standards will be integrated in the formal national curriculum at the beginning of the school year 2007-2008.

ICT in education: observed differences

The question remains as to what degree teachers integrate ICT into teaching and learning activities. Despite large expenditures, increased access and almost universal use by school-age children, several observers have questioned the extent to which ICT is affecting teaching and learning. Research reveals that, although we observe an increase in the use of ICT, computers are poorly integrated into teaching and learning processes (Cox, Abbott, Webb, Blakeley, Beauchamp, & Rhodes, 2003; Murphy, Penuel, Means, Korbak, Whaley, & Allen, 2002; Waxman, Connell, & Gray, 2002). The requirement that ICT should be developed across curriculum areas (educational rationale) is not yet mirrored in actual use of ICT (Ofsted, 2001; Tearle, 2004). These results are largely in accordance with findings of other studies suggesting that ICT is hardly used as a tool to support the learning process; the focus in general is on skill-based ICT use (Loveless & Dore, 2002; Niederhauser & Stoddart, 2001; Smeets, 2005).

Research in the classroom (Hennessy, Deaney, & Ruthven, 2005; Schofield & Davidson, 2002) documents that some teachers are beginning to integrate ICT into teaching and learning across subjects. Nonetheless, evidence indicates that only a small number of teachers have integrated ICT and are using it to make significant changes in the classroom (Kirschner & Selinger, 2003; Kozma, 2003; Smeets, 2005). Smeets (2005) found that the use of ICT in teaching and learning merely showed characteristics of traditional approaches to learning. According to Haddad and Draxler (2002), it is a myth that providing computers to schools transforms the learning process. Also Windschitl and Sahl (2002) stipulate that the conditions of ubiquitous ICT alone do not automatically initiate educational change. Finally, several studies (Goodison, 2002; O'Dwyer, Russell, & Bebell, 2004; Tang & Ang, 2002) reported that, although teachers are gradually starting to integrate ICT into their teaching strategies, significant differences are observed in the way ICT is implemented in classroom and school settings.

These studies demonstrate that the aspirations of national educational authorities to foster ICT integration in schools do not easily result in concrete changes in practice at class level. In this respect, Tang & Ang (2002) point at the differences between schools, suggesting that general, central policies and reforms do not automatically lead to educational change in schools. Schools are considered to differ with respect to performance level, innovation capacity and contextual characteristics. This implies that educational improvement or innovation efforts should consider to a larger extent the "power of site or place" (Fullan, 2001). Therefore, it is important to study the role of school characteristics associated with ICT integration in education.

However, ultimately it is still the teachers who must alter their practices for ICT to become integrated (Tearle, 2004). Teachers' attitudes and beliefs are therefore important and seen as the main factors in implementing change (Robbins, 2000). An example comes from Marcinkiewicz (1993), and more recently furthered by van Braak (2001), who talks of teachers' technological innovativeness as a key component in influencing how likely they are to make changes in practice with regards to ICT use. Clearly, no "off-the-shelf" configuration meets the diversity of needs and conditions for integrating ICT in education. A formidable challenge, therefore, continues to face educational researchers.

Research in ICT integration: some challenges

A review of the available research results in a list of critical points that can be raised about earlier research approaches in the area of educational ICT use.

(1) ICT integration in education: What to measure?

The first problem is related to the measurement used in analysing ICT integration. Within the context of educational computer use, a range of definitions, classifications and typologies can be found. Policymakers, practitioners and researchers often refer to computer use as one monolithic entity. Such inquiry is unanswerable because computer applications are very

different. The potential of ICT depends on what we use it for (Ertmer, 2005; Haddad, & Draxler, 2002; Niederhauser & Stoddard, 2001).

Published studies reflect particular views on computer use in a learning environment. Many researchers measure computer use by reporting the amount of technology used in the classroom or the time teachers and pupils spend working with computers (e.g., Mathews & Guarino, 2000; Mumtaz, 2001; O'Dwyer, Russell, & Bebell, 2004). In other studies, the focus is on specific software applications. The questionnaire designed by Kent and Facer (2004) reflects a range of computer activities in order to compare pupils' home and school use of computers. Becker (2000) presented both a software and an instructional application approach; the survey asked teachers to name the software that is considered to be most valuable in their teaching. Similarly, Waite (2004) reported teachers' responses about the uses of computers and the goals of their use in primary schools.

Although these indicators are valuable, they do not provide a complete picture of ICT use in the classroom. Only a limited number of studies are centered on the instructional objectives pursued by integrating computers into curricula. Ainley, Banks and Fleming (2002), for instance, differentiate between categories of educational computer use such as "computers as information resource tools" and "computers as authoring tools". In the same way, Baylor and Ritchie (2002) differentiate between types of educational computer use, including "the use of computers for collaboration" or "the use of computers for higher order skills". Another example is the Second Information Technology in Education Study (SITES) Module 2 (Kozma, 2003). Based on qualitative and quantitative methods, clusters of educational practices building on computer use were identified.

Although each of the available studies enriches the whole picture of educational computer use, a comprehensive instrument that integrates types of computer use in the context of primary education is not yet available.

(2) Focus on individual characteristics: what about school characteristics?

In the literature, the question is repeatedly put forward as to what variables determine the integration of ICT in education. In this respect, research on ICT integration often focuses on measuring teacher characteristics, such as teachers' computer attitudes (Albirini, 2004; Dementrias, et al., 2003), teachers' innovativeness (Marcinkiewicz, 1993; Roehrich, 2004; van Braak, 2001) and gender differences (Shapka & Ferrari, 2003; Volman, van Eck, Heemskerk, & Kuiper, 2005). This focus has oriented research on ICT integration towards "individual blame" rather than "system blame" (Tang & Ang, 2002). Previous research largely ignores the complex systemic nature of ICT integration, including the role of national policies (macro level) and local school policies (meso level).

However, recent studies reveal that ICT is successfully integrated in some schools and very poorly in others because of school characteristics (Baylor & Ritchie, 2002; Dawson & Rakes, 2003; Otto & Albion, 2002; Tang & Ang, 2002). The research centres on the hypothesis that school-related policies might affect integration of ICT in the classroom and that an important factor is the development of a shared vision concerning how ICT is to be

used for teaching and learning (Bryderup & Kowalski, 2002; Hughes & Zachariah, 2001; Otto & Albion, 2002). It appears that teachers in schools engaged in ICT planning are more likely to apply ICT in an innovative way (Kozma, 2003). Dexter, Anderson and Becker (1999) also conclude that successful ICT implementation depends upon goals shared by different actors and at different organisational levels. Successful ICT integration, then, seems to be related to actions taken at school level. Examining school characteristics associated with ICT use has the potential to lead to a greater understanding of the systemic nature of ICT integration.

(3) ICT integration cannot be explained solely on the basis of technology-related factors

Similarly, in order to effect educational changes, it is necessary to understand educational beliefs of teachers that are associated with the use of ICT in the classroom. Many studies with a focus on ICT integration are limited to the impact of technology-related factors, such as "computer experience" (Bovée, Voogt, & Meelissen, 2007; Williams, Coles, Wilson, Richardson, & Tuson, 2000; van Braak, 2001). However, there is a growing consensus that the adoption of educational innovations can only be explained when the educational beliefs of teachers are taken into account (Becker, 2001; Ertmer, Addison, Lane, Ross, & Woods, 1999; Higgins & Moseley, 2001; Becker, 2001).

Teachers' educational beliefs are understandings, premises or propositions about education (Denessen, 2000), established by multitudinous experiences (Nespor, 1987, Pajares, 1992). Teachers' beliefs are considered relatively stable and act as a filter through which new knowledge and experiences are screened for meaning (Campbell, Kyriakides, Muijs, & Robinson, 2004; Kagan, 1992; Nespor, 1987; Pajares, 1992). In contrast to integrated models of teaching, beliefs consist of an eclectic mix of rule of thumb, generalisations, opinions, values and expectations (Lowyck, 1994) that underlie teachers' planning, decision making and behaviour in the classroom (Kagan, 1992; Nespor, 1987; Pajares, 1992).

According to Pajares (1992), teachers interpret innovations according to their personal beliefs. In other words, teachers accept more easily innovations that are in accordance with their personal conceptions of teaching and learning. A computer does not embody one single pedagogical orientation; it includes a spectrum of approaches to teaching and learning. According to Niederhauser and Stoddart (2001), teachers select applications of computers in line with their selection of other curricular variables and processes (e.g., instructional strategies) that fit into their existing educational beliefs. ICT integration in education is, therefore, unlikely to succeed unless we understand teachers' personal educational beliefs and their relationship to teaching practices.

(4) The search for a holistic approach

Based on the previous research, which will be reviewed in more detail in the following chapters, it can be concluded that there are many factors influencing the use of ICT in education. However, the cause of differences in ICT integration can only be explained in part. One of the reasons for this is that most researchers have investigated the influence of just a

few characteristics on the integration process; there has been little overlap between these influencing characteristics (O'Dwyer, Russell, & Bebell, 2004; Tang & Ang, 2002). Perhaps there was, and still is, a lack of appreciation or understanding of the complexity of integrating ICT in education.

ICT does not exist in isolation; it is interwoven with the rest of the tools and participants in the learning environment (Lim, 2002). Therefore, research studies in ICT need to shift their attention towards the whole configuration of events, activities, contents and interpersonal processes taking place in the context in which ICT is used (Salomon, 1993). Some researchers argue for a more holistic approach to study innovations in schools such as ICT integration (Fullan, 2001; Kennewell, Parkinson, & Tanner, 2000; Kozma, 2003; Salomon, 1991). They assume an integral, multidimensional relationship between computer use and a set of personal, pedagogical and organisational factors. In this respect, researchers are faced with the challenge of investigating the many influencing characteristics of ICT integration in conjunction with each other.

Research objectives

On the basis of previous limitations observed in earlier research, four research objectives are defined in this dissertation.

Objective 1: Measuring how ICT is integrated in the context of primary education
Objective 2: Identifying a broad spectrum of teacher characteristics associated with ICT integration
Objective 3: Exploring school characteristics associated with ICT integration
Objective 4: Building a model that integrates teacher and school characteristics associated with educational ICT use

These objectives form the basis for the main research questions. Before identifying those questions, the theoretical framework will be discussed, including the factors that can be relevant from a school improvement perspective.

Research questions in a theoretical context

ICT integration from a school improvement perspective

While there is understandably a great desire among policymakers to examine the impact of ICT on student learning, a critical preliminary step is necessary to understand how ICT is being used and to examine the characteristics that are associated with the use of ICT in the classroom. This distinction can also be identified in the theory of educational change. ICT integration can be discussed from either a school improvement or a school effectiveness perspective. Each perspective has its own approach to change.

In brief, the school improvement movement is a practice- and policy-oriented approach to strengthen schools' capacities for change management (Creemers, 2002). In contrast to "school effectiveness", "school improvement" tries to find out *how* schools can change in order to improve, whereas school effectiveness is strongly focused on *what* is to be changed in order to become more effective (Hopkins & Reynolds, 2001; Reynolds, Teddlie, Hopkins, & Stringfield, 2000; Stoll, 1999). The school effectiveness approach has an outcome focus in terms of student achievement and those characteristics which are correlated to achievement (Creemers, 2002; Mortimore, Sammons, Stoll, Lewis, & Ecob, 1998). School effectiveness brought a large-scale, known-to-be-valid knowledge base about "what works" at school level to potentiate student outcomes (Teddlie & Reynolds, 2000). School improvement is mainly concerned with the quality of changes with less attention being paid to the consequences at the level of pupil outcomes (Bennett & Harris, 1999; Hulpia & Valcke, 2004). Nonetheless, we acknowledge that both approaches are indispensable in view of improving educational processes. They should not be considered as opposing processes, but rather as complementary ones (Hopkins & Reynolds, 2001; Reynolds et al., 2000).

This dissertation explores ICT integration from a school improvement approach. Reynolds, Teddlie, Hopkins and Stringfield (2000) argue that a school improvement approach to educational change embodies the long-term goal of establishing a self-renewing school. They stress the central role of the school level in mediating change and focus on the problems and internal conditions schools (Hopkins, Ainscow, & West, 1994; ten Brummelhuis, 1995; Wikeley, Stoll, & Lodge, 2002). A sufficient level of school autonomy, the development of school policies and a collaborative team seem to be positively related to school improvement (Wikeley, Stoll, & Lodge, 2002). In this respect, Stoll (1999) highlights the importance of clear goals and systematic strategies to direct educational change, with team development and professionalism of principals and teachers being necessary conditions (Fullan, 2001; Galanouli, Murphy, & Gardner, 2004; Hopkins, & Reynolds, 2001).

Moreover, Gray (1997) stresses the value of strong leadership to guide change efforts. The literature on school improvement stresses the importance of leadership in developing a commitment to change (Fullan, 2001). Other important aspects of the school improvement process are cooperation between schools (Hopkins & Reynolds, 2001) and "school culture" (Bennet & Harris, 1999; Robertson & Briggs, 1998). Any attempt to improve a school that neglects school culture is, according to Fullan (1988), "doomed to tinkering" because school culture influences readiness for change. But school culture is complex because it is largely implicit, and we only see surface aspects (Hargreaves, 1994).

Besides school characteristics, nothing is more important to school improvement than a teacher (Hopkins, Reynolds, & Gray, 1999; Robertson & Briggs; Teddlie & Reynolds, 2000). The individual teacher as learner is right at the centre of educational change (Stoll, 1999). Teacher experiences, beliefs, emotions, knowledge, skills, motivations, etc. interact within any learning context. Teachers' perceptions about and actions towards changing and developing their teaching methods are influenced by what they believe, as well as their knowledge (Borko & Putnam, 1995; Fullan, 2001). Their priorities, therefore, are extremely important (Goodson, 1992). Each teacher experiences his or her own career pattern, which

influences the desire to learn and the readiness to engage in improvement activities (Huberman, 1988).

Despite the existence of differences in school improvement approaches, there is general agreement on the basic set of factors mentioned above. Yet this list of school factors cannot depict the complexity of school improvement. The knowledge base for school improvement presented in this dissertation is by no means definitive or exhaustive. Understanding one element leads to the necessity to understand the foundation on which that element rests, which in turn leads to the discovery of other significant elements (Beach & Lindahl, 2004). Although, in the broadest sense, the process for school improvement appears to be straightforward, underlying it are a complex set of inter-related factors (Fullan, 2001). Just like ICT integration, school improvement is an incredibly complex process and no simplified "cookbook approach" can promise success (Beach & Lindahl, 2004).

ICT integration can be seen as a specific case in the wider field of school improvement. Research set out to identify the factors influencing ICT integration showed that these same factors could be applied to school improvement in general (Cox & Rhodes, 1989: Dawson & Rakes, 2003; Otto & Albion, 2002). A clear example is the development of a shared vision concerning how ICT is to be used for teaching and learning (Hughes & Zachariah, 2001; Otto & Albion, 2002). As stated earlier, it appears that teachers belonging to schools engaged in ICT planning are more likely to apply ICT in an innovative way (Kozma, 2003). Dexter, Anderson, and Becker (1999) also conclude that successful ICT implementation depends upon goals shared by different actors and at different organisational levels. As a consequence, the development of an ICT school plan with clear goals and defining the means to realise these goals is a crucial step towards actual ICT integration (Bryderup & Kowalski, 2002).

Analysis of available research also reveals the importance of leadership in managing ICT integration. School principals are in a position to create the conditions to develop a shared ICT policy. Several studies (e.g., Anderson & Dexter, 2000; Dawson & Rakes, 2003) support the claim that leadership in promoting change is a key factor when it comes to merging ICT and instruction. Baylor and Ritchie (2002, p. 412) also describe leadership as a critical predictor of ICT integration since it focuses on promoting the use of ICT at a strategic and action level: "School principals who wish to nurture a technology culture need to join in rather than sitting by the side". Other ICT-related school factors that can be connected to school improvement approaches are the degree of ICT training (e.g., Galanouli, Murphy, & Gardner, 2004), ICT-related support (e.g., Lai & Pratt, 2004), teachers' educational beliefs (e.g., Becker, 2001; Granger, Morbey, Lotherington, Owston, & Wideman, 2002) and cooperation between schools (e.g., Triggs & John, 2004).

Conceptual framework: a multidimensional approach

In this dissertation, we adopt the available school improvement literature to frame a broad and diverse body of factors emerging from the field of research related to the use of ICT in education. While there can be many factors influencing computer use in education, it

is helpful to develop a conceptual framework that captures the major factors. In this context, we adopted the conceptual framework, based on concentric circles, of Veenstra (1999) to structure the determinants of ICT integration (Fig. 1). This framework was originally developed to explain differences in student achievement (Veenstra, 1999) but proves to be an adequate framework for the present study.

In this framework, ICT use is embedded in a concentric set of levels that effect and mediate change. Using this framework, we assume an integral, multidimensional relationship between computer use and a set of teacher and school characteristics. Although this framework is not based on a school improvement approach, there is considerable synergy between the school improvement theory and the conceptual framework because the school improvement theory also defines personal, pedagogical and organisational factors that contribute to the process of change.

Figure 1 depicts the conceptual framework in which several determinants of ICT integration could be ordered on the basis of four categories of variables both at the individual teacher level and at school level. These factors are the independent variables that explain the differences in ICT integration:

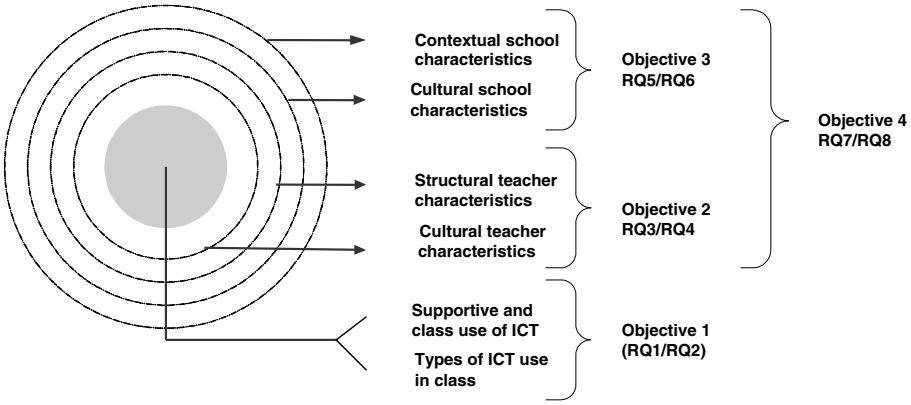
Cultural teacher characteristics: The teacher level includes one category with structural characteristics and one with cultural characteristics.. These comprise, for instance, “teacher’s beliefs about good education” or “computer attitudes”. The cultural characteristics are positioned as an intermediate circle between the structural characteristics and the dependent variables. An attempt will be made to explain the effects of characteristics from the outer circles by means of characteristics from the inner circle.

Structural teacher characteristics: These teacher characteristics are non-changeable, in this case referring to “age” and “gender”.

Cultural school characteristics: These include characteristics such as “leadership” and “ICT school policy”.

Structural school characteristics: The outermost circle consists of contextual characteristics such as “infrastructure” and “school size”.

The numbers that appear in Figure 1 correspond to the objectives and research questions elaborated in the next section.



Note. RQ=Research Question

Figure 1. Conceptual framework of the study based on the structure of concentric circles by Veenstra (1999).

Using this framework, we can structure the different variables and offer a better insight into the relationships between the different characteristics. The final selection of the operational variables that will be analysed in our study will be based on a review of the literature and the findings of the subsequent studies.

Overview of the research questions

Based on a school improvement approach, this study explores a statistical model for the teacher and school characteristics associated with the integration of ICT in Flemish primary schools. More specifically, this study responds to the following research questions in line with the research objectives:

Objective 1: Measuring how ICT is integrated in the context of primary education

Research question 1: To what degree have Flemish primary school teachers integrated the computer for supportive use and class use?

Research question 2: To what degree have Flemish primary school teachers integrated different types of computer use in class?

Objective 2: Identifying a broad spectrum of teacher characteristics associated with ICT integration

Research question 3: Which teacher characteristics are associated with the use of computers in class?

Research question 4: To what degree are teachers' educational beliefs related to how computers are used in class?

Objective 3: Exploring school characteristics associated with ICT integration

Research question 5: To what degree are local school policies related to the use of computers in class?

Research question 6: What is the impact of school culture characteristics on the use of computers in class?

Objective 4: Building a model that integrates teacher and school characteristics associated with ICT integration

Research question 7: What is the combined impact of teacher and school characteristics on computer use in class?

Research question 8: What is the differential impact of teacher and school characteristics on specific types of computer use in class?

In order to study the questions formulated above, two preliminary questions have to be dealt with first:

Preliminary question 1: Can we develop an instrument that measures the integration of computers for supportive and class use?

Preliminary question 2: Can we develop an instrument that integrates different types of computer use in class?

Design of the studies

The design of this dissertation is based on the results of four studies over a period of three school years (2004-2007). Our methodologies are represented in Table 1.

Table 1
Study design

Study	Research design
Study 1 (April-June 2004)	Teacher survey (*N*= 570)
Study 2 (October-November 2004)	Structured interviews with school principals (*N*= 53)
Study 3 (March-April 2005)	Teacher survey (*N*=352)
Study 4 (April-June 2006)	ICT coordinator (*N*= 53) and teacher survey (*N*= 527)

In order to generalise our research findings, we developed a quantitative research design to study the list of research questions. There is a clear lack of quantitative research on the influencing characteristics of ICT integration in primary education. Therefore, large samples were needed (Table 1). Three studies are based on the results of a questionnaire distributed to Flemish primary school teachers. At least one teacher at each grade level took part in the study, resulting in data from at least six teachers per school. Stratification variables were related to the type of educational network and the degree of urbanisation (rural/urban). A

separate questionnaire for ICT coordinators provided information about ICT-related school characteristics, such as infrastructure and the availability of software. One study reflects a qualitative research design in order to get more in-depth information in addition to the data gathered via the surveys.

Overview of the dissertation

The dissertation is structured in seven chapters. All chapters have been published or submitted for publication in international peer-reviewed journals. Table 2 provides an overall picture of the four studies and the research questions discussed in the different chapters.

Table 2

Overview of the research questions addressed by chapter

	Study 1	Study 2	Study 3	Study 4
Chapter 1	*Chapter 1 presents an overview of all questions*			
Chapter 2[a]	PQ1, RQ1, RQ3			
Chapter 3[b]	RQ1, RQ3	RQ5		
Chapter 4[c]			PQ2, RQ2	
Chapter 5[d]				RQ4
Chapter 6[e]				RQ6, RQ8
Chapter 7	*Chapter 7 presents an overview of the answers to all questions*			

PQ = Preliminary Question; RQ = Research question

[a] Manuscript published in *European Journal of Psychology of Education*

[b] Manuscript accepted for publication in *Computers & Education*

[c] Manuscript published in *Journal of Computer Assisted Learning*

[d] Manuscript accepted for publication in *Computers in Human Behavior*, subject to minor revisions

[e] Manuscript submitted for publication in *Journal of Computer Assisted Learning*

Throughout our study on the development and validation of a model of ICT integration, we deal with a number of issues successively. *Chapter 2* presents research about the development of an instrument that measures the integration of computers for supportive use (e.g., administration, preparing worksheets for pupils and looking for information on the Internet for lesson preparation) and the use of computers in the classroom (e.g., computers as a tool for presentation, encouraging pupils to improve their computer skills, instructing pupils in the possibilities of computers). Moreover, it provides an overview of the differential impact

of teacher characteristics on both types of computer use. Teacher characteristics were categorised in three levels: demographics, computer experience and technology-related attitudes (e.g., computer attitudes and technological innovativeness). The focus is on the central person in the innovation process of ICT integration – the teacher.

Chapter 3 presents a more complete picture of the determinants of computer use in the classroom to address whether local school policies are related to the use of computers in class. In view of answering this research question, we conducted structured interviews with school principals. Teachers' perceptions about the ICT school policy are also examined in order to investigate whether these perceptions are vital for successful implementation. Finally, a number of teacher characteristics that were found to be effective in the research reported in chapter 2 were added to the model in order to consider and compare their impact on school policies.

Chapter 4 describes the development of instruments for assessing different types of computer use in the classroom. This objective goes beyond studying percentages of time that teachers spend on computers, focusing on a better understanding of the variety of computer uses in view of supporting learning and instructional processes.

This brings us to the central research question of *Chapter 5*: Are teachers' educational beliefs related to how computers are used in class? Based on the typology of computer use (Chapter 4), this research addresses the impact of teachers' beliefs on their typical approaches to computer use in the classroom. Therefore, the research first examines whether profiles can be developed that reflect a set of beliefs adopted by teachers, based on the extent to which they possess traditional and constructivist teaching beliefs.

Chapter 6 integrates the findings from the studies reported in the previous chapters. Two research questions are central in this chapter: (a) What is the impact of school culture characteristics on the use of computers in class? and (b) What is the differential impact of teacher and school characteristics on specific types of computer use in class?

Chapter 7 brings together the findings of the subsequent chapters. It provides an overview of the answers to the questions formulated above and presents an integrated discussion of the results and their practical implications. Finally, it includes a discussion of the limitations of the studies and suggestions for future research.

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Chapter 2
Explaining different types of computer use among primary school teachers*

Abstract

In order to identify differences in determinants of supportive and class use of computers, path modelling was applied in a sample of 468 primary school teachers. Independent variables were categorised in three levels: demographics (age and gender), computer experience (computer training, computer experience expressed over time, intensity of computer use), and attitude measures (general computer attitudes, attitudes toward computers in education, and technological innovativeness).

Computer support and class are not related to the same set of variables. Computer support was mainly predicted by computer experience variables and general computer attitudes. Strongest predictors of class use were technological innovativeness and gender. Yet, the degree of explained variance for class use of computer was considerably lower compared to supportive computer use. These results indicate the limitations of explaining complex forms of professional computer use on the basis of both individual determinants and quantitative models. The article concludes with some practical implications and recommendations for further research.

Introduction

Since about a quarter of a century, the educational potential of computers is being explored by educationalists. Many authors point to the ability of computers to support and even enhance teaching and learning processes in primary education (Cox et al., 2004; Loveless & Dore, 2002). Other voices are more critical and raise questions concerning the effectiveness of computers (Cuban, Kirkpatrick, & Peck, 2001; Robertson, 2002). Although the number of computer users is constantly increasing, few individuals still refuse to accept the value of computer technology for professional purposes.

Given the ever-increasing growth of computer use in education, it is essential for researchers to investigate the factors affecting different types of computer use. However, there are many different ways in which the concept of computer use can be defined. From a technical point of view, teachers differ in their abilities to manipulate computers. Many instruments were developed to measure individuals' degree of technical computer competence (Furst-Bowe, et al., 1995; van Braak, 2004; Winter, Chudoba, & Gutek, 1998). Next to a technical approach, a task-related approach can be adopted. Hogarty, Lang, & Kromrey (2003) for example developed a survey to measure teachers' reported use of technology in their classroom, clustered in different categories: integration, support, confidence and comfort, and attitudes. In this contribution, two general categories of professional computer

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* Based on:
van Braak, J., Tondeur, J., & Valcke, M. (2004). Explaining different types of computer use among primary school teachers. *European Journal of Psychology of Education 14,* 407-422.

use will be distinguished for primary education teachers. The first one, supportive computer use, refers to the use of computers for pro-active and administrative tasks. Examples are the use of computers for student administration and evaluation, preparing worksheets and keeping track of pupils' learning progress. Second, we focus on class use of computers. This refers to the use of computers to support and/or enhance the teaching or learning process, such as the use of computers for demonstration, drill and practice, instruction, and differentiation.

The use of computers for both types of professional activities will be assessed. The vast majority of teachers use computers for support in the educational practice; fewer teachers actually integrate computers as a teaching tool or learning device. This leads to the question whether supportive computer use is influenced by other factors than class use. Based on the available literature, possible determinants of teachers' computer use will be identified. This will be followed by an assessment of the impact of background variables, computer experience and attitude measures on supportive and classroom use of computers.

Theoretical framework

What is affecting the degree of computer use by teachers? In many studies, researchers have focused on measures of computer attitudes and experience. A general finding is that computer experience is positively related to computer attitudes. The more experience individuals have with computers, the more likely their attitudes toward computers will be favourable (Al Khaldi & Al Jabri, 1998; Levine & Donitsa-Schmidt, 1998; Potosky & Bobko, 2001; Rozell & Gardner, 1999; Shashaani, 1997, Williams et al., 2000). Shashaani (1997) demonstrated that computer training has a positive impact on computer attitudes. Using path modelling, Rozell & Gardner (1999) found computer experience to be predictive of computer attitudes. Potosky & Bobko (2001) also demonstrated a strong and positive relationship between computer attitudes and computer experience. In their survey computer attitudes were found to contribute significantly to the prediction of computer experience. Other components related to computer use include access to computers, computer ownership, and age at first computer use (Bradley & Russell, 1997).

To examine the correlation between computer attitudes and measures of computer use and experience, researchers developed and validated a considerable number of attitude scales, such as the Computer Attitude Scale (Loyd & Gressard, 1984), the Bath County Computer Attitude Scale (Francis & Evans, 1995), the Computer Attitude Measure (Kay, 1989), the Computer Apathy and Anxiety Scale (Charlton & Birkett, 1995), the General Computer Attitudes Scale (van Braak & Goeman, 2003), and the Technology Profile Inventory (DeYoung & Spence, 2004). As the importance of computers in education is shifting from information towards communication tasks, researchers are beginning to develop instruments to measure the communicative effectiveness of computers in education (Mitra, 2001).

Findings of Marcinkiewicz (1993) stress the role of innovativeness as an important determinant of different levels of computer use. Innovativeness is a well studied concept in communication and business research in understanding why individuals adopt a certain innovation or not (for an overview, see Roehrich, 2004). Innovativeness can be defined as a

personal attitude towards the adoption of an innovation. Innovativeness refers to the willingness to change, or to the relative speed at which an individual adapts to an innovation as compared to others in the same social system (Rogers & Shoemaker, 1971). In addition to a favourable disposition towards the adoption of a new idea, method or technology, the concept of innovativeness includes an intentional dimension. The members of a given social system can be divided into different categories based on their degree of innovativeness (Rogers, 1995). In this study, the concept of technological innovativeness will be introduced and operationalised as an attitudinal component.

Many authors have stressed the existence of a gender gap in computer use and attitudes (De Young & Spence, 2004; Jenson, De Castell, & Bryson, 2003; Kadijevich, 2000; Khine, 2001; Looker & Thiessen, 2003; Mathews & Guarino, 2000; Shashaani, 1997; Volman & Van Eck, 2001). Therefore it seems imperative to include this variable in the research.

Purpose of the study

The main objective of this study was to examine the effect of demographics (age and gender), computer related experience (duration of computer use, intensity of computer use, and followed computer training), and three attitudinal constructs (general computer attitudes, attitudes toward computers in education and technological innovativeness) on two different types of computer use: supportive computer use and class use. The research question centres on the differential effects of individual teacher characteristics on the two different types of professional computer use. In order to investigate the effect of the independent variables on the two dependent computer use variables, path modelling was applied (Marcoulides & Schumacker, 2001).

Research method

Sample

The subjects were 468 teachers working in primary education in East-Flanders, one of the five provinces in Flanders, the Dutch speaking region of Belgium. All primary schools were included in the population, with the expectation of the schools for special education, given the specific nature of ICT implementation in these schools. The sample was stratified according to governance (private/official) and degree of urbanization. 60 school principals were contacted to cooperate to this research. At least one teacher per school year would fill in a printed questionnaire. Fifty three principals agreed, representing an 88.3 % response at school level. The questionnaires were distributed and recollected by the school principals. The data were collected in April 2004. As a token of appreciation, a small financial reward was offered to all participating schools for each filled out questionnaire. This incentive served as a stimulating factor in raising the response rate. Based on gender, age and governance, the respondents served as a representative sample of the population.

Demographics, computer use and experience

The sample included 349 females and 119 males; the age range varied from 22 to 61 years, with an average age of 38 years. All teachers in the sample reported to be somehow familiar with computing. The average computer experience was 9.04 years (SD = 4.14). Only 2.6 % of the sample currently does not use a computer, neither for supportive tasks, class use or leisure purposes. On average, teachers use the computer 9.05 hours (SD = 7.27) a week, mostly for professional support (M = 4.35 hours; SD = 3.86) and to a lesser extent for class use (M = 2.28 hours, SD = 2.81) and leisure (M = 2.42 hours; SD = 3.88). Only 12.3 % reported never to use computers in class. Most of the teachers use the computer between one and two hours a week (62.3%) and 25.4% integrate the computer three hours or more in their classrooms. This implies that computers have found their way into classrooms, but the degree of class use expressed over time stays rather limited.

More than half of the teachers (56.2%) have followed at least one computer training course during the five previous years. The average computer training courses followed over the last five years was 1.05 (SD = 1.49).

Instruments

Two types of computer use

Based on the literature on computing in education (f.e. Becta, n.d.; Kennewell, Parkinson, & Tanner, 1999; Maier et al., 1999), two scales were composed to measure how often teachers use computers for support and in class. The respondents were asked to indicate, on a five point scale, the extent to which they use the computer for various tasks (0 never, 1 every term, 2 monthly, 3 weekly, 4 on a daily basis).

A principal component analysis (with orthogonal -varimax- rotation) was used to investigate whether computer support and class use were two substantially distinct constructs. Results are reported in Table 1. One support and two class use items were removed from the item set due to low variability among the respondents (‘using education related discussion list or newsgroups’, ‘keeping contact with pupils after school hours’, ‘giving homework to be submitted on the computer’) . The two-component structure accounted for 43.4 % of the shared variance among the items. The eigenvalues were respectively 7.9 and 3.6 for supportive computer use and class use items.

Table 1
Results of the principal component analysis: supportive computer use (PC1) versus class use (PC2); and frequency of use (at least once a week) (N = 468)

	PC1 1	PC2 2	Freq %
keeping an agenda on the computer	**.79**	-.10	57
administration, such as letters and reports	**.77**	.16	48
using e-mail for my job	**.69**	.23	37
looking up information on the Internet for lesson preparation	**.66**	.21	37
looking for educational software	**.58**	.29	17
preparing worksheets for the pupils	**.54**	.16	53
(co-)constructing a school website	**.38**	.29	6
using a student tracking system	**.29**	.06	7
calculating pupils' test scores	**.24**	.11	16
Encouraging collaborative learning	.13	**.75**	33
using the computer for differentiation	.12	**.73**	46
encouraging pupils to train skills	.13	**.70**	53
asking pupils to do assignments on the computer	.03	**.66**	33
using the computer as a tool for demonstration	.23	**.56**	13
using the computer as a tool for instruction	.21	**.49**	12
Encouraging pupils to search for information on the Internet	.26	**.44**	16
teaching about the possibilities of computers	.32	**.40**	8

The last column in Table 1 reports the proportion of teachers that use the different tasks at least once a week. For support, teachers report using the computer mostly for keeping an agenda (57%) and preparing worksheets (53%). In class, the computer is mainly used for training skills (drill and practice) (53%) and differentiation activities (46%).

Based on the results of the principal component analysis, two summated rating scales were constructed to obtain overall measures of how frequently computers are implemented for supportive and class use.

For the nine support tasks, the item-scale correlation varied between r = .24 and r = .73, with an internal consistency, Cronbach's α = .78. The overall scale mean ranged theoretically between 0 (none of the support tasks are used) and 100 (all the tasks are performed on a daily basis). Scale mean for the total sample was M = 40.6 (SD = 19.4).

The eight class use items showed high intercorrelations of r = .39 and r = .62, with an internal consistency (α) of .79. Scale mean for the total sample was M = 34.2 (SD = 18.6), which is significantly lower than the mean score for the support scale (t = -33.0, df = 467, p < .001).

Computer attitudes and innovativeness

The instruments employed in this study were developed by adapting a wide range of items assessing attitudes toward computers and technological innovation attributes. Three existing instruments were used which were designed and described by van Braak (2001) and van Braak & Goeman (2003). All items followed a 5-point Likert response format (strongly disagree, disagree, neither agree/disagree, agree, strongly agree).

The first instrument is the General Attitudes toward Computers Scale (GACS) (van Braak & Goeman, 2003), which is a 7-item scale, containing adapted items from Loyd and Gressard's Computer Attitude Scale (Loyd & Gressard, 1984; Loyd & Loyd, 1985). It comprises items relating to computer liking, computer anxiety, and computer confidence. The original scale was validated on a sample of 381 subjects (van Braak & Goeman, 2003) and showed a high internal consistency, with Cronbach's $\alpha = .85$. In the current survey, internal consistency was $\alpha = .84$. Scale mean was M = 73.8 (SD = 16.9).

The second instrument assesses attitudes toward the use of computers in the classroom. The Attitudes toward Computers in Education Scale (ACES) was developed by van Braak (2001) and measures teachers' attitudes toward the effects of computer adoption in the classroom. Compared to general computer attitudes, attitudes toward computers in education are a distinct construct (van Braak, 2001). The original instrument contains 12 Likert-items and showed an internal consistency of $\alpha = .89$ (van Braak, 2001). Since the original instrument was developed for a sample of secondary school teachers, four items specific for secondary education were removed from the instrument. The 8-item Attitudes toward Computers in Education Scale in this survey showed a high internal consistency ($\alpha = .83$). Scale mean was M = 64.4 (SD = 13.2).

Technological innovativeness is a measure used to assess a person's attitudes towards the need to introduce technology (ICT) in education, coupled with a personal willingness to introduce computer technology in the classroom. Van Braak (2001) developed an 11-item technological innovativeness scale. In this survey, an adaptation of the original scale was used. Five items measuring innovativeness were included. The internal consistency of the five-item scale was $\alpha = .79$; scale mean was M = 75.8 (SD = 14.8).

The conceptual difference of the three attitude measures was assessed by a factor analysis. A three-component model with orthogonal rotation was run for the 468 subjects. A three-component structure was confirmed. The eigenvalues obtained were 7.0 for the attitudes toward computers in education scale, 2.0 for the general computer attitude scale and 1.2 for the technological innovativeness scale. This solution accounted for 51.4% of the shared variance among the items. Items and factor loadings are presented in Table 2.

Table 2

Factor analysis on the three attitude scales: Attitudes toward Computers in Education (Factor 1), General Computer Attitudes (Factor 2), and Technological Innovativeness (Factor 3)

	factor {1}	factor {2}	factor {3}
the computer increases the level of creativity of pupils	**.77**	.20	.04
the use of computer helps pupils to achieve better text writing	**.72**	.09	-.06
the efficiency of the learning process is increased through the use of computers	**.68**	.12	.30
computer knowledge and practical experience should be more integrated in the curriculum	**.58**	.14	.26
the computer provides opportunity for improving the learning performance	**.56**	.13	.38
pupils with learning difficulties can strongly benefit from the didactic possibilities which the use of computers entail	**.55**	.04	.33
the computer used as a learning tool, increases student motivation	**.48**	.15	.32
computers can help the teacher to apply differentiation among the students	**.45**	.15	.38
when using computers, I'm afraid to break something*	.05	**.81**	-.07
computers make me nervous*	.20	**.76**	.16
I like working with computers	.25	**.68**	.32
computers don't frighten me	.11	**.66**	.21
I will never be able to use computers*	.09	**.65**	.21
I have more negative than positive experiences with computers*	.14	**.57**	.43
Learning about computers is too time-consuming	.15	**.45**	.27
I believe in the need for the introduction of ICT in my practice	.25	.22	**.73**
I find technological innovation beneficial for my teaching practice	.21	.18	**.72**
I'm not interested in the introduction of ICT in my classroom	.06	.33	**.59**
I believe a progressive introduction of technology into education responds to our society's changing needs	.28	.17	**.59**
I highly value the introduction of ICT in the classroom as an example of innovation	.41	.23	**.52**

* Negative items were reversed before analysis.

Results

Correlations

Table 3 provides the bivariate correlates among the research variables. Although factor analysis confirmed that the attitude scales could be broken down into three distinct constructs, the three attitude scales intercorrelate strongly. The product moment correlations between the three attitude measures vary between r = .45 and r = .60.

Further, the results suggest high interrelationships among the two dependent computer use variables (supportive computer use and class use of computers) and the other research variables. Both supportive computer use and class use are significantly related to the demographic variables, the computer experience variables and the three attitude measures. The only exceptions are the absence of connections between supportive use of computers and gender, and between class use of computers and age.

Table 3
Pearson product-moment correlation coefficients among the research variables (*N*=468)

	{1}	{2}	{3}	{4}	{5}	{6}	{7}	{8}	{9}
{1} supportive computer use									
{2} class use of computers	.39**								
{3} gender	.05	.20**							
{4} age	-.26**	-.02	.27**						
{5} computer experience (in years)	.40**	.21**	.16**	-.14**					
{6} intensity of computer use	.57**	.25**	.07	-.24**	.24**				
{7} computer training	.21**	.22**	.12*	.13**	.11*	.03			
{8} general computer attitudes	.61**	.30**	.09	-.26**	.38**	.44**	.16**		
{9} attitudes toward comp in education	.35**	.31**	-.01	-.14**	.21**	.28**	.07	.45**	
{10}technological innovativeness	.43**	.35**	.04	-.15**	.24**	.24**	.19**	.57**	.60**

* p < .05 ** p<.001

The results give a first impression of the relationship among the research variables. Yet, these bivariate correlations measures do not provide sufficient information on possible causal relationships when controlling for the effect of other influencing variables. In a next step, the effects of the attitude measures on the dependent computer use variables will be assessed, together with the influence of demographic and computer experience variables.

Path modelling

Path analysis was used to model the complex relationships between demographic factors, computer experience variables and the attitudinal variables upon the two computer use variables. A first goal was to estimate the predictive power of a set of independent variables on the two different types of computer use (expressed as the adjusted R^2 coefficient). Secondly, the strength of the direct and indirect effects of the predictor variables on the dependent variables was assessed. At the same time, the models allowed to look for possible differential effects of the predictors on the two types of computer use. Interrelations among variables were calculated as correlation coefficients (*r*) and direct effects on endogenous variables as standardized beta-weight (path coefficients or β'*s*). The path models were estimated using AMOS 5.0 (Arbuckle & Wothke, 1999; Arbuckle, 2003).

For each dependent variable, three path models were estimated. In a first model (Model A), the effect of the demographic variables on the dependent computer use variable was tested. In a second model (Model B), the effect of the computer experience variables was added to the demographic variables. In a third model finally, the three attitude measures were added. In each step, the increase in the explained variance in the dependent computer use variable can be assessed (R^2 change). The three steps are presented in Table 3 for the supportive computer use variable and in Table 4 for the class use of computers variable. For all models, fit measures are reported (Goodness of Fit, Adjusted Goodness of Fit, X^2 and corresponding p-value). Finally, the differential effect of the research variables on both dependent computer use variables was analysed.

Supportive computer use

8% of the variance in supportive computer use can be attributed to age and gender. Especially age is negatively associated with this variable (ß = -.29). When computer experience variables (Model B) are added, the direct influence of age and gender decrease significantly and disappear when attitudes are added (Model C). In Model B the addition of computer experience variables leads to a high increase in explained variance, from 8 % to 45 %. Intensity of computer use is the strongest predictor (ß = .48). Teachers' home use of computers is mainly oriented toward school related tasks. This explains the high impact of intensity of computer use. Computer experience (ß = .25) and the degree computer training (ß = .19) also affect the supportive computer use variable. The longer teachers are familiar with computers and the higher the number of earlier computer training, the higher the reported level of supportive computer use. In the final model (Model C) supportive computer use can be explained for 53 %, which is enormous. The addition of general computer attitudes leads to a supplementary proportion of explained variance of 8 % over demographics and computer experience variables. Attitudes toward computers in education and technological innovativeness do not seem to have any direct significant impact on supportive computer use when controlling for the effects of the other variables.

Table 3
Overview of the direct effects on supportive computers use: standardised regression coefficients (ß) and fit indices ($N = 468$)

	Model A	Model B	Model C
Demographics			
Gender	.14**	n.s.	n.s.
Age	-.29***	-.14***	n.s.
Computer experience			
Computer experience in years	-	.25***	.16***
Intensity of computer use	-	.48***	.37***
Computer training	-	.19***	.13***
Attitude measures			
General computer attitudes	-	-	.37***
Attitudes towards computers in education	-	-	n.s
Technological innovativeness	-	-	n.s.
Adjusted R^2 'class use of computers'	.08	.45	.53
X^2	0.00	2.11	27.15
df (p-value)	0 (-)	3 (.550)	17 (.56)
Goodness of Fit Index (GFI) (+ Adjusted GFI)	1.00	.99 (.99)	.99 (.97)

- not included in model; n.s. not significant ; * p <.05; ** p < .01; *** p < .001

The full path model (Model C) is depicted in Figure 1. The figure includes a visual representation of the direct effects on supportive computer use reported in Table 3, but provides also additional information on the indirect effects and the interactions among the independent variables. For instance, the figure contains information on age and gender on the computer experience variables and attitude measures. Age is negatively related to computer experience (ß = -.29), intensity of computer use (ß = -.16), general computer attitudes (ß = -

.24). When controlled for these variables, age has no significant effect on supportive computer use. Gender is also strongly related to different computer experience variables: males have on average a longer experience with computers (ß = .21), report a more intensive use (ß = .08), possess more favourable general computer attitudes (ß = .10). As for age, the effect of gender on supportive computer use disappears when controlled for these variables. The relationship between age and gender (r = .27) might be surprising. This finding indicates no sample bias, but demonstrates the gradual decrease of the number of male teachers over the last decennia.

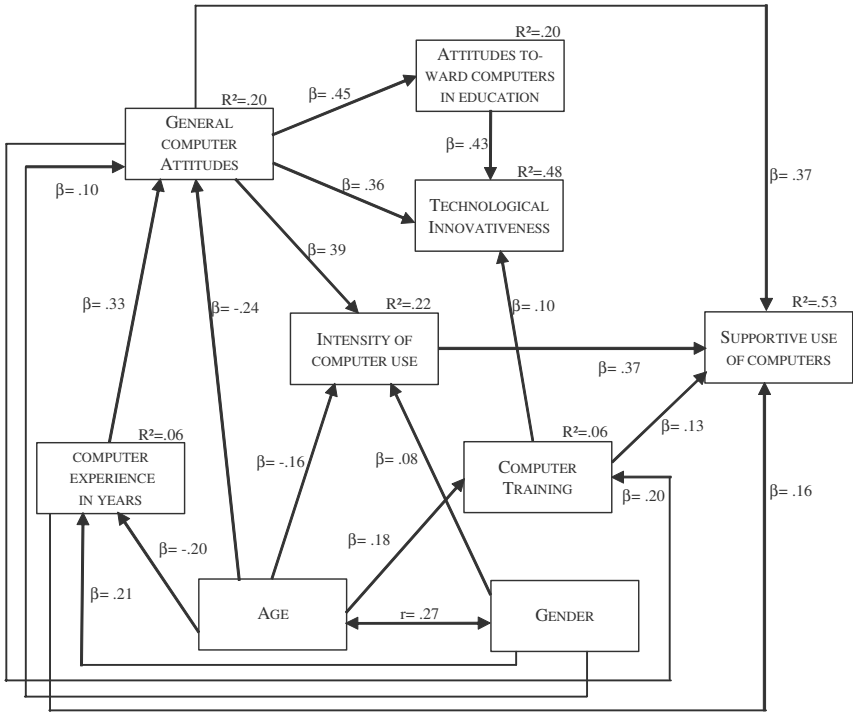

Figure 1. Predictors of supportive use of computers: estimates of direct and indirect effects: Final path model (N = 468).

Class use of computers

In Table 4 the determinants of class use of computers are demonstrated.

Table 4
Overview of the direct effects on class use of computers: standardised regression coefficients (ß) and fit indices (*N* = 468)

	Model A	Model B	Model C
Demographics			
Gender	.20***	.15***.	.17***
Age	n.s	n.s.	n.s.
Computer experience			
Computer experience in years	-	.12**	n.s
Intensity of computer use	-	.21***	.15***
Computer training	-	.18***	.15***
Attitude measures			
General computer attitudes	-	-	n.s
Attitudes toward computers in education	-	-	.15**
Technological innovativeness	-	-	.18***
Adjusted R^2 'class use of computers'	.04	.14	.21
X^2	3.11	2.32	17.48
df (p-value)	1 (.078)	3 (.507)	16 (.355)
Goodness of Fit Index (GFI) (+ Adjusted GFI)	.99 (.97)	.99 (.98)	.99 (.98)

- not included in model; n.s. not significant ; * p <.05; ** p < .01; *** p < .001

The results of the path analyses indicate that class use of computers is not age-related. Gender however seems to have a significant effect on class use of computers. Male teachers, as opposed to their female colleagues, report to integrate computers more often. This gender effect does not seem to disappear when controlling for other variables. In the first model (Model A), gender alone contributes for 4 % to the explanation of class use of computers. Another 10 % is added to the model when computer experience variables are included (Model B). Computer experience in years (ß = .12), intensity of computer use (ß = .21) and followed computer training (ß = .18) all seem to affect class use (Model 2). When attitudes measures are added (Model C), the effect of computer experience in years disappears. The final model reveals that both technological innovativeness (ß = .18) and attitudes toward computers in education (ß = .15) contribute significantly to the explanation of class use of computers. Technological innovativeness is even the strongest predictor and seems to mediate the effect of the computer experience variables. The total explanation of class use of computers (R^2 = .21), however, is considerably lower compared to supportive computer use (R^2 = .53).

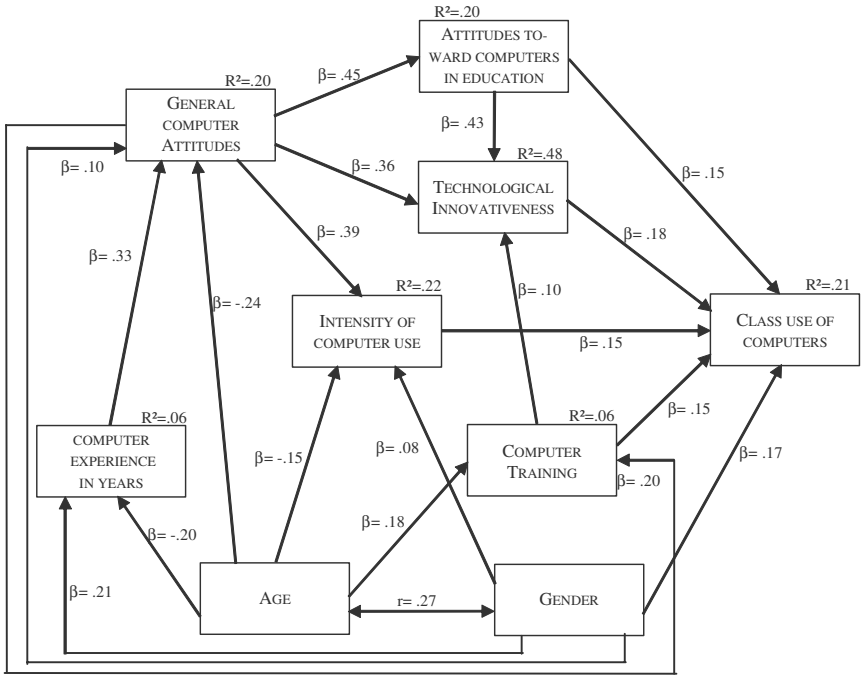

Figure 2. Predictors of class use of computers: estimates of direct and indirect effects: Final path model (N = 468).

Figure 2 depicts all interrelationships among the research variables. This clearly demonstrates that the effect of general computer attitudes on class use of computers is entirely mediated through attitudes toward computers in education, technological innovativeness and intensity of computer use.

Discussion

Favourable attitudes seem to be the strongest predictors of supportive computer use. However, the effect of past experience and behaviour is even stronger. Computers are intensively used for professional support by those who have more years of computers experience, those who are frequent computer users and those who have high experience with computer training. In the case of class use of computers, past computer experience and behaviour have the same importance. Intensity of computer use and followed computer training have about the same impact on class use compared to attitudes toward computers in education and technological innovativeness. The findings of our study are in accordance with the literature in which the straightforward relationship between attitudes and behaviour is discussed (Eiser & van der Pligt, 1988). One of the central problems in gaining clear

understanding in the relationship between attitudes and behaviour is the development of a great number of instruments. It is recommendable to provide a clear definition of the attitude constructs being used (Kay, 1992). One of the main findings in our research is the importance of using domain-specific attitudes. A general measure of computer attitudes is a good measure to explain why teachers use computers for professional support, but is not powerful enough to explain a specific type of professional computer use, i.e. classroom integration. In our example, class use of computers is strongly affected by attitudes toward computers in education and technological innovativeness. The direct effect of general computer attitudes disappears when specific attitude measures are used. The relationship between attitudes and behaviour becomes more important when attitude measures are closely tied to the task (Eiser & van der Pligt, 1988, Shapka & Ferrari, 2003).

An important finding was that more than half of the variance in supportive computer use could be explained while the explanation for class use of computers was significantly lower (21 %). A valuable implication of this finding is the complexity of accounting for class use of computers relying only on variables measured at an individual level. Although we employed a rich set of determinants and found significant predictors on an individual level, most of the variance in class use could not be explained. Contextual and school-specific factors should be incorporated in the theoretical model in order to gain more insight into the levels of class use of computers. Tuijnman & Ten Brummelhuis (1993), for example, highlighted the importance of the perceptions of school leadership with regard to the relevance of computer use. In a study by Chiero (1997), it was confirmed that many variables are involved in explaining the adoption of computers in various aspects of teachers' work routines. In addition to personal factors, organisational factors should be identified, such as time constraints, available resources, support, teamwork, and training. The importance of appropriate planning and school level decision making should be stressed to enhance the successful integration of computers in the teacher's classroom routine (Baylor & Ritchie, 2002; Tearle, 2003).

The current findings on the relationship between gender and computing are in line with previous research. Mathews & Guarino (2000) for example found that female teachers reported significantly lower levels of computer ability than their male counterparts. This may account for the lower level of ICT-implementation of females in their classroom. Jenson & Rose (2003) argue that computers and gender are delimited by the social and cultural context in which they are produced and utilised. Not all studies, however, show consistent results. Shapka & Ferrari (2003) found no gender difference for computer attitudes and computer outcomes and argue that gender differences are gradually dissipating. In our study, the effect of gender on class use of computers stayed significant when controlled for attitudes and measures of computer experience. Shapka & Ferrari (2003) stipulate that gender differences might still exist in the use of computer applications that are less familiar. Teachers in primary education show higher familiarity with supportive computer use than class use. This might partially explain why gender differences only exist in class use. Differences between sexes might gradually disappear when teachers become more and more acquainted with the educational potential of computers.

In our analyses, the measure of technological innovativeness as a substitute for a specific behavioural intention to use computers did not appear to be an adequate determinant of supportive computer use. It did however affect the degree of class use of computers. Moreover, when all individual factors were taken into account, technological innovativeness was the strongest predictor of class use of computers. This finding is in line with other studies that stress the importance of the concept of innovativeness for understanding teachers' computer use (Marcinkiewicz, 1993; van Braak, 2001). Technological innovativeness is strongly entangled with general and education specific attitudes. Teachers who report favourable attitudes toward computers in general and computers for teaching and learning in particular, are more likely to show high degrees of technological innovativeness, which positively and directly affects the degree of computer use in class. Also the relationship between computer training and technological innovativeness is noteworthy. This brings us to another important finding in our study: teachers who followed more computer training show higher levels of technological innovativeness. We found a positive effect of computer training in predicting computer use both for both support and integration. The findings suggest that higher computer training leads to higher levels of supportive and class use of computers. The positive effect of computer training has been well documented in previous studies (Galanouli, Murphy, & Gardner, 2004; Shashaani, 1997; Tan, Wong, & Wettasinghe, 2003). The descriptive results of our data show that the attendance to in-service teacher education for computers is rather limited, despite the large scale governmental initiatives for computer training for teachers. An average of about one computer course followed by each teacher over the last five years is fairly low. Professional development should stay at the focal centre of innovating educational policies (Galanouli, Murphy, & Gardner, 2004; Williams et al., 2000).

Conclusion

In this study, we explored the different factors that contribute to the explanation of two types of computer use among primary school teachers. The study is not without limitations. First, the results in this study cannot simply be generalised to other educational levels. Our support and integration variables were specifically measured in the context of primary education. In secondary education, computers as a supportive or class tool might be implemented in different ways. Secondly, the effect of contextual factors, such as computer infrastructure or school policy can differ in other educational levels. This indicates that the results have a limited generalisability. A third limitation of the study concerns the quantitative nature of our survey. In future studies, researchers might wish to collect in depth information through interviews and/or observations to explore why teachers integrate (or refuse to integrate) computers in their classrooms. Interpretative research is required to investigate the reasons why teachers (refuse to) use computers for professional support. A problem with interpretative research, however, is that teachers are inclined to report external hindering factors such as a lack of adequate infrastructure (cf. Williams, et al., 2001) that could mask individual factors, such as experience and attitude measures. A third limitation of this study is the assumed independence of individuals as units of analysis. In their computer behaviours,

teachers are probably not only influenced by individual factors, but also by factors that are related to the school they work in (policy planning, infrastructure, leadership). Multilevel analysis is a powerful technique to analyse data both on individual and school level (Kreft & De Leeuw, 1998). Future research might analyse both the impact of individual determinants and school-level factors upon teachers' professional uses of the computer.

Despite the limitations, the current study contributes to the literature on computers and education in different ways. First, using data reduction techniques, two different types of computer use could be distinguished: supportive computer use and class use. Secondly, differential effects of individual determinants on both types of computer use could be identified. Computer experience variables affected both dependent factors, but different attitude measures impacted computer support and integration: supportive computer use is affected by general computer attitudes and class use of computer by technological innovativeness and attitudes toward computers in education. However, the question whether high levels of professional computer use have positive effects on teaching and learning efficiency remains unanswered in this study.

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Chapter 3*
ICT integration in the classroom: Challenging the potential of a school policy

Abstract

Despite the assumption that the integration of ICT influences the entire school system, research focusing on ICT in schools is generally limited to the study of variables at classroom level. In contrast to these studies, the present research explores ICT integration from a school improvement approach. More particularly, it examines the local school policy with respect to ICT integration from both the principal's perspective and perceptions of teachers. Furthermore, it studies the relationship between school policies and the actual use of ICT in the classroom. To answer the research questions, a representative sample of 53 primary school principals was interviewed. In addition, the interview data were supplemented with survey data of 574 teachers from the same 53 schools. What emerged from the analyses was that school-related policies, such as an ICT plan, ICT support and ICT training have a significant effect on class use of ICT. In addition, the findings from the interviews indicate that school policies are often underdeveloped and underutilised. The discussion section focuses on challenges to improve the potential of an ICT school policy.

Introduction

In the literature, the question is repeatedly put forward as to what variables determine the integration of information and communication technology (ICT) in education. In this respect, many studies have focused on measuring the impact of variables at class level (micro level), such as computer attitudes (Albirini, 2004; Dementrias, Barbas, Molohides, Palaigeorgiou, Psillos, Vlahavas, et al., 2003; van Braak, Tondeur, & Valcke, 2004), computer experience (Becker, 2001; Williams, Coles, Wilson, Richardson, & Tuson, 2000), and gender differences (Shapka & Ferrari, 2003; Volman, van Eck, Heemskerk, & Kuiper, 2005). The focus on these individual factors has oriented research focusing on ICT integration towards 'individual blame' rather than 'system blame' (Tang & Ang, 2002). Previous research largely ignores the complex systemic nature of ICT integration, including the role of national policies (macro level) and local school policies (meso level). The latter requires more sophisticated statistical techniques (i.c. a multilevel approach) to examine the effects of different factors, measured on different levels, reported by different actors on the dependent ICT integration variable.

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* Based on:
Tondeur, J., van Keer, H., van Braak, J. & Valcke, M. (in press). ICT integration in the classroom: Challenging the potential of a school policy. *Computers & Education.*

Results from an earlier study (Tondeur, van Braak, & Valcke, 2007) indicate a gap between the proposed ICT curriculum at the macro level and the actual use of ICT in the classroom. The study more specifically demonstrated that aspirations of national educational authorities to foster ICT integration in schools do not easily result in concrete changes in instructional practices at classroom level. In this respect, Visscher and Coe (2003) point at the variability between schools, suggesting that general, central policies and reforms do not automatically lead to educational change in schools. Schools are considered to differ with respect to performance level, innovation capacity, and contextual characteristics. This implies that educational improvement or innovation efforts should consider to a larger extent the 'power of site or place'. Fullan (2001) concludes that large-scale change could be effective, but requires a degree of top-down initiative at the beginning, followed by larger attention paid to local conditions.

It can be argued that local policies do reflect to a lager extent what happens in the classroom. If teachers share the values expressed within a school-related policy and understand the implications, this policy is able to influence practice (Kennewell, Parkinson, & Tanner, 2000). Therefore, it is important to study the role of local ICT policies on actual ICT integration in education. Recent studies reveal that ICT works in some schools and hardly in other schools because of school factors (Baylor & Ritchie, 2002; Tang & Ang, 2002). The present study is in line with research focusing on the latter school factors. It centres on the hypothesis that school-related policy factors might affect the integration of ICT in the classroom. In addition, teachers' perceptions about the ICT school policy are examined in order to investigate whether these perceptions are vital for successful implementation. Finally, a number of factors at teacher level, which were found to be effective in previous study (van Braak et al., 2004), were added to the model in order to consider and compare their impact on school policies when explaining ICT integration in the classroom.

Theoretical framework

School policies from a school improvement perspective

The role of local school policies with respect to ICT integration can be discussed from a school improvement perspective. In brief, the school improvement movement is a practice- and policy-oriented approach to strengthen schools' capacity for change management (Creemers, 2002). In contrast to 'school effectiveness', 'school improvement' tries to find out *how* schools can change in order to improve, whereas school effectiveness is strongly focused on *what* is to be changed in schools in order to become more effective (Hulpia & Valcke, 2004). School improvement is mainly concerned with the quality of changes with less attention paid to the consequences at the level of pupil outcomes.

Reynolds, Teddlie, Hopkins, and Stringfield (2000) argue that a school improvement approach to educational change embodies the long-term goal of establishing a self-renewing school. They stress the central role of the school level in mediating change. A sufficient level

of school autonomy, the development of school policies and a collaborative school team seem to be positively related to school improvement. In this respect, Stoll (1999) highlights the importance of clear goals and systematic strategies to direct educational change.

Subsequently, team development and professionalism of principals and teachers are necessary conditions (Stoll, 1999). Moreover, Gray (1997) stresses the value of strong leadership to guide change efforts. Other important aspects of the school improvement process are continuous quality control, i.e. assessment and reflection (MacBeath, 1999) and schools being part of a network working toward comparable reform goals (Hopkins & Reynolds, 2001). These key factors entail the development of a local school policy in order to guarantee the establishment of the necessary conditions supporting the continuous change processes. ICT integration is considered as an instantiation of such change processes. As a consequence, in the present study, it is hypothesised that local school policies play a significant role in promoting ICT integration in the classroom.

The impact of ICT school policies

Recent studies focusing on ICT integration demonstrate that a substantial proportion of the variation in educational ICT use is due to school improvement related aspects (e.g., Dawson & Rakes, 2003; Otto & Albion, 2002). Table 1 distinguishes five key factors from the school improvement approach and links these concretely to school policies fostering ICT integration in the classroom. Despite the existence of differences in school improvement approaches, there seems to be a general agreement on this basic set of factors. Yet, this list of school factors cannot depict the complexity of school improvement.

Table 1
Five areas of local ICT policies from a school improvement approach

School improvement	Local ICT policies
Clear goals and systematic strategies for educational change (Reynolds et al., 2000)	Development of an ICT plan facilitating comprehensive ICT integration and fostering an environment towards the realisation of the vision in the ICT plan (Otto & Albion, 2002)
Strong leadership to guide change efforts (Gray, 1997)	Leadership to effectively direct the process of ICT integration (Dawson & Rakes, 2003)
Profession development and support for the implementation of reforms (Stoll, 1999)	Support and training to ensure ICT integration (Lai & Pratt, 2004)
(Self) evaluation systems for monitoring change processes (MacBeath, 1999)	Evaluation to monitor the integration of ICT and guide ICT planning (Kennewell, Parkinson, & Tanner, 2000)
Networking and exchange of good practice with other schools working on the same reform (Hopkins & Reynolds, 2001)	Cooperation to create between-school communities for the dissemination of ICT-related knowledge (Triggs & John, 2004)

In this respect, a first important factor is the development of a shared vision concerning how ICT is to be used for teaching and learning (Hughes & Zachariah, 2001; Otto & Albion, 2002). It appears that teachers belonging to schools engaged in ICT planning are more likely to apply ICT in an innovative way (Kozma, 2001). Dexter, Anderson, and Becker (1999) also conclude that successful ICT implementation depends upon goals shared by different actors and at different organisational levels. As a consequence, the development of an ICT school plan aiming at setting clear goals and defining the means to realise these goals, is a crucial step towards actual ICT integration (Bryderup & Kowalski, 2002). In addition, Kennewell et al. (2000) suggest that a good ICT plan should also comprise an assessment and evaluation approach to obtain a clear picture of current ICT use. This fosters an iterative approach in planning and monitoring ICT integration.

Analysis of the available research also reveals the importance of leadership in managing ICT integration. School principals are in a position to create the conditions to develop a shared ICT policy. Several studies (e.g., Anderson & Dexter, 2000; Dawson & Rakes, 2003) support the claim that leadership promoting change is a key factor when it comes to merging ICT and instruction. Baylor and Ritchie (2002, p. 412) also describe leadership as a critical predictor of ICT integration, since it focuses on promoting the use of ICT at a strategic and action level: 'school principals who wish to nurture a technology culture need to join in rather than sitting by the side'.

Other ICT-related school factors that can be connected to school improvement approaches are the degree of ICT training (e.g., Galanouli, Murphy & Gardner, 2004), ICT-related support (e.g., Lai & Pratt, 2004), and cooperation between schools (e.g., Triggs & John, 2004). Baylor and Ritchie (2002) conclude that ICT training has an important influence on how well ICT is embraced in the classroom. According to Cohen and Hill (2001), the most effective teacher training experiences are school subject specific practices, immediately relevant for classroom instruction and connected to school policy. While ICT training is clearly useful, continuous support is an issue that concerns many teachers to a larger extent. Williams et al. (2000) argue that mechanisms need to be put in place to ensure that teachers have adequate access to support. In this respect, Lawson and Comber (1999) stress the provision of ongoing support usually supported by the ICT coordinator. From the study of Lai and Pratt (2004) it is clear that the ICT-coordination is in a good position to guide and successfully integrate ICT in schools. Also cooperation between schools is seen as an important key factor for the integration of ICT. The central features that underpin this process are contact with colleagues who share similar interests, interaction that involves knowledge exchange, and encouragement to take risks, combined with support in analysing why things go wrong and how they can be improved (Triggs & John, 2004).

Purpose of the study

The literature suggests that the success of ICT integration depends partly on factors at school level. In this respect, a first purpose of the present study is to describe the state of the art regarding ICT school policies with respect to five areas emerging from the school

improvement approach as discussed above: the presence of an ICT policy plan, leadership supporting the process of ICT integration, school internal support, evaluation of ICT use, and between-school cooperation.

The second aim of the study explores the extent to which the use of ICT in the classroom practice can be associated with these school factors. Furthermore, the impact of teachers' perceptions of ICT school policies on ICT integration in the class was studied. Finally - taking into account previous research (van Braak et al., 2004) - additional relevant teacher variables were included in the analyses in order to examine their relative impact on ICT practice compared to the impact of school policy-related variables.

Research method

Participants

The data collection was restricted to actors involved in primary schools in Flanders, the Dutch speaking region of Belgium. A stratified sample of 60 schools was involved in the study. Stratification variables were related to the type of educational network and the degree of urbanisation (rural/urban). At least one teacher at each grade level was asked to participate, resulting in data from at least six teachers per school. The sample comprises 574 teachers, of which 75.6% were female. Teacher age varied from 22 to 61 years, with an average age of 38.

Fifty three principals of the same 60 schools were willing to participate in the study, reflecting a high response rate at school level. School principles were 49 years old on average. One out of three principals was female.

Procedure and instruments

In view of the first objective of the study, a structured interview with the principals was organised. To direct the structured interviews, an instrument was developed reflecting variables at meso level. Table 2 gives an overview of all meso and micro variables in the present study. Open-ended questions were formulated for each variable, and a number of pre-defined response categories were prepared for each question. Elements of answers that could not be related to the available coding categories were written down literally. This resulted in the need for additional coding. All interviews were audiotaped after obtaining informed consent from the participants.

Table 2
School and teacher variables involved in the teacher survey and/or interviews with principals

Variable	*Short description*	*Teachers' Survey*	*Principals' Interviews*
Meso level			
ICT policies			
ICT policy plan	Content ICT plan	√	√
Leadership	Leadership style (stimulate, delegate, …)		√
Support	Actors supporting ICT integration		√
	Extent and type of internal ICT support	√	
	In-service-training (extent and effectiveness)	√	
Evaluation	Extent and type of evaluation ICT use		√
ICT-related cooperation (internal and external)	Extent and type of cooperation with colleagues from the same school	√	
	Extent and type of cooperation with colleagues from other schools		√
ICT infrastructure	Number and place of computers		√
	Number of computers with Internet connection	√	√
	Pupil/pc-ratio (in the classroom)	√	√
School characteristics			
School size	Number of pupils		√
Gender	% male/female teachers at school level		√
Micro level			
Teachers' ICT profile			
Attitudes towards computers in education	Teachers' Attitudes towards Computers in Education Scale (van Braak, 2001)	√	
General computer attitudes	Teachers' General Attitudes toward Computer Scale (van Braak & Goeman, 2003)	√	
Technological innovativeness	Teachers Attitudes about the Need and Willingness to Introduce Computers in the Classroom (van Braak, 2001)	√	
Computer experience	Years of computer experience	√	
Intensity of computer use	Degree of computer use (hours a week)	√	
Demographics			
Age	Date of birth	√	
Gender	Male/female	√	

In view of the second research objective, data from the school principals were linked to the data from the teacher survey. A questionnaire was developed in order to gather information from teachers about the central dependent variable 'class use of computers' and about the determinants of class use of computers, presented in Table 2. The 'Class Use of Computer Scale' (van Braak et al., 2004) was developed for measuring how often teachers use computers in their classroom (Table 3).

Table 3
Overview of the Class Use of Computer Scale items and % of teachers using specific applications at least once a week

	Freq %
Encouraging pupils to train skills	53
Using the computer for differentiation	46
Encouraging collaborative learning	33
Asking pupils to do assignments on the computer	33
Encouraging pupils to search for information on the Internet	16
Using the computer as a tool for demonstration	13
Using the computer as a tool for instruction	12
Teaching about the possibilities of computers	8

Results in table 3 illustrate that the computer is mainly used for training skills, such as drill and practice (53%) and differentiation activities (46%). The eight class use items showed high internal consistency of α=.79. Scale mean for the total sample was M = 34.2 (SD = 18.6), varying between a 0-100 range.

Data analysis

With regard to the first research aim, all responses to the questions in the principal interview were analysed as quantitative variables. Considering the exploratory nature of the first research objective, descriptive statistics were initially applied to analyse the interview data.

In view of the second research objective, multilevel analysis was performed to determine the impact of school policies on ICT integration in the classroom. Taking into account the hierarchical structure of teachers nested within schools, we opted for multilevel modelling to analyse the impact of teacher and school level variables on the classroom use of ICT, since these models are specifically geared to the statistical analysis of data with a clustered structure (Goldstein, 1995). More specifically, two levels were distinguished: teachers (level 1) are clustered within schools (level 2). The multilevel model was built up from a null model to a model including relevant explanatory variables. The first step in the analysis was to examine the results of an unconditional two-level null model, with only an intercept term included. This model permits partitioning the total variance into within-school and between-school components. It serves as a baseline with which to compare subsequent more complex models and is unconditional because the variance components are not predicted by any variables. The second step in the construction of the models concerned the inclusion of explanatory variables at both teacher and school level. Initially, all variables were included in the model as fixed effects, assuming that their impact does not vary from teacher to teacher or from school to school. Afterwards, the assumption of a fixed linear trend was verified for each explanatory variable by allowing the parameter coefficients to vary randomly across schools and across teachers within schools. Since parsimonious models are preferred, only significant predictors improving the model were retained. The parameters of the multilevel model were estimated using the iterative generalized least squares (IGLS)

estimation procedure made available in the MlwiN software (Rasbash, Browne, Goldstein, Yang, Plewis, & Healy, et al., 1999).

Results

In this section we first present the results with respect to five areas of ICT policies, based on the interviews with the school principals. Subsequently, we focus on the analyses regarding the impact of school policies on the integration of ICT in the classroom.

ICT policy plan

As to the presence of an ICT plan at school, only 22.2% of the principals reported the availability of a comprehensive ICT plan including clear goals and determining the means to realise these goals. 38.9% of the principals referred to a limited ICT plan, only consisting of goals but incorporating no information about strategies to pursue these goals. Another 38.9 % of the principals indicated the school had no ICT plan whatsoever. Half of these schools, however, planned to develop an ICT plan during the following school year. In schools with an ICT plan present, the plan particularly reflects policies related to the 'use of computers in the forthcoming school years' (in 59.3% of the cases), as well as 'agreements concerning ICT infrastructure and software' (in 22.2% of the cases). More detailed analysis of the ICT plan reveals that the focus is primarily on developing pupils' technical skills. Less information is included about the integrated use of ICT in learning and instructional processes. Nevertheless, a number of principals argue that, even if policies are articulated, the implementation is often lagging behind.

> "*Despite the effort of the ICT coordination to set up a strategic plan, teachers are not aware of the specifics of the plan."* [Principal/School 17]

One of the problems explicitly mentioned in this respect has to do with poor communication between the school management and the teachers. Lack of time was singled out as one of the main causes for the absence of developing a shared vision on the applications of ICT in the class. The development of a vision about ICT integration was in most of the cases limited to a top-down strategy, initiated by the school principal or the ICT coordinator.

Leadership

Principals see their role mainly as a catalyst (48.1%) and facilitator (23.1%) of ICT integration in the classroom. In Flanders, the use of ICT in education is not yet part of the formal curriculum. But teachers are encouraged by the educational authorities and policy developers to adopt computers in their classroom, but this is not yet a compulsory instructional activity. During the interviews, the non-compulsory nature was stressed as the main reason why only a few principals (7.7%) instruct the teachers to use ICT. In this respect,

it can be assumed that ICT integration in Flemish primary schools will strongly depend on individual teachers.

"I cannot push teachers to implement ICT in their teaching.
The current situation of informal (national) policies builds on the willingness of the individual teacher.
In this school, a number of teachers respond as creative and productive users of ICT, some are experimenting, and others are inexperienced for effective uses of ICT in learning." [Principal/School 62]

When principals report their personal impact on the degree of ICT integration, in 55% of the cases this impact is perceived as limited. Most of the principals mention a lack of time for managing this process in their schools.

"You cannot be the architect, the engineer, and the builder at the same time" [Principal/School 53]

Support

Principals were questioned about the barriers and needs they perceive with regard to integrating ICT in the classroom. The first and most frequently (50%) mentioned barrier, was the lack of access to resources.

"In 2002, the Flemish government reached the aim of one PC for every 10 pupils,
but they forget that these computers need an update." [Principal/School 27]

Schools from our sample were reported to have on average one computer for every 6 student (SD = 6.6). Generally, each regular classroom was assigned 2.0 computers (SD = 1.8). The second most reported barrier (29.6%) refers to the lack of adequate skilled staff to coordinate and support the adoption of ICT. As principals mainly define their role as a facilitator, they especially expect ICT coordinators to direct the integration process. Interestingly, many principals reported that it would be advisable to appoint a teacher as a 'change agent' in order to maintain the innovation when direction of the ICT coordination is no longer available.

"Last year, our school had an excellent ICT coordinator;
now that he's gone, ICT integration doesn't receive a lot of attention anymore." [Principal/School 37]

A majority of principals reported that ICT coordinators mainly perform as technical experts. Due to a lack of time, their impact on educational or policy-related issues remains restricted.

"Within three hours a week, our ICT coordinator has sufficient time to repair our computers
but not enough to deal with pedagogical issues" [Principal/School 4]

The third ICT-related barrier was the limited ICT skills level of the teachers (27.8%). Considering the needs, put forward by the principals, the list comprises more and better infrastructure, more ICT coordination, and more professional development of teachers

regarding their ICT skills. Principals emphasise the responsibility of national authorities to tackle these needs. Few principals stress the importance of a local ICT-related policy.

Evaluation

From the interviews it became clear that the implementation of ICT in schools is hardly ever submitted to any kind of evaluation: 32.1% of principals claimed that the ICT policy has been evaluated occasionally and only 17% reported a systematic evaluation. Again, it appears that the evaluation emphasis is mostly related to the infrastructure (hardware and software). In a small number of schools, the evaluation also centres on the actual use of ICT for learning and instruction.

"Evaluation of ICT use for learning activities has a powerful impact on the practice in my school. Our assessment tools oblige teachers to reflect about the specific ICT competencies they intend to obtain each time they plan to use ICT in their lessons. This detailed view of how teachers use the potential of ICT in their teaching is also the starting point for reflection and policy planning." [Principal/School 3]

Comments of a number of principals reflect the central need for a regular evaluation in order to understand 'where they are' and identify 'where they wish to be' after a period of time. This suggests that in some cases ICT policies are not seen as static, but as an instrument that needs to be reviewed on a regular base.

Cooperation

It is worth noting that schools in Flanders need to set up cooperation with other schools in order to receive funds for ICT coordination. This has encouraged most of the schools (75%) to develop partnerships. Beside the opportunity to share an ICT coordinator, the cooperation often also led to shared initiatives related to hardware and software (25.9%) solutions.

'Schools should work together on a wide range of technical issues. It is clear that all our partner schools benefit from the experience of the ICT coordinatior. But in terms of motivating our staff as well as supporting them in integrating ICT into teaching, this person risks missing the culture of our school' [Principal/School34]

A common theme in the interviews was – as a result of the requirement to cooperate with other schools – that principals and ICT coordinators felt stimulated to discuss the complex issue of ICT integration. Some principals also stress the importance of involving teachers in this collaboration process; but in only one school did this result in the actual partaking of teachers.

'Last year, my teachers were invited to observe examples of good practice in another primary school. In my opinion, observation of each others practice can be a good incentive.' [Principal/School61]

Impact of school policies and teacher characteristics on ICT integration in class

Table 4 presents the results of the multilevel analyses concerning teachers' use of ICT in the class. More specifically, the impact of school policy factors, teachers' perceptions regarding ICT school policies, and teacher variables, such as teachers' computer attitudes, computer experience, and technological innovativeness, was studied.

As can be seen in Table 4, the random part of the null model provides justification for applying multilevel models, for the variances at both the school and teacher-level are significantly different from zero (resp. χ^2=6.153, *df*=1, *p*=0.013; χ^2=242.847, *df*=1, *p*<0.000). This model serves as a baseline to compare subsequent more complex models with, and it partitions the total variance of ICT class use (347.8 = 31.878 + 315.922) into between-schools (31.878) and between-teachers within-schools variance (315.922). Respectively 9.16% of the total variance in teachers' use of ICT in the classroom is related to differences between schools, while the remaining part of 90.83% of the variance can be attributed to differences between teachers within schools.

As the fixed parameters in the final model in Table 4 reveal, variables at both the school and teacher level significantly influence teachers' use of ICT in their class. The results highlight the significant positive effect of teachers' 'attitudes towards computers in education' (χ^2=8.410, *df*=1, *p*=0.003), 'technological innovativeness' (χ^2=4.453, *df*=1, *p*=0.030), 'intensity of computer use' (χ^2=10.552, *df*=1, *p*=0.001), 'number of in-service training sessions about ICT' (χ^2=10.186, *df*=1, *p*<0.000), 'perceptions regarding the contents of the school ICT plan' (χ^2=17.435, *df*=1, *p*<0.000), and 'perceptions regarding school internal ICT support' (χ^2=22.401, *df*=1, *p*<0.000). In addition, a positive effect of the 'percentage male teachers at school' was identified (χ^2=7.324, *df*=1, *p*=0.007). A significantly negative effect was observed for the 'pupil/PC-ratio in the classroom' (χ^2=19.375, *df*=1, *p*<0.000), indicating that the availability of a higher number of computers invoke a higher level of ICT integration in the classroom.

Table 4

Model Estimates for the Two-level Analysis of Teachers' Use of ICT in the Classroom

Parameter	Null model	Final Model	Effect size
Fixed			
Intercept	34.531 (1.124) ***	-1.771 (5.191)	
Perception internal ICT support		0.199 (0.042)***	0.22 *SD*
Pupil/PC-ratio		-0.532 (0.121)***	0.19 *SD*
Perception content of ICT plan		0.106 (0.025)***	0.18 *SD*
Number of in-service trainings		1.891 (0.592)**	0.15 *SD*
% male teachers		0.158 (0.058)**	0.13 *SD*
Attitudes towards computers in education		0.218 (0.075)**	0.15 *SD*
Technological innovativeness		0.138 (0.066)*	0.11 *SD*
Intensity of computer use		0.467 (0.144)**	0.15 *SD*
Random			
Level 2			
$\sigma^2_{\mu 0}$	31.878 (12.850)*	14.936 (8.524)	
Level 1			
$\sigma^2_{\varepsilon 0}$	315.922 (20.273)***	197.718 (15.310)***	

Note. Per cell: regression coefficient and standard error
*p < .05 **p < .01 ***p < .001

The results point out the fact that ICT integration in daily class practice is significantly associated with teachers' perceptions of policy related factors. No significant effect on teachers' ICT use was found from the principals' perspective. Teachers' perceptions about the ICT school policy seem to be more important for ICT integration in the classroom than a teachers' ICT profile.

Discussion

The findings of the present study highlight the potential impact of policy-related factors on the actual integration of ICT in daily classroom instruction. First, the study confirmed that teachers in schools with an explicit ICT school policy stressing shared goals, are using ICT more regularly in their classroom. This corroborates previous research findings, suggesting that successful ICT integration depends upon the development of a shared vision (Hughes & Zachariah, 2001; Otto & Albion, 2002). It should be stressed, however, that in the present study only 'teachers' perceptions regarding the content of the ICT school plan' and not the actual content of the ICT plan has a significant impact on class use of ICT. As a consequence, an ICT policy plan seems to be an important incentive to foster the integration of ICT use in classroom, but only when teachers are aware of its content. In other words, successful ICT integration becomes much more likely when teachers share the values expressed within the school policy and understand their implications (Kennewell et al., 2000).

Nevertheless, as could be derived from the interviews, teachers in the present study were often overlooked during the development of the school's ICT policy. The results point at a lack of communication between principals and teachers. This reinforces the fact that policy

decisions and change models currently do not acknowledge the pivotal role of the teacher in affecting change (Olson, 2000). Olson (2000) suggests that a dialogue should be established based on parity between principals, teachers, and other stakeholders. Engaging teachers in the development of an ICT plan gives them the opportunity to reflect on their particular educational use of ICT (Tondeur et al., 2007). It determines the subjective meaning of how and why individual teachers will respond to ICT. In addition, Tang and Ang (2002) highlight the impact of communication on ICT integration. They suggest that teachers should not be considered as 'recalcitrant recipients' but as 'structurally constrained participants'.

Next to the importance of a shared vision on ICT, three other significant determinants of ICT class use are subject to the influence of school policies, namely the number of teachers' attended in-service trainings, the availability of school-internal ICT support, and the pupil/PC-ratio at school. It is interesting to note that, parallel with the result of the ICT plan, only the perceptions of the teachers and not the principals with regard to school-based ICT support were statistically significant. It appears that teachers reporting a high degree of ICT-related support, incorporate these technologies more often in their practice. This confirms previous research findings pointing to teachers' needs for considerable support in view of ICT integration (e.g., Lai and Pratt, 2004). Building on the interviews with the principals it is clear that most support is supplied by ICT coordinators. ICT coordinators, however, primarily provide schools with technical expertise, while their impact on educational or policy-related issues seems to remain limited. As Somekh (1996) noted, needs for technical support tend to take precedence over curriculum support. The government in Flanders is aware of this problem and has therefore redefined the role and position of ICT coordinators. According to Lai and Pratt (2004), the main responsibly of the ICT coordinatior is especially to guide ICT integration in teaching and learning (curriculum support). Principals in our study indicate the lack of time as an important obstacle for receiving such curriculum related support. It seems therefore recommendedable to distinguish between technicians providing schools and teachers with technical support, next to ICT coordinators who focus primarily on educational support in view of ICT integration into the curriculum.

Building on the positive effect of the 'number of in-service ICT training sessions' on higher levels of ICT class use, professional development should stay at the centre of an ICT policy. Another finding with policy implications is the impact of the pupil/pc-ratio on ICT class use. But it has to be stressed that this impact is only valid when the computers are located in the classroom. An explanation for this specific impact might be that the in-classroom provision of computers maximises usage-potential, in contrast to computer labs where computer use depends on time-allocation mechanisms. Also, in this context authors state that computer labs are less effective because the separation between computer and classroom reduces ICT integration in learning activities (Salomon, 1990).

The findings on the impact of teacher characteristics on ICT use confirms results reported earlier (van Braak et al., 2004) concerning 'innovativeness', 'attitudes regarding computers', 'intensity of ICT use', and 'gender'. Compared to teacher characteristics, the present study stresses that policy-related factors are important for successful ICT integration. Nevertheless, findings from the interviews indicate that school policies are often

underutilised, and it is clear that ICT integration is not yet achieved in a systemic or systematic way in most schools. Very few schools can be labelled as 'learning organisations' with a shared commitment to ICT integration. Only 22% reported to have developed an extensive ICT plan, and only 17% of those plans included information on the educational use of ICT.

As ICT continues to drive changes in society and in education, school policies need to define their organisational vision and actions more clearly in view of planned change (Senge, 2000). The literature about school improvement stresses the importance of leadership in developing a commitment to change (Fullan, 2001). Building on the notion that school principals play a central role in this context, the international society for Technology and Education has established Technology Standards for school leaders (Knezek, Rogers, & Bosco, 2001). These "final attainment levels" require primary school principals to implement ICT in a successful way. Their capacity to develop and articulate, in close collaboration with other actors from the school community, a shared vision about ICT use and integration is considered as a critical building block in this process. Therefore, training of principals should be a priority. The study from Dawson and Rakes (2003) underpins the former: the more training principals receive, the more ICT integration at school level is being observed. Their findings suggest that without well-trained, ICT-capable principals, the integration of ICT into school curricula will remain deficient.

In the present study, principals report that their personal impact on the current level of ICT integration is rather limited. They refer in this context to the fact that ICT is not yet included in the formal curriculum. To respond to this problem the Flemish government has recently put forward ICT standards that determine what should be attained by the majority of the pupils at the end of primary education. Considering this decision, it will be interesting to study the impact of these standards on school policies in the near future. This would also help clarify whether class use of ICT changes significantly when the school policy is more established. In addition, interpretative research, e.g., case studies, can be set up to identify in more detail why other specific school-related variables affect the (non) adoption of ICT in certain schools.

Conclusion

The present research studied class use of ICT from a broader perspective, namely from an ICT school policy point of view. The findings suggest that successful ICT integration is clearly related to actions taken at the school level, such as the development of an ICT plan, ICT support, and ICT training. The results also suggest that principals have to develop a more collaborative approach when defining this policy. The study underpins the importance of a shared and school-wide vision about ICT integration that reflects the opinions and beliefs of the principal, the ICT coordinator, and the teachers.

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Chapter 4*
Towards a typology of computer use in primary education

Abstract

In the present study, we reject the view that computer use can be studied as a single variable in the learning environment. Our main objective is to develop an instrument to measure different types of class use of computers. This builds on a comprehensive review of the literature on computer use in education. The review helped to construct a questionnaire to study the typology of computer use in primary education. In addition, the questionnaire was enriched by statement of experts in this field. The questionnaire was presented to a sample of 352 primary school teachers. The input from a first sub-sample was used to carry out an exploratory factor analysis; the other sub-sample was used to verify the identified factor structure via confirmatory factor analysis. A three-factor structure of computer use in primary education was identified: "the use of computers as an information tool", "the use of computers as a learning tool" and "learning basic computer skills". The three-factor structure was confirmed in the confirmatory factor analysis. The results underpin a number of meaningful differences in the current practice of computer use in primary education.

Introduction

The use of computers in education is steadily increasing. In this context, it is essential for educational researchers to investigate the extent of computer integration and the factors influencing computer implementation. The actual use of computers in education can be defined and determined in different ways. Many researchers measure computer use by reporting the percentage of teachers who use computers in their classroom, or the amount of technology used in the classroom, or the time teachers and pupils spend working with computers, and so forth. Although these indicators are valuable, they hardly help to understand the actual educational use of computers in the classroom.

This introduces the question how to identify different types of computer use. The available instruments in the research literature suggest that computer use in classrooms is a complex phenomenon, and represents multiple interrelated factors. Any research on computer use in education involves selecting specific facets. This includes making choices about what aspects of computer use are important and how these should be measured. In prevalent empirical research, the arguments behind these choices have rarely been described. In this study, we will pursue transparency in this process by describing step-by-step the instrument design and development. A particular difficulty in this context is the fact that much of the research on computer use in education is value laden in an additional sense; it adopts,

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* Based on:

Tondeur, J., van Braak, J., & Valcke, M. (2007). Towards a typology of computer use inprimary education. *Journal of Computer Assisted Learning, 23*, 197-206.

implicitly or explicitly, a philosophical stance (Twining, 2002). The question is how to avoid bias in the process of instrument development.

In an earlier study (van Braak et al., 2004) two different types of computer use by teachers could be identified: “class use of computers” (e.g., computer as tool for presentation, encouraging pupils to train skills, instructing pupils in the possibilities of computers) and “supportive use of computers” (e.g., administration, preparing worksheets for the pupils, looking for information on the Internet for lesson preparation). Further research pointed out that supportive and class use of computers were influenced by computer experience and teacher attitudes. Computer experience affected both types of computer use. Supportive computer use was influenced by “general computer attitudes”, whereas class use of computers was rather influenced by “technological innovativeness” and “attitudes towards computers in education”. This illustrates that different types of computer use could refer to a different set of characteristics and rejects the view that computer use in the classroom can be studied as one single variable.

The main objective of this present study is to develop an instrument to determine types of classroom use of computers. This aim goes beyond studying percentages of time teachers or pupils spend on computers, but focuses on the question how computers are used in view of supporting learning and instruction. Before describing the empirical study, we first examine recent approaches of computer integration research. This review of literature was set up in order to gather a comprehensive set of different applications of classroom related computer use. This set will be the starting point to develop questionnaire items in the context of our instrument development. In the next section the development approach is described, building on a survey conducted among 352 primary school teachers. The article concludes with a discussion of the results and the implications for future research.

Types of computer use in education

A range of sources of information has been analysed with respect to educational computer use: government agency reports, theoretical frameworks and empirical studies from peer reviewed journals. Examination of these sources has resulted in a wider conceptual understanding of the various applications of classroom use of computers. This paper emphasises the (limited number of) empirically based literature.

Government agency reports

From the point of view of Baron and Bruilllard (2003), any evaluation of computer usage in education depends on its educational uses as defined by society. In this context, an analysis of (inter) national computer curricula (e.g., Qualification and Curriculum Authority, 1999; Commission of the European Communities, 2002; Ministry of the Flemish Community, 2004) reveals two main aims. A first aim builds on the rationale that all children must be digitally literate in order to be prepared for a knowledge-based society. A second aim is related to the assumption that computer use can improve student learning. The first aim

legitimates the study of computers as a separate school subject in view of developing a number of operational skills. The second aim states that computers should be embedded in the curriculum and should take its point of departure in pedagogy. Despite the growing convergence between the socio-economic and the pedagogical rationale (OECD, 2001), the distinction implies two types of computer use: computers as a subject and computers as an educational tool.

In Flanders (Belgium), these two types of computer use are reflected in the official information and communication technology (ICT) attainment targets (Ministry of the Flemish Community, 2004). The core of this non-compulsory curriculum, formulated as ICT competencies, focuses on supporting the learning process, for example "pupils exercise autonomously with computers". A second cluster encompasses technical competencies, such as "pupils are able to use the computer, peripheral equipment, the technical system, and software". According to the Ministry of the Flemish government (2004), it is preferable to develop these competencies while embedding computer use into subject related learning activities. A third cluster of competencies contains the social and ethical dimension of the application of ICT (e.g., "to be able to cope in a responsible manner with the new technology"). Tondeur et al., (2007) point out that – currently – teachers in Flemish primary education principally stress the acquisition of technical ICT skills. ICT competencies focusing on the learning process and social and ethical components reflect lower priority levels.

Theoretical frameworks

A large number of theoretical frameworks are available in the literature about educational computer use. Squires and McDougall (1994, cited in Twining, 2002) differentiate between three types of frameworks: (1) frameworks that are based on categories of software use; (2) frameworks that focus on the instructional role of the software; and (3) frameworks that relate software to educational rationales. The authors criticise the narrow and isolated focus in these frameworks on software use. They stress "the perspectives interactions paradigm", because they want to stress educational issues, such as classroom practices and teacher roles. In the same way, Lim (2002) also rejects an isolated view of computers in education. He stresses the integrated nature of computer use in the learning environment. He adopts an activity theory when defining a "concentric" model to demonstrate the mechanisms that link computer use to learning, and the sociocultural setting. This alternative approach results in a more complex picture of educational computer use that goes beyond the scope of the present study. School characteristics are yet not considered. A future study could examine how different types of computer use are related to contextual school variables.

The theoretical frameworks can help to get a better understanding of the relationship between computer use and educational practices. As stated above, they provide us with a more holistic approach towards the study of educational computer use. However, there is little empirical evidence to ground the conceptual frameworks. This is the focus of the present article.

Empirical studies

The distinction between "computers as a subject" and "computers as an educational tool" is the focus in a series of recent studies that aim at obtaining a more in-depth understanding of classroom use of computers. In the study of Baylor and Ritchie (2002) computer use was delineated according to nine subcomponents, including "subject-matter content". Other subcomponents refer to the use of computers as an educational tool, such as "the use of computers for collaboration", and "the use of computers for higher order skills". Computers as an educational tool may fit into a spectrum of instructional approaches, varying from traditional to innovative. Niederhauser and Stoddart (2001) differentiate between two main types of educational computer use: "skill-based transmission use" and "open-ended constructivist use". "Skill-based computer use" aims at enhancing pupils' basic knowledge and skills by supporting drill and practice exercises and embraces two subtypes of traditional software: "drill and practice" and "key-boarding". "Open-ended computer use" presents computers as a tool for helping learners to construct their own knowledge. Three subtypes of open-ended constructivist software are identified: "educational games", "exploratory programs" (e.g., LOGO), and "tool programs" (e.g., Word). The results of their evaluation study indicate that the majority of teachers centre on skill-based educational computer use.

Typologies of computer use are required to construct research instruments in view of empirical studies. Very few studies, published in the literature, report in an explicit way how the research instruments have been designed. Hogarty et al. (2003) are an exception, since the development and validation of their instrument is clearly described. Factor analytic and correlation methods were used to identify two factors delineating types of software use by teachers. The first factor represents the use of "instructional software", including the use of educational software, drill and practice, and educational games. The second factor encompasses "application software use". Typical examples of the latter are the use of word processors, web browsers, and presentation programs. Similarly, two factors were identified regarding student use of software.

"Application" of software is explored in many studies, but these studies hardly help to clarify the educational use of the software. The questionnaire designed by Kent and Facer (2004) reflects a range of computer activities (e.g., e-mailing, gaming, writing, and drawing) in order to compare pupils' home and school use of computers. In Pelgrum (2001), a list of seven items of computer use is presented in order to identify the main obstacles regarding computer integration in education: operating a computer, writing documents, making illustrations, calculating, etcetera. In only a few studies, the focus is on the instructional objectives that are pursued by adopting types of computer use. E.g., Ainley et al. (2002) identified four broad categories, based on a proposal by Rubin (1996): "computers as information resource tools" (to provide access to an information base), "computers as authoring tools" (to work with and present information), "computers as knowledge construction tools" (to explore knowledge), and "computers as knowledge reinforcement tools" (to engage in drill and practice activities). In Becker (2000), both an instructional and a software application approach can be found when he studies the relationship between types of

computer use and teachers' educational beliefs. The survey asked teachers to select three instructional objectives out of a list of ten, such as "communicate electronically", "improve computer skills", and "learn to collaborate". The survey also asked teachers to name the software that is considered to be most valuable in their teaching. The data suggest that teachers with a strong constructivist orientation are eager to adopt types of computer use that foster constructivist learning approaches, e.g., Internet browsers. Similarly, Waite (2004) reported teachers' responses about the aims and uses of computers for literacy in primary schools.

To summarise, most available studies reflect particular views on the educational use of computers. Though each study enriches the picture, a comprehensive view is lacking: some studies focus on software applications, other studies only define broad categories of computer use; in some studies the focus is on the teacher, in others on the pupils. Only a few studies centre on the educational assets of computer use.

Research design

Purpose

The purpose of the present study is to develop an instrument that integrates types of actual computer use in the classroom. To serve this purpose, the research was set up along four distinct phases, involving at each phase particular respondents to empirically underpin design decisions. In a first phase, the analysis of the literature helped to define questionnaire items that reflect types of computer use in primary education. Second, exploratory factor analysis was carried out to identify clusters in the variety of educational computer use. In a third phase, confirmatory factor analysis was conducted to examine the stability of the exploratory factor structure. Finally, the psychometric quality of the final version of the instrument was determined.

Procedure

A first version of a research instrument, based on types of computer use identified on the base of the review of the literature, was evaluated by 25 stakeholders (e.g., teachers, computer co-ordinators, and policy makers). The review focused on the identification of relevant applications of "class use of computers" in the context of Flemish primary education, to direct the wording of the test items and to reduce item complexity. This resulted in the refinement of the instrument and the removal of some irrelevant items (e.g., the pupils' use of computers to make graphics). The review process resulted in a pool of 29 items, reflecting classroom use of computers in primary education. The item set is presented in Table 1.

This new version of the instrument was presented to a sample of 352 primary school teachers. The results of a first sub-sample (n = 176) were used to carry out an exploratory factor analysis (EFA). The responses of the second sub-sample (n = 176) were included in a confirmatory factor analysis (CFA).

Measure

The 352 teachers were contacted through their principals. A paper version of the questionnaire was completed anonymously by these teachers. Each item in the questionnaire was presented as a statement about the adoption of a particular kind of computer use. Respondents were asked to rate each statement on a Likert-scale: 0 = “never”, 1 = “every term”, 2 = “monthly”, 3 = “weekly”, and 4 = “daily”. The questionnaire also included information about a number of background characteristics (age, gender, teaching grade) and computer experience profile (computer experience and level of class use of computers).

Demographics and computer profile

Questionnaire data were collected from a sample of 352 primary school teachers in 70 primary schools in Flanders (Belgium). All participants teach in grade 1-6. The sample included 72.6 % females. The age ranges from 22 to 59 years, with an average age of 38. The sample was randomly divided into two equal sub-samples. Both samples were matched based on gender, grade and age.

All teachers in the sample reported to be at least somehow familiar with computers. Only 2.0 % of the sample reported not using a computer. The average computer experience was 9.48 years (*SD* = 4.22). On average, teachers use the computer 4.70 hours (*SD* = 4.08) a week for professional support and 2.94 hours a week for leisure activities (*SD* = 3.49).

Results

Item analysis

Descriptive item statistics are presented in Table 1. Based on the results, 13 items are deleted from the list due to a too low degree of reported application in Flemish classrooms (< 15 % of the teachers using the application weekly or more). These items were excluded from the further analyses (items 17 - 29 in Table 1).

Table 1
Descriptive statistics for the 29 applications of computer use in primary education (n = 352)

		Weekly or more regular use (% of teachers)
Item 01	The pupils use the computer to practice knowledge or skills	61.3
Item 02	I teach the pupils how to make good use of the keyboard and mouse	48.3
Item 03	I teach pupils to use computer terms correctly	47.2
Item 04	The pupils use the computer to elaborate learning content	39.4
Item 05	The pupils use the computer to 'catch up' if they have fallen behind with their work	39.2
Item 06	The pupils use the computer to do further research on specific subject matter	38.1
Item 07	I teach pupils the basics of the operating systems used at school	32.6
Item 08	The pupils use the computer to select and retrieve information	27.9
Item 09	I teach pupils the basic operations of generic programs	27.1
Item 10	The pupils use the computer for writing text	23.2
Item 11	The pupils use computer for direct instruction, i.e. to learn something new	20.9
Item 12	I teach the pupils how to print a document	20.2
Item 13	I use the computer as a demonstration tool	19.0
Item 14	The pupils use the computer as an encyclopaedia	17.2
Item 15	I teach pupils about how to use specific peripherals and facilities	15.4
Item 16	The pupils use the computer to store information	15.2
Item 17	The pupils use the computer for problem solving	14.0
Item 18	I give the pupils computer-based tests	13.1
Item 19	The pupils use the computer to organise information	11.9
Item 20	The pupils use the computer to present information	10.5
Item 21	I use time in class to teach pupils keyboard skills	9.8
Item 22	The pupils use the computer to exchange information with others	8.5
Item 23	The pupils use the computer for looking up the meaning of a word	8.0
Item 24	The pupils use the computer to compare information from different sources	7.0
Item 25	The pupils use the computer to make drawings	6.3
Item 26	The pupils use the computer to organise their thinking e.g., mind mapping	4.9
Item 27	The pupils use the computer to undertake calculations	4.3
Item 28	I use the computer to simulate events the pupils cannot otherwise experience	4.3
Item 29	The pupils use the computer to make diagrams or tables	0.9

Exploratory factor analysis

Exploratory factor analysis helped to identify a number of factors to cluster types of educational computer use. A maximum likelihood analysis (orthogonal rotation) was adopted.

As a first solution, a three-factor structure was apparent, by building both on the K1 criterion (Kaiser, 1960) and the parallel analysis method (O'Connor, 2000). Three items were deleted due to loadings across factors (item 9, 12, and 15 in Table 1). An additional item was removed due to a low communality value (item 11).

A second analysis resulted again in a three-factor model, representing three types of educational computer use: "Basic Skills", "Information tool" and "Learning tool". Figure 1 represents the eigenvalues in the scree plot (Cattell, 1966), in combination with the results of the parallel analysis.

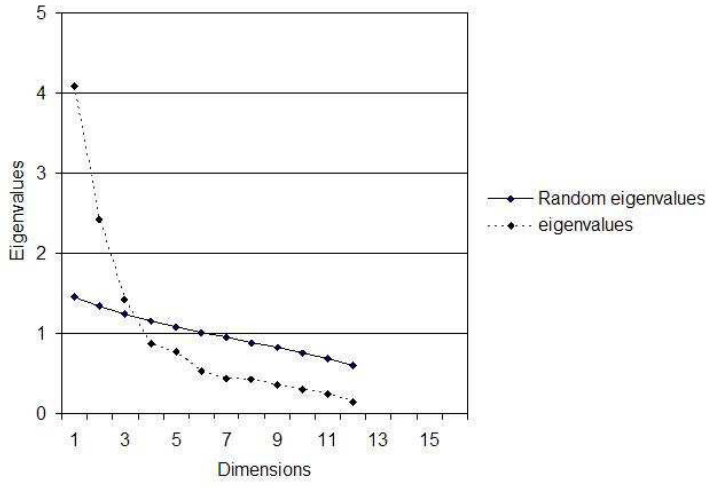

Figure 1. Scree plot and parallel analysis evidence for the fifteen perceived attributes of class use of computer.

The eigenvalues of the three factors are 4.08, 2.41 and 1.42. Table 2 summarizes the results of the exploratory factor analysis.

Table 2
Results of the exploratory factor analysis (sample 1, *n* = 176)

		Factor 1	Factor 2	Factor 3
Item 14	The pupils use the computer as an encyclopaedia	**0.83**	0.05	0.07
Item 08	The pupils use the computer to select and retrieve information	**0.78**	0.06	0.13
Item 16	The pupils use the computer to store information	**0.69**	-0.06	0.09
Item 13	I use the computer as a demonstration tool	**0.56**	0.09	0.27
Item 10	The pupils use the computer for writing text	**0.53**	0.09	0.10
Item 06	The pupils use the computer to do further research on specific subject matter	0.08	**0.93**	0.12
Item 04	The pupils use the computer to elaborate learning content	0.06	**0.88**	0.09
Item 05	The pupils use the computer to 'catch up' if fallen behind with school work	0.02	**0.53**	0.16
Item 01	The pupils use the computer to practice knowledge or skills	0.04	**0.52**	0.23
Item 03	I teach pupils to use computer terms correctly	0.17	0.20	**0.82**
Item 02	I teach the pupils how to make good use of the keyboard and mouse	0.13	0.26	**0.76**
Item 07	I teach pupils learning basics of the operating systems used at school	0.21	0.14	**0.63**

All items in Table 2 represent a significant loading (>.50) on one of the three factors. The three factors can be labelled as "computers as an information tool" (IT), "computers as a learning tool" (LT) and "basic computer skills" (BS). Together, the three factors can be regarded as comprising the types of computer application in primary education.

Confirmatory factor analysis

Confirmatory factor analysis was conducted to examine the stability of the exploratory factor structure. Several fit indices were calculated: Goodness of Fit Index (GFI), the Adjusted Goodness of Fit Index (AGFI) (Jöreskog & Sörbom, 1993), the Normed Fit Index (NFI) and the Comparative Fit Index (CFI) (Bentler, 1990). A critical value of .90 was put forward to draw conclusions about the adequacy of the model fit.

The results of the confirmatory factor analysis, including the individual item coefficients, are presented in Figure 2.

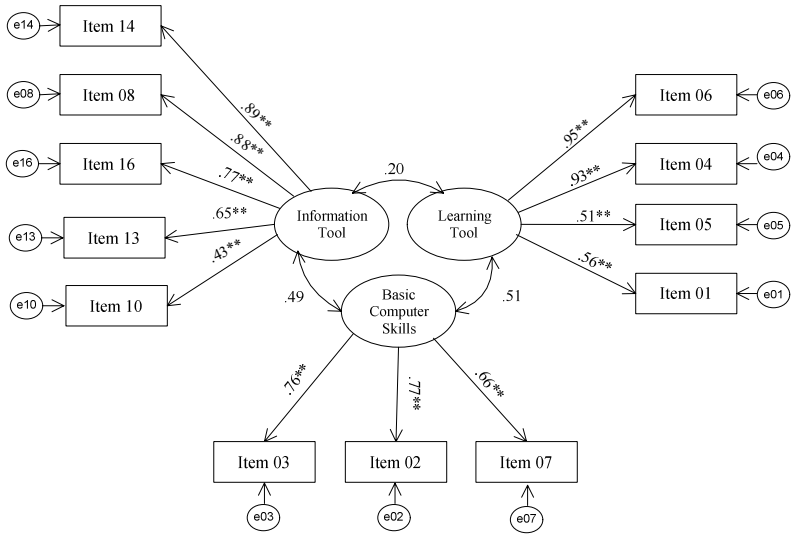

Figure 2. Results of the Confirmatory Factor Analysis: Structure coefficients for the Information Tool, Learning Tool and Basic Computer Skills items.

The results show a good fit between the structure based on the analysis of the data from the first teacher sample and the data structure drawn from the second sample: $\chi^2 = 104.3$, (degrees of freedom = 27), GFI = 0.91, AGFI = 0.87, CFI = 0.95, and NFI = 0.90. The results point at significant loading of all items on the three latent factors (all pattern coefficients between 0.43 and 0.95 and statistically different from zero at the .001 level). No error terms were allowed to be correlated.

Correlations between the latent factors are significant (r = 0.20 for IT and LT; r = 0.49 for IT and BS; r = 0.51 for LT and BS). Therefore a one-factor confirmatory factor analysis was carried out. A test of this model revealed poor model fit results ($\chi^2 = 562.4$, (degrees of freedom = 54), GFI = 0.61, AGFI = 0.43, CFI = 0.48, and NFI = 0.46). These results help to conclude that it is not possible to consider the three types of computer use – identified earlier – as a one-dimensional construct.

Scale characteristics

In the next step, the psychometric quality of the newly designed instrument was determined. Internal consistency was measured with Cronbach's alpha coefficient. Alpha coefficients for both samples are presented in Table 3; these point at high internal consistency levels (α>.70).

Table 3
Cronbach's alpha and correlation coefficients for sample 1 and 2

	Cronbach's α		(1)		(2)		(3)	
	S1	S2	S1	S2	S1	S2	S1	S2
(1) Information tool	.82	.84	1.00	1.00				
(2) Learning tool	.84	.83	.18*	.20*	1.00	1.00		
(3) Basic Skills	.82	.78	.36**	.49***	.37**	.42**	1.00	1.00

*** p < .001 , ** p < .01 , * p<.05

Table 3 also includes the correlations between the three sum scales. The results suggest that there is a reasonable positive association between "Basic Skills" and both "Information tool" (r = .36 (S1), r = .49 (S2)) and "Learning tool" (r = .37 (S1), r = .42 (S2)). Figure 3 relates the frequency of the adoption of the three types of computer use to primary education grade level.

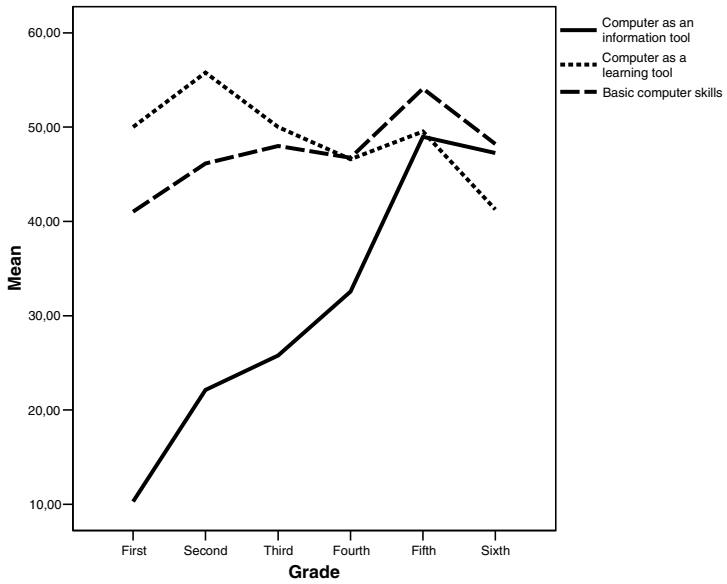

Figure 3. Frequency of use of computers as an information tool, computers as a learning tool, and basic computers skills in relation to primary education grades.

From Figure 3 it is clear that the use of "computers as a learning tool" (M = 48.9; SD = 25.0) and "basic computer skills" (M = 46.0; SD = 26.4) receive the highest priority in primary education as compared to the use of "computers as an information tool" (M = 30.5; SD = 24.0). The use of computers as an information tool seems to be related with grade; higher grade levels reflect higher levels of computer use as an information tool. Univariate analysis of variance (ANOVA) was used to test the differences in frequency of computer use as "information tool" between grade levels statistically. The primary education grade levels were included as dependent variables; the adoption of computer use as "information tool" was included as the independent variable. The results reveal a significant upward trend in the use of computers as "information tool" throughout primary grade levels (F = 35.3; df = 5; p = .00).

Discussion

Within the context of educational use of computers, a range of definitions, classifications and typologies can be found. In the present article, we rejected a uni-dimensional approach. As a result, an instrument has been developed to measure different types of computer use in the classroom. Three types of educational use could be identified: "basic computer skills" (BS), "computers as an information tool" (IT), and "computers as a learning tool" (LT).

The first type "basic computer skills" identifies the use of computers as a (separate) school subject to teach pupils technical computer skills, such as "making good use of the keyboard and mouse" and "learning basics of operating systems". This type is regularly found in the literature, though it is conceptualised in a variety of ways.

The second and third type represent educational uses of computers. According to these two categories, computer use is considered as a general support tool; not restricted to its use in view of a particular school subject. This distinction can be linked to main categories found in certain national curricula (e.g., Qualification and Curriculum Authority, 1999; Ministry of the Flemish Community, 2004): computers as a subject versus computers as an educational tool.

The "computers as an information tool" dimension encompasses the following aspects: "using computers to select and retrieve information", "using the computer for demonstration", etcetera. Emphasis is on the interaction between pupils and the subject-domain content: researching and processing information and communication. These items cover the four broad categories of computer application classified by Ainley et al. (2002). "Computers as learning tools" include items such as: "using the computer to do future research on specific subject matter" and "using computers to practice knowledge or skills". According to Hogarty et al. (2003) this factor is defined as "instructional software" and represents similar items (e.g., drill and practice).

In educational practice, it is often less easy to differentiate in a straightforward way between the three types of computer use. This complicates the problem of evaluating computer use in education (Baron & Bruilllard, 2003). For example, the distinction between

basic computer skills and educational computer use can be marred by the fact that technical use of computers involves nevertheless some knowledge construction. In the present study, analysis results suggest that when teachers stress the use of computers as an information and learning tool, they are also likely to stress the development of basic computer skills.

A number of studies shows that, although the use of computers in education is increasing, computers are rather poorly integrated into the teaching and learning process (e.g., Loveless & Dore, 2002, Sutherland et al., 2004). A recent study (Hennessy & Deaney, 2004) reports that teachers only recently started to integrate computers into their own learning and teaching processes. These results seem to reinforce the point that teachers especially focus on basic computer skills. However, the present findings suggest an alternative explication. The results propose that the frequency of "computers use as an information tool" is different depending on grade level in primary education. Fifth and sixth grade teachers are more likely to provide opportunities to use computers as an information tool. It could be argued that this represents a "higher order use" of computers and that this is related to the curriculum of fifth and sixth graders. But, as stated earlier, this alternative explanation introduces a value judgement about preferable or less preferable types of computer use. However, the three types of computer use do not comprise value judgements about 'good practice'.

Many studies provide a longer list of dimensions to distinguish between types of computer use. A too large number is less helpful to identify relevant use patterns. This illustrates an apparent tension between the need for simplicity and the need to present a rich picture of computer use (Twining, 2002). The three dimensions presented in this study synthesise actual types of computer use in Flemish primary education. Since types of computer use that have hardly been observed in current education have been excluded from the instrument, innovative computer-based learning activities can be ignored; such as "the use of computers to organise their thinking (e.g., mind mapping or concept mapping)" or "the use of computers for problem solving".

In this study an attempt is made to link computer use and classroom practice without taken the underlying educational beliefs into consideration. In a next step, teachers' educational beliefs can be explored as one of the potential determinants of the three subsets of computer use. Different types of computer use could refer to different teacher characteristics and/or antecends. For instance, teacher beliefs about learning and instruction could be a critical predictor of types of computers use: teachers with a strong constructivist orientation are eager to adopt "computers as an information tool" and this in view of computer use to "communicate electronically" or to "present information to an audience" (Becker, 2000).

Beside the possibility to explore potential determinants on different types of computer use, the instrument can be used as a tool to examine whether teachers are using computers within their teaching practice in accordance to policies of guidelines of educational authorities. A transparent understanding of the types of computer use can result in adequate management measures of policy developers to foster the integration of computers in the classroom. These can include information and awareness campaigns, or in-service training. Finally, it encourages individual schools to reflect on the educational use of computers at school level. A better understanding of types of computer use stimulates the discussion about

the adoption of specific computer related school policies. Computer use will – as a result – become linked to teacher, classroom and school variables.

Conclusion

Based on the adoption of a multidimensional approach towards computer use in primary education, a new scale was developed and evaluated in this study. The instrument helped to identify three different dimensions in computer use at primary education level: "basic computer skills", "computers as an information tool", and "computers as a learning tool". A clear attempt was made to avoid value-laden in the development of the instrument. Future use of the instrument is envisioned to explore the determinants on the types of computer use in primary education; e.g., at teacher, classroom and school level.

Further refinement and evaluation of the instrument might be needed: use and evaluation at other educational levels and an evaluation outside the Flemish educational context. Follow-up studies have to examine whether the factor structure is sufficiently robust. In addition, solutions will have to be found to incorporate innovative types of computer use.

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Chapter 5*
Exploring the link between teachers' educational belief profiles and different types of computer use in the classroom

Abstract

The purpose of the study reported in this article was to analyse the relationship between teachers' educational beliefs and typical approaches to computer use in the classroom. In this context, the question arises whether particular profiles of teachers can be distinguished based on their beliefs about good education. A survey of 574 elementary school teachers was conducted that focused both on teachers' traditional or constructivist beliefs about education and on different types of computer use: "computers as an information tool", "computers as a learning tool" and "basic computer skills". Cluster analysis resulted in four distinct teacher profiles, reflecting relatively homogeneous scale scores, based on varying levels of traditional and constructivist beliefs teachers hold about education. Overall results indicate that teachers with relatively strong constructivist beliefs who also have strong traditional beliefs report a higher frequency of computer use. In addition, results point to a specific relationship between teachers' beliefs profiles and how computers are used in the classroom. Implications for the role of educational beliefs in supporting teachers to integrate ICT in the classroom are discussed.

Introduction

The integration of information and communication technology (ICT) in education has challenged researchers for almost 20 years. In this respect, many studies have focused on measuring the impact of attitudes toward computers (Albirini, 2006; Shapka & Ferrari, 2003), computer experience (van Braak, 2001; Bovée, Voogt, & Meelissen, 2007) and computer training (Galanouli, Murphy, & Gardner, 2004; Tan, Hu, Wong, & Wettasinghe, 2003). However, results of an earlier study (van Braak, Tondeur, & Valcke, 2004) indicate that the overall impact of these variables on the use of computers in the classroom remains rather low.

Clearly, the issue cannot be restricted to merely technology-related factors. The integration of educational computer use in professional competencies of teachers implies a more complex approach. What determines whether and how a teacher uses computers in the classroom? There is a growing consensus that the adoption of educational innovations can only be explained when educational beliefs of teachers are also taken into account (Ertmer, Addison, Lane, Ross, & Woods, 1999; Higgins & Moseley, 2001; Becker, 2001). According to Pajares (1992), teachers interpret innovations according to their personal beliefs. In other words, teachers more easily accept innovations that are in accordance with their personal conceptions of teaching and learning. ICT integration in education is therefore unlikely to

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* Based on:
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succeed unless we understand teachers' personal educational beliefs and their relationship with teaching practices (Niederhauser & Stoddart, 2001).

There is a growing body of published research that underpins the hypothesis that teachers' beliefs affect classroom practices (Fang, 1996; Haney, Lumpe, Czerniak, & Egan, 2002). But research about the relation between teacher beliefs and ICT integration is still scarce. However, recent studies (Becker, 2001; Ertmer, 2005; Higgins & Moseley, 2001; Sugar, Crawley, & Fine, 2004) reveal that teachers' educational beliefs tend to be associated with their use of computers in the classroom. Becker (2001), for instance, revealed that constructivist beliefs foster computer use in education. But the latter findings are not helpful to explain the nature of educational computer use. Little is know about the relationship between educational beliefs and specific types of computer use in the classroom.

This study aims to determine which teacher beliefs are connected to which types of computer use. Therefore the study first researches whether profiles can be developed that reflect a typical set of beliefs adopted by teachers. The next step is to examine how different teacher profiles are related to different types of computer use. Before presenting the results of the empirical study, we first examine how computer use has been defined in recent educational computing research. Then, we describe the concept of teachers' educational beliefs and how they are likely to influence the use of computers in the classroom.

Background

Computer use in the classroom

Within the context of educational computer use, a range of definitions, classifications and typologies can be found. Published studies reflect particular views on computer use in a learning environment. Many researchers have measured computer use by reporting the time teachers and pupils spend using computers or the amount of technology used in the classroom (e.g., Mathews & Guarino, 2000; O'Dwyer, Russell, & Bebell, 2004). In other studies, the focus is rather on specific software applications. The questionnaire designed by Kent and Facer (2004), for example, reflects a range of computer activities in order to compare pupils' home and school use of computers. Although these studies are valuable, they hardly help to clarify the integrated educational use of the software. Becker (2000) presented both a software and an instructional application approach. His survey asked teachers to name the software that is considered to be most valuable in their teaching. Similarly, Waite (2004) reported teachers' responses about the aims and uses of computers in primary schools.

Only a limited number of studies centre on the instructional objectives pursued by integrating computer use. A clear example is the Second Information Technology in Education Study, (SITES, Module 2 by Kozma, 2003). Based on qualitative and quantitative methods, clusters of pedagogical practices building on computer use were identified. Also, Ainley, Banks and Fleming (2002) identified categories of educational computer use such as "computers as information resource tools", "computers as authoring tools" and "computers as knowledge construction tools". In the same way, Baylor and Ritchie (2002) differentiate

between types of educational computer use, including "the use of computers for collaboration" or "the use of computers for higher order skills".
Although each of the available studies enriches the picture of educational computer use, a comprehensive instrument that integrates types of computer use in the context of primary education is not yet available. Therefore, a prior empirical study was set up to identify a typology of actual computer use in primary education (Tondeur, van Braak, & Valcke, 2007[a]). The results suggest a three-factor structure labelled "basic computer skills" (to develop pupils technical computer skills), "the use of computers as an information tool" (to research and process information) and "the use of computers as a learning tool" (to practice knowledge and skills) and demonstrate the need to examine computer use from a multi-faceted, rather than a singular, perspective (O'Dwyer et al., 2004). The scales to identify these three types of computer use are described in the research method section. In the present study we relate these types of computer use to teachers' educational belief profiles and investigate possible differences. Different types of computer use could refer to different beliefs about learning and instruction.

Educational beliefs

"Beliefs" can be described as psychological understandings, premises or propositions felt to be true (Richardson, 2003). The complete set of someone's beliefs on the physical and social world and the self is clustered in a belief system (Rokeach, 1976). Beliefs and belief systems serve as personal guides in helping individuals to define and understand the world and themselves (Pajares, 1992). They allow us "to proceed as if the world makes perfectly good sense" (Cunningham, Schreiber, & Moss, 2005, 179).

Teachers' educational beliefs are understandings, premises or propositions about education (Denessen, 2000), established through multitudinous experiences (Nespor, 1987, Pajares, 1992). Teachers' beliefs are considered as relatively stable and act as a filter through which new knowledge and experiences are screened for meaning (Campbell, Kyriakides, Muijs, & Robinson, 2004; Kagan, 1992; Nespor, 1987; Pajares, 1992). In contrast to integrated models of teaching, beliefs consist of an eclectic mix of rule of thumb, generalisations, opinions, values and expectations (Lowyck, 1994) that underlie teachers' planning, decision making and behaviour in the classroom (Fang, 1996; Kagan, 1992; Nespor, 1987; Pajares, 1992).

Scholars in the field of educational research have been developing and validating a variety of instruments for measuring teachers' educational beliefs (e.g., Hermans, van Braak, & Van Keer, in press; Kerlinger & Kaya, 1959a, 1959b; Woolley, Benjamin, & Woolley, 2004). In the past, a conceptual shift in research on the dimensionality of the belief construct has taken place, and researchers have turned their attention toward a multidimensional approach to structure the belief system. Fifty years ago, for example, Kerlinger and Kaya (1959a, 1959b) criticized the bipolar distinction between teacher-centred "traditionalistic" and more "progressive" or student-centred educational beliefs. Their study provided support for the hypothesis that teachers hold both "traditionalistic" and "progressive" educational beliefs.

Recently, Woolley et al. (2004) developed the "Teachers Beliefs Survey" (TBS). In their instrument, the dimension "traditional teaching" mainly focuses on traditional approaches to curriculum and assessment. The second dimension, "constructivist teaching", embraces student-centred approaches to teaching and learning. Considering that teachers are expected to adopt concurrent educational beliefs, the question is whether specific belief profiles can be identified in teachers, based on the extent to which they adopt traditional and constructivist teaching beliefs.

The link between educational beliefs and computer use in the classroom

Even though the conditions for successful ICT integration finally appear to be in place - such as access to infrastructure, increased computer skills and sufficient computer training - the implementation of educational computer use has not yet reached a critical level (Scrimshaw, 2004; van Braak et al., 2004). This suggests, as stated above, that additional barriers specifically related to teachers' educational beliefs might be at work (Ertmer, 2005). In the research literature it is acknowledged that teachers' beliefs tend to be associated with their specific use of ICT in the classroom (e.g., Becker, 2001; Ertmer, 2005; Windschitl & Sahl, 2002). Several studies explain this by hypothesizing that teachers who use computers do so because their conceptions of using ICT fit into their existing teaching beliefs or belief system (Higgins & Moseley, 2001; Sugar et al., 2004). If the teacher perceives that the computer addresses important instructions and learning needs, the perceived value will be higher (Niederhauser & Stoddart, 2001).

There is growing evidence that teachers, adopting constructivist beliefs, are highly active computer users (Becker, 2001; Niederhauser & Stoddart, 2001). It appears that computers serve as a valuable instructional tool in classrooms in which teachers hold personal beliefs aligned with constructivist pedagogy. Since educational authorities present ICT especially as a tool for enacting student-centred curricula (Hawkridge, 1990), teachers adopting strong traditionalist educational beliefs are less likely to use computers in their classroom practice (Ertmer, 2005).

Given the differences in beliefs, it is expected that teachers' approaches to ICT use will also differ. It is therefore necessary to understand *how* computers are being used in the context of teaching and learning (O'Dwyer et al., 2004; Tondeur et al., 2007 [a]). A computer does not embody one single pedagogical orientation; it offers a spectrum of approaches to teaching and learning. According to Niederhauser and Stoddart (2001), teachers select applications of computers in line with their selection of other curricular variables and processes (e.g., instructional strategies) that fit into their existing educational beliefs. Only recently have researchers studied educational computer use in relation to teacher belief systems (Windschitl & Sahl, 2002). The evidence shows that low-level computer use tends to be associated with teacher-centred practices, while high-level use tends to be associated with student-centred, or constructivist practices (Ertmer, 2005). Constructivist teachers are also more likely to use computers in more challenging ways (Becker, 2001).

General aim of the present study

This study builds on the idea that educational beliefs affect decisions about classroom practices, including the issue of computer use. While previous researchers have documented the link between teachers' educational beliefs and computer use, this paper studies the relationship between profiles in teacher beliefs and different types of computer use. The first step in this study was to delineate teacher profiles based on the extent to which they possess traditional and constructivist teaching beliefs. The second step was to examine how different teacher profiles relate to different types of computer use, more specifically (1) "basic computer skills", (2) "the use of computers as an information tool" and (3) "the use of computers as a learning tool".

Research method

Sample

Data collection was restricted to teachers in primary schools in Flanders, the Dutch-speaking part of Belgium. A stratified sample of 70 schools was involved in the study. Stratification variables were related to the type of educational network and the degree of urbanisation (rural/urban). Fifty-seven school principals were willing to participate in the study, reflecting an 81.4% response rate at school level. At least one teacher at each grade level completed a questionnaire, resulting in data from at least six teachers per school. The sample comprised 574 teachers, of which 81.5% were female. Teacher age varied from 22 to 64 years, with an average age of 37.

Instruments

A questionnaire was developed in order to gather information from teachers about their educational beliefs and about their use of computers in the classroom. The questionnaire consisted of two parts: (1) teachers' educational beliefs and (2) different types of computer use in the classroom.

Measuring teachers' educational beliefs

In this study, teachers' beliefs about education were measured through two scales, developed by Woolley et al. (2004). Their "teacher beliefs survey" for primary teachers contains two subdimensions: "traditional teaching" (TT) and "constructivist teaching" (CT). The TT scale contains items such as, "I teach subjects separately, although I'm aware of the

overlap of content and skills" or "For assessment purposes, I'm interested in what students can do independently". In addition to the traditional dimension, examples of the CT scale are "I involve students in evaluating their own work and setting their own goals" and "I make it a priority in my classroom to give students time to work together when I am not directing them". Respondents were asked to rate each statement on a five-point scale: 0 = "totally disagree", 1 = "disagree", 2 = "neither agree nor disagree", 3 = "agree" and 4 = "totally agree". Internal consistency was measured with Cronbach's α: TT scale (α = .74) and CT scale (α = .68). The results also suggest that there is a positive association between both beliefs scales (r = 0.22).

Measuring different types of computer use

To verify whether profiles in teacher beliefs are related to different types of computer use in the classroom, an additional instrument (Tondeur et al., 2007 [a]) was included in the questionnaire. This instrument synthesises the actual types of computer use in Flemish primary education. "Basic computer skills" (3 items) identifies the use of computers as a (separate) school subject to teach pupils technical computer skills, such as "I teach the pupils to make good use of the keyboard and mouse" and "I teach pupils learning basics of operating systems used at school". The second and third categories represent educational uses of computers not restricted to its use as a school subject. "Computers as an information tool" (5 items) encompasses such aspects as "The pupils use the computer to select and retrieve information" and "The pupils use the computer as a demonstration tool". Emphasis is on the interaction between pupils and the subject-domain content: researching and processing information and communication. Finally, the category "Computers as learning tools" (4 items) includes items such as "The pupils use the computer to practice knowledge or skills" and "The pupils use the computer to elaborate learning content". The respondents were asked to indicate, on a five point scale, the extent to which they use the computer for various tasks: 0 = "never", 1 = "every term", 2 = "monthly", 3 = "weekly" and 4 = "daily". Control of the psychometric quality of the research instrument reveals a high internal consistency level for "basic computer skills" (α = .81), "computers as an information tool" (α = .83) and "computers as learning tools" (α = .77). Table 1 shows the correlations between the three sum scales.

Table 1
Pearson product-moment correlation coefficients among the three types of computer use

	IT	LT
Basic computer skills (CS)	.48**	.41**
Computers as learning tools (LT)	.30**	
Computers as an information tool (IT)		

** Correlation is significant at the .001 level

The results suggest that there is a reasonably positive association between "Basic Skills" and both "Information tool" and "Learning tool". In educational practice, it is often

less easy to differentiate in a straightforward way between the three types of computer use (Tondeur et al., 2007 [a]). For example, the distinction between basic computer skills and educational computer use can be marred by the fact that technical use of computers involves some knowledge construction. In the present study, analysis results suggest that when teachers stress the use of computers as information and learning tools, they are also likely to stress the development of basic computer skills.

Data analysis

First, a cluster analysis was performed to identify profiles in the teacher educational beliefs (k-mains clustering procedure). Cluster analysis helps to group a number of individuals into clusters so that individuals within a cluster are more similar to each other than those from other clusters (Aldenderfer & Blashfield, 1984); this is also called multivariate similarity (Gore, 2000). Scores on the two educational belief scales "traditional teaching" and "constructivist teaching" (Woolley et al., 2004) were used to develop the profiles. The results thus obtained allow us to better understand how teachers possess both traditional and constructivist teaching beliefs. Since cluster analysis is also an interpretative quantitative procedure, there is no single solution to the analysis, and the choice for a specific number of final clusters is subjective. A four-solution analysis was pursued in this study, building on the scores on the two scales (Fig.1).

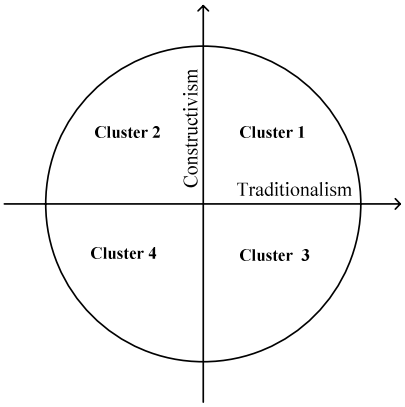

Figure 1. Four cluster solution based on the TT Scale and CT Scale.

Second, the differential impact of the four profiles in teacher beliefs on types of educational computer use was studied by computing one-way ANOVAs. Scheffe post-hoc tests were computed to study specific contrasts between teacher profiles when significant differences were found.

Results

Four profiles in teachers' educational beliefs

The first analysis examined whether teacher profiles can be defined by classifying them according to traditional and constructivist educational beliefs. Based on cluster analysis, respondents were distributed among four clusters: 180 were classified as cluster 1 (34% of the 523 respondents), 140 were grouped in cluster 2 (27%), 171 teachers belonged to cluster 3 (33%), and 32 could be found in cluster 4 (6%). Figure 2 presents the mean scores of the two classification measures of each cluster. To facilitate data analysis, sum scores were calculated for the two educational belief scales (minimum 0 - maximum 100).

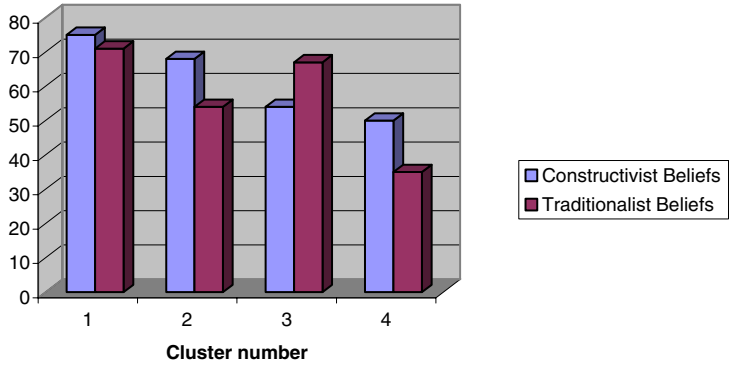

Figure 2. Mean scores of the clusters (profiles) on the TT Scale and CT Scale.

The differences between the mean scores of the clusters were statistically significant for both scale scores, with the exception of the difference between cluster 3 and 4 on the CT scale score. Teachers in cluster 1 reflect a profile with relatively high scores on both the TT Scale and the CT Scale. In contrast to this "constructivist and traditional profile" (C&TP), are teachers in cluster 4, which brings together teachers with a profile that reflects low scores on both the CT and the TT Scale. Teachers in this cluster are stated to reflect an "undefined profile" (UP). Teachers in cluster 2 had relatively high mean scores on the CT Scale but relatively low scores on the TT Scale. Therefore, the profile of teachers in this cluster is labelled as "constructivist profile" (CP). In contrast, teachers in cluster 3 are defined as reflecting a "traditional profile" (TP).

Linking teacher profiles and types of computer use

In the next step, we included Multivariate Analysis of Variance (MANOVA) to test the differences in computer use statistically. The belief profiles were entered as independent variables to compare the three types of computer use in each cluster. Based on the Wilks' lambda criterion, the multivariate test shows a significant cluster effect ($F(3, 507) = 5.284$; $p < 0.001$). The corresponding ANOVA's also reveal significant cluster effects: "computer skills" ($F(3, 507) = 3.676$; $p = 0.012$), "information tool" ($F(3, 510) = 13.535$; $p = 0.000$) and "learning tool" ($F(3, 510) = 13.535$; $p = 0.000$). Figure 3 shows the cluster mean for three types of computer use in the classroom.

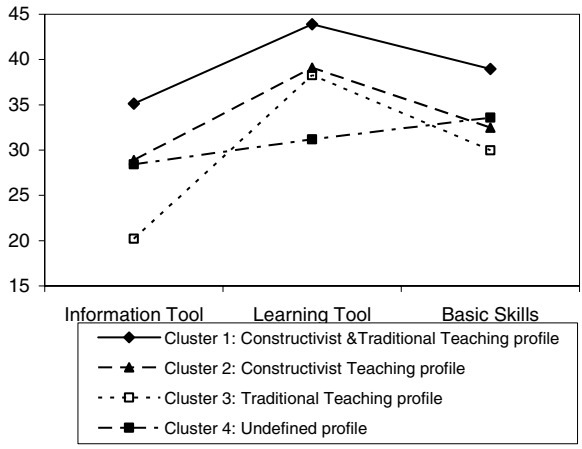

Figure 3. Mean scores of the clusters on three types of computer use.

In accordance with the findings mentioned above, teacher profiles represented in clusters 1 and 2 (C&TP and CP) with relatively stronger constructivist beliefs, report a higher frequency of computer use on the three different scales. Post hoc analyses (Sheffe criterion) were conducted to verify whether different teacher profiles are related to different types of computer use in the classroom. Significant differences are summarised in Table 2.

Table 2
Overview of significant difference between the clusters for each type of ICT use

Type of ICT use	Multiple comparisons			
	Clusters/profile	Mean difference	Standard error	*p*
Computer skills	1-3	8.99	2.79	0.016
Information Tool	1-3	14.92	2.35	0.000
	2-3	8.69	2.50	0.007
Learning Tool	1-4	12.72	4.41	0.041

The results highlight a significant difference between cluster 1 (C&TP) and 3 (TP) in the categories "computer skills" and "use of computers as an information tool". Teachers in cluster 1 (C&TP) scored significantly higher on both types of computer use. The post hoc tests also revealed a significant relationship between cluster 2 (CP) and cluster 3 (TP). Teachers in cluster 2 (CP) rated significantly higher in the use of "computers as an information tool". Finally, teachers belonging to cluster 4 (UP) reported on average a significantly lower score on the "use of computers as a learning tool" than teachers in cluster 1 (C&TP). Remarkably, compared to teachers in cluster 1 (C&TP), teachers cluster 3 (TP) had a significantly lower mean score on both "computer skills" and "use of computers as an information tool" but not on "use of computers as a learning tool".

No significant effect was found between clusters 1 (C&TP) and 2 (CP). These teachers reflect relatively high scores on "constructivist teaching". However, teachers in cluster 1 (C&TP) report higher scores on the three types of computer use. Furthermore, no significant differences were found between teachers in cluster 3 (TP) and cluster 4 (UP). Although the differences are not statistically significant, it is worth noting that the mean scores of teachers with an undefined profile were higher in comparison with traditionalist profile teachers, with the exception of the scores on the "learning tool" scale.

Discussion

Results of the present study indicate a consistent relationship between teacher profiles, based on their educational beliefs, and the frequency of class use of computers: a teacher profile with relatively high constructivist beliefs tends to show a high frequency of educational computer use. This finding is in accordance with earlier research about the role of educational beliefs in relation to ICT integration in classroom practice (Becker, 2001; Granger, Morbey, Lotherington, Owson, & Wideman, 2002). As stated earlier, it could be argued that computers serve as a valuable instructional tool in classrooms in which teachers hold personal beliefs aligned with constructivist pedagogy (Becker, 2000). Interestingly, a teacher profile with relatively high constructivist beliefs and also high traditionalist beliefs leads to the most frequent adoption of all types of computer uses. One possible explanation is that, since teachers use computers in ways that are consistent with their personal beliefs, a broader spectrum of educational beliefs might result in a more diverse use of ICT. This result provided support for the hypothesis that teachers hold both traditionalist and constructivist educational beliefs. As stated earlier, researchers (e.g., Kerlinger & Kaya, 1959a, 1959b) criticized the bipolar distinction between teacher-centred "traditionalistic" and more "progressive", or student-centred, educational beliefs and have turned their attention toward a multidimensional approach to structure the belief system.

Furthermore, teacher belief profiles tend to be associated with different types of computer use. This result confirms the importance of examining different types of computer use (O'Dwyer et al., 2004; Tondeur et al., 2007 [a]). Teachers with a traditional teaching profile, for example, are less likely to use "computers as an information tool" where the emphasis lies on the autonomous interaction between the pupil and the subject domain content. Pupils are

given more degrees of freedom when the computer is used to research and processing information when compared to the two other types of computer use. It could be suggested that the use of "computers as an information tool" is a high-level use of computers, associated with more student-centred, or constructivist practices. In addition, teachers with a traditional teaching profile are much more likely to use "computers as a learning tool" as compared to using "computers as an information tool". For this group of primary teachers, drill-and-practice activities on the computer are more common. It can be suggested that teachers are likely to adopt practices with computers that are in line with their beliefs about teaching.

Our results indicate that the use of ICT is mediated by teachers' beliefs about teaching and learning. Considering these result, how do we use the role of teachers' educational beliefs to supporting them in integrating ICT in their classrooms? Since professional development is a crucial factor in the process of ICT integration in education, it might be useful to design professional development schemes that take into account educational beliefs (Antonietti & Giorgetti, 2006; Higgins & Moseley, 2001). How to facilitate and support this in a pre- or in-service training approach is less clear, especially for staff developers who are familiar with the development of technical ICT skills. In this respect, staff developers might consider introducing ICT to accomplish that which is already valued (Ertmer, 2005). According to Zhao and Cziko (2001), the further a new teaching practice is from the existing practice, the less likely it will be implemented successfully. Once a computer application is integrated, the emphasis can switch to its potential for achieving additional aims, including those that are supported by broader or different educational beliefs (Ertmer, 2005).

The belief-action relationship must be seen as bi-directional: beliefs lead to actions, which, in turn, lead to the creation of new, reconstructed or reaffirmed beliefs (Haney et al., 2002). Teachers' practices and belief profiles are continually shaped by their ongoing experiences as teachers (Becker & Ravitz, 1999). Past studies indicate that, in conjunction with the use of ICT over time, teachers often change their classroom practice and adopt more student-centred, constructivist beliefs (e.g., Becker & Ravitz, 1999; Honey & Moeller, 1990). However, these studies have not offered clear explanations for why some teachers transform their beliefs or change their belief profile. Windschitl and Sahl (2002) stipulate that the conditions of ubiquitous ICT alone do not automatically initiate teachers' shift towards constructivist beliefs. It can be argued that, to include the use of computers, teachers must have models of how computers work in the classroom and must be supported to reflect on their own role in the learning process. Observing successful ICT integration might increase teachers' perceived need for change as well as assure them that the required changes are not impossible (Zhao & Cziko, 2001). They must be personally convinced of its benefits and see the utility of using a particular technology (Lam, 2000). This might explain why in-service approaches that build on good practices are appreciated and valued by teachers.

Policymakers still tend to operate as if educational change is a unidirectional process (Niederhauser & Stoddart, 2001). They assume teachers will accept and implement innovations such as ICT integration mandated from top down. This is often not the case (Tondeur et al., 2007[b]). In fact, if teachers feel pressured to change their educational beliefs in order to integrate ICT, they are more likely to resist it (Zhao & Cziko, 2001). In this context,

the school level plays a key role. It is in the workplace that the model should be situated, opportunities for learning provided and positive reinforcement and support offered. Problems can arise if teachers, working within the same project, have different perceptions about the role of ICT (Antonietti & Giorgetti, 2006). It is recommended that school administrators work closely with teachers to address their beliefs and concerns about ICT integration and provide an influential level of personal support and resources (Sugar et al., 2004). In this respect, preparing an ICT curriculum at school level can be a crucial step towards the practical integration of ICT through the setting of shared educational goals and the means to realise them. The development of an ICT school policy gives stakeholders the opportunity to reflect about their educational beliefs in relation to their use of ICT.

Given the current emphasis on ICT integration in education and the importance of teacher beliefs, future research should focus in depth on the belief/teaching relationship. The next step is to adopt qualitative approaches that build on classroom observation and to study whether teachers adopt types of computer applications that are consistent with their educational beliefs. Another issue which requires further study is the influence of contextual school factors on teachers' capacity to apply their beliefs in daily classroom practice. In this context, local school policies are of great importance. The latter requires more advanced statistical techniques (i.e. multilevel analysis) that recognize the hierarchical structure of teachers nested within schools. Finally, research is needed to verify the relative impact of professional development initiatives in influencing teachers' belief profiles.

Conclusions

This research has focused on how profiles of teachers' educational beliefs affect the integration of ICT in education. Overall results suggest that teachers with a profile that represents both strong constructivist and strong traditionalist beliefs are more likely to adopt educational computer use. It seems that to fully utilise the wide range of educational possibilities offered by ICT, a broad profile of educational beliefs is required. Furthermore, teachers' belief profiles tend to be associated with different types of computer use. This relationship might gain a greater appreciation for why teachers don't make wider use of ICT. As a consequence, an understanding of teacher beliefs is an important factor in supporting further ICT integration in education.

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Chapter 6*
Teacher and school characteristics associated with educational computer use: A multidimensional approach

Abstract

The central aim of this study was to test a model that integrates determinants of educational computer use. In particular, the article examines teacher and school characteristics that are associated with different types of computer use by primary school teachers. A survey was conducted, involving 527 teachers from 68 primary schools. A separate questionnaire was administered to ICT coordinators from the same schools to gather additional information about cultural and contextual school characteristics. The combined impact of both teacher and school characteristics was explored through a multilevel analysis. Besides the importance of school characteristics, the results point to differential effects on specific types of computer use.

Introduction

Researches are now beginning to face the critical characteristics associated with ICT (Information and Communication Technology) integration, such as computer attitudes (Albirini, 2006; van Braak et al., 2004), computer experience (Bovée, et al., 2007; van Braak, 2001) and computer training (Galanouli, et al., 2004; Tan, et al., 2003). However, current studies only partly explain differences in the integration of educational computer use. One of the reasons for this might be that most researchers have investigated the influence of just a few characteristics on the integration process; there has been little overlap between these fields of interests. As a consequence, studies tend to ignore the complex systemic nature of ICT integration (Tang & Ang 2002).

In addition, research focusing on ICT integration is generally limited to the study of factors at class level. Until now, few empirical studies have been set up to assess the impact of school-related factors. In our view, research has to investigate teacher and school characteristics in concurrence. The latter requires more advanced statistical techniques. For that reason, we explored the complex relationship between teacher and school characteristics and ICT integration by means of multilevel analysis. An essential advantage of this statistical technique is that it recognizes the hierarchical and/or clustered structure of variables in a multidimensional model (Rasbash et al., 2004). In this case, teachers are clustered within schools. To ignore this relationship risks overlooking the importance of school effects.

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Tondeur, J., Valcke, M., & van Braak, J. (2007). *Teacher and school characteristics associated with educational computer use: A multidimensional approach.* Manuscript submitted for publication to Journal of Computer Assisted Learning.

Another difficulty is that ICT integration in education can be defined in different ways. On the basis of a previous study (Tondeur, et al., 2007), we distinguish between three different types of educational computer use: "basic computer skills", "the use of computers as an information tool" and "the use of computers as a learning tool". The main objective of this study is to determine teacher and school characteristics that help to explain the differences in implementing these three types of computer use. In the present article "level of ICT integration" and "level of adoption of the three types of computer use" will be used as interchangeable concepts.

There are many factors influencing computer use in education. A framework that helps to structure this variety in processes and variables is therefore helpful. In the present study we adopt a framework that presents a model based on concentric circles to organize the determinants of ICT integration (Meelissen, 2005; Veenstra, 1999; Veenstra & Kuyper 2004). The model in Fig. 1 was originally developed to illustrate differences in student achievement (Veenstra, 1999) but might be an appropriate framework for this study.

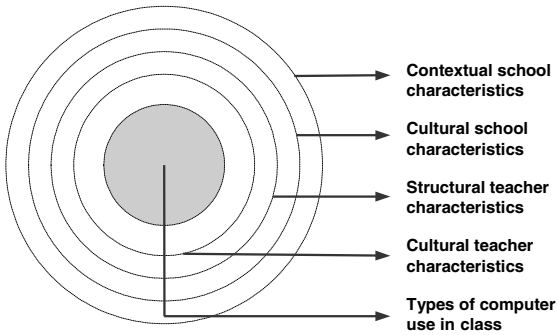

Figure 1. Conceptual model of the study, based on the structure of concentric circles by Veenstra (1999).

The core of the model represents the dependent variable(s), which in our case are the "types of educational computer use". Further, we distinguish two categories of variables both at the individual teacher level and at the school level. The teacher level includes a category of structural teacher characteristics and a category of cultural teacher characteristics. The structural characteristics such as "computer experience" and "gender", form the outermost circle. The cultural teacher characteristics are placed as an intermediate circle between the structural characteristics and the dependent variables. These comprise, among others, "teacher's beliefs about good education" and "computer attitudes". At school level, a similar distinction is made between contextual characteristics (e.g., infrastructure) and cultural school characteristics (e.g., leadership, ICT school policy). Our central aim is to test a model that

integrates both cultural and structural characteristics when explaining differences in levels of ICT integration, both at individual teacher level and at school level. Following this framework, we can develop a deeper insight into the relationships between the influencing characteristics. Furthermore, this study explores the relationship between these characteristics on different types of computer use.

Background

In this background section, we review the theoretical and/or empirical literature grounding the importance of the variables and processes that are presented in the five concentric circles of the present research framework. In particular we concentrate on studies that link these variables to ICT integration in education. First, we elaborate on the dependent variables.

Types of educational computer use

In the literature, a range of definitions, classifications and typologies can be found to determine types of educational computer use, (Tondeur, et al., 2007). Some studies determine computer use by reporting the time teachers and pupils spend using computers (e.g., O'Dwyer et al., 2004). In other studies, the focus is on the adoption of specific software applications (e.g., Kent & Facer 2004). Although these studies are valuable, they hardly help to clarify the qualitative nature of educational use of computers. Only a limited number of studies centre on the instructional objectives pursued by integrating computer use. The study of Ainley et al. (2002) is an exception since they focus on how ICT is used for learning and instruction. They differentiate between categories of educational computer use such as "computers as information resource tools", and "computers as authoring tools". Similarly, Waite (2004) reported teachers' responses about the aims and uses of computers for literacy in primary schools.

Although each of the available studies enriches the entire picture of educational computer use, a comprehensive instrument that integrates types of computer use in the context of primary education is not yet available. Therefore, a prior study was set up to identify a typology of actual computer use in primary education (Tondeur et al., 2007). The results suggest a three-factor structure: "basic computer skills" (to develop pupils' technical computer skills), "the use of computers as an information tool" (to research and process information) and "the use of computers as a learning tool" (to practice knowledge and skills). In the present study, we relate these three types of computer use to teacher and school characteristics.

Cultural teacher characteristics

What kind of teacher characteristics affects the adoption of computer use? Many studies have focused on measuring the impact of computer attitudes (Bovée et al., 2007;

Shapka & Ferrari 2003; van Braak et al., 2004). Attitudes towards computers may be defined as specific feelings that indicate whether a person likes or dislikes using computers (Simpson et al., 1994). A general finding is that teachers adopting a more positive computer attitude are more likely to use computers in the class (van Braak et al., 2004). Other cultural teacher characteristics that can be connected to the educational use of ICT are "innovativeness" and "teachers' educational beliefs". Innovativeness refers to the willingness to adapt to an innovation compared to others in the same social system (Rogers 1995). A high degree of innovativeness implies a clear knowledge about the innovation, favourable attitudes and an intention to adopt the innovation (van Braak, 2001). The findings of van Braak et al., (2004) underpin the role of innovativeness as an important determinant to explain the use of computers in class.

It is also acknowledged that teachers' educational beliefs are associated with specific uses of computers in the classroom (Becker, 2001; Ertmer, 2005; Song et al., 2007). Several studies explain this by hypothesizing that teachers who use computers do so because their conceptions of using ICT fit into their existing teaching beliefs or belief system (Niederhauser & Stoddart, 2001). A variety of instruments are available to determine teachers' educational beliefs. Woolley et al. (2004) for instance developed the "Teachers Beliefs Survey" (TBS). In their instrument, the dimension "traditional teaching" mainly focuses on traditional approaches to the curriculum and assessment. The second dimension, "constructivist teaching", embraces student-centred approaches to teaching and learning. Current research shows that low-level computer use tends to be associated with teacher-centered practices, while high-level use tends to be associated with student-centered or constructivist practices (Ertmer 2005).

Structural teacher characteristics

Research about computing in education puts much emphasis on the "gender issue" (Shashaani, 1997; van Braak et al., 2004; Volman & Van Eck 2001). For example, it was found that female teachers report significantly lower levels of educational computer use than their male counterparts (van Braak et al., 2004). Not all studies, however, show consistent results. Shapka & Ferrari (2003) found no gender differences in computer outcomes and argue that gender differences are gradually dissipating. Another structural teacher characteristic is "computer experience". Research showed that computers are more intensively used by teachers who have more years of computer experience (Rozell & Gardner 1999; Shashaani 1997). Also "age" is frequently related to computer use (e.g., Bradley & Russell 1997). When controlled for computer experience however, class use of computers does not seem to be age-related (van Braak et al., 2004).

Cultural school characteristics

Previous studies demonstrate that a substantial proportion of the variation in educational computer use is due to school-related characteristics (Dawson & Rakes 2003; Lim

2007; Otto & Albion, 2002). In this respect, an important factor is the development of a shared vision concerning the used of computers for teaching and learning (Hughes & Zachariah, 2001; Otto & Albion, 2002). It appears that teachers working in schools that are engaged in ICT planning are more likely to apply ICT in an innovative way (Kozma, 2003). Analysis of the available research also reveals the importance of leadership in managing ICT integration. School principals are in a position to create the conditions to develop such a shared ICT policy. Several studies (e.g., Anderson & Dexter, 2000; Dawson & Rakes 2003) support the claim that leadership promoting change is a key factor when it comes to merging ICT and instruction. Other school-related factors that can be connected to educational computer use are the degree of computer training (Galanouli et al., 2004) and ICT-related support (Lai & Pratt, 2004). Baylor and Ritchie (2002) conclude that training has an important influence on how well ICT is embraced in the classroom. Lawson and Comber (1999) stress the need for ongoing support by an ICT coordinator, who is in a good position to guide and successfully integrate ICT at school level.

A final characteristic emerging from the literature regarding ICT integration is "school culture" (e.g., Kennewell et al., 2000; Tearle, 2003), which can be defined as "the basic assumptions, norms and values, and cultural artefacts that are shared by school members" (Maslowski, 2001, p. 8-9). These meanings and perceptions can be linked to the "readiness" of a school to adopt the planned change (Tearle, 2003), as well as to teachers' actual take-up of ICT (Bennett et al., 2000). In the present study, we centre on two other underlying aspects of school culture: "innovativeness" (Maslowski, 2001) and "goal orientedness" (Staessens & Vandenberghe, 1994). A school's innovativeness reflects the staff's attitude towards educational innovations and to what extent they adapt themselves to changes; goal orientedness reflects to what extent the vision of innovations are clearly formulated and shared by the school members (Devos et al., 2007).

Contextual school characteristics

In this study, contextual school characteristics related to computer use are limited to access to computers and software. Without adequate recourses, there is little opportunity for teachers to integrate computers into their teaching (Bradley & Russell, 1997). Access is more than simply the availability of computers; it also includes the proper amount and the right type of technology available on the sites where teachers and students can use them (Fabry & Higgs, 1997). To achieve optimum educational results, each school should base infrastructure decisions on a clear assessment of technical factors and educational needs and objectives. In this context, the authors hypothesize that computer labs are less effective because the physical separation of computer and the actual classroom reduces opportunities for ICT integration in learning activities (Salomon, 1990; Tondeur et al., in press). In this study, a distinction is therefore made between the availability of computers in general and the availability of computers in the classroom.

Purpose

As stated earlier, the main research question is: To what extent do individual teacher characteristics and school characteristics influence the adoption of specific types of computer use in education? Considering the theoretical framework, we study the specific influence of cultural and structural/contextual variables at (1) teacher and at (2) school level and in a next step (3) their combined impact to explain the adoption of different types of computer use: "basic computer skills", "the use of computers as an information tool" and "the use of computers as a learning tool".

Research method

Sample

Sixty-eight primary schools in Flanders (the Dutch speaking region of Belgium) took part in this study. At least one teacher at each grade level was asked to participate, resulting in data from at least six teachers per school. The sample comprises 527 teachers, of which 428 were female. Teacher age range varied from 22 to 64 years, with an average age of 38 (*SD* = 9.7). In addition, 53 ICT coordinators from the same 68 schools were involved in the study. ICT coordinators were 36 years old on average (*SD* = 9.9). Ten ICT coordinators were female.

Procedure and instruments

A questionnaire was developed in order to gather information from teachers about the central dependent variables and about the cultural and structural teacher characteristics presented in Table 1. In view of the dependent variable, the instrument of Tondeur et al. (2007) was used to identify the extent to which three different types of computer use were implemented: "basic computer skills" (3items, $\alpha = .80$), "computers as an information tool" (5 items, $\alpha = .83$) and "computers as learning tools" (4 items, $\alpha = .77$). Along with to teacher characteristics, the questionnaire also addressed "teachers' perceptions about the ICT school policy" in order to investigate whether these perceptions are vital for a successful ICT implementation.

A separate questionnaire for ICT coordinators provided information about contextual and cultural school characteristics (Table 1). Since 2002, all schools in Flanders receive financial support for ICT-coordinators. Their work profile includes both pedagogical and technical tasks as well as an advisory function to the school board. However, in reality most of their time is devoted to technical aspects of ICT-coordination (Ministry of the Flemish Community, Department of Education, 2005). ICT coordinators are in the best position to provide information about the ICT infrastructure, software, the development of an ICT school policy and ICT-related support.

Table 1

School and teacher characteristics as measured in the teacher and ICT coordinator surveys

Variable	*Short description*	*Teacher*	*ICT co-ordinator*
Contextual school characteristics			
ICT infrastructure	Availability of computers (with Internet)	√	
	of computers in the classroom (with Internet)	√	
	Pupil/pc-ratio		√
Software	Availability of software		√
Cultural school characteristics			
Aspects of school culture	Goal-orientedness (Staessens & Vandenberghe, 1994)	√	
	Innovativeness (Maslowski, 2001)	√	
Leadership	Supportive leadership (Hoy & Tarter, 1997)	√	
ICT School policy	Development ICT school policy		√
	Teachers' perceptions ICT school policy	√	
	Content ICT plan		√
ICT Support	ICT related support		√
	ICT training (extent)	√	
Structural teacher characteristics			
Computer experience	Years of computer experience	√	
Gender	Male/female	√	
Cultural teacher characteristics			
Teaching beliefs	Traditional teaching beliefs (Woolley et al., 2004)	√	
	Constructivist teaching beliefs (Woolley et al.,2004)	√	
Computer attitudes	General Computer Attitudes (van Braak & Goeman, 2003)	√	
Innovativeness	Teachers' willingness to change (van Braak, 2001)	√	

Data analysis

Considering the earlier discussion about the integration of ICT, interplay can be assumed between teachers as individuals and the school context to which they belong. This assumption strongly affects the statistical analysis procedures to be adopted when studying ICT integration. In this study, the influence of teacher and school characteristics on different types of educational computer use has been explored by means of multilevel analysis in order to examine teacher-level effects and school effects in the context of one and the same analysis. While linear regression techniques attempt to explain the variation in a dependent variable in terms of one or more independent variables, the adoption of multilevel modelling techniques is helpful to take different levels within a hierarchy of nested variables into account (Goldstein, 1995). In the present study, data from teachers (level 1) are not considered as completely independent, due to the school context shared by the teachers in this school (level 2).

In order to determine the differential impact of determinants on the three types of computer use, three models were tested. In this way we could test, for example, if "innovativeness" is related to the use of "computers as an information tool" but unrelated to "basic computer skills" or if "computers in the classroom" tend to a specific type of computer use. For each model, we initially analysed an unconditional two-level null model with only one intercept term included. This null model permitted partitioning the total variance into

within-school and between-school components. We then added - step by step - effects of independent variables one at a time to the null model to detect their potential as significant determinants of computer use. The step-by-step procedure was based on the variable structure presented in the conceptual framework of Veenstra & Kuyper (2004) that was discussed earlier. An attempt will be made to explain the effects of characteristics from the outer circles by means of characteristics from the inner circles. The parameters of the multilevel model were estimated using the iterative generalized least squares estimation procedure made available in the MlwiN software (Rasbash, et al., 1999).

Results

Null model

As derived from Table 2, the random part of the null models provides justification for the application of multilevel analysis. Both the variances at teacher level and at school level are significantly different from zero for the three types of computer use (Table 3). These null models serve as a baseline to compare subsequent, more complex models, and they partition the total variance of educational computer use into "between schools" and "between teachers within schools" variance (Table 2).

Table 2
Unconditional variance components for CS, LT and IT

	"basic computer skills" (CS)	"computers as a learning tool" (LT)	"the use of computers as an information tool" (IT)
% of variance between teachers within schools	82%	84%	91%
% of variance between schools	18%	16%	9%

The greatest differences between schools can be observed in "basic computer skills" (CS). Respectively, 18% of the total variance in CS is related to differences between schools, while the remaining 82% of the variance may be attributed to differences at teacher level. 16% of the variance in "computers as a learning tool" (LT) is related to differences between schools. The least school-to-school differences occur in "use of computers as an information tool" (IT).

Final model

After estimating the null models, school and teacher characteristics were added one by one. As explained earlier, the sequence for entering the structural and cultural variables into the model was based on the framework of Veenstra & Kuyper (2004). The results of these analyses are summarized in Table 3. Since parsimonious models are preferred, only significant predictors that are helpful to improve the model were retained.

Table 3
Model Estimates for the Two-level Analysis of Types of ICT use in the Classroom

Parameters	Computer Skills (CS)		Learning Tool (LT)		Information Tool (IT)	
Fixed	Null Model	Final Model	Null Model	Final Model	Null Model	Final Model
Intercept	33.21(1.74)***		39.69(1.50)***		27.94(1.28)***	
Contextual school characteristics						
Availability of computers		0.82(0.15)***		-		-
Computers with Internet connection		-		-		0.61(0.13)***
Computers in the classroom		2.57(0.80)**		3.47(0.72)***		-
Computers in the classroom with Internet connection		-		-		5.855(0.68)***
Cultural school characteristics						
Openness to change		0.49(0.18)**		0.53(0.15)**		-
Perceptions ICT school policy		0.14(0.05)**		0.19(0.05)***		-
ICT training (extent)		2.19(0.79)**		-		-
Structural teacher characteristics						
Gender		-		-		12.73(2.15)***
Computer experience		0.70(0.23)**		-		-
Cultural teacher characteristics						
Traditional teaching beliefs		-		-		-0.15(0.07)*
Constructivist teaching beliefs		0.19(0.08)*		0.17(0.08)*		0.35(0.07)***
Innovativeness		-		0.12(0.05)*		0.15(0.05)**
Level 2 – school $\sigma^2_{\mu 0}$	123.3(35.01)***	57.3(21.48)**	86.55(26.06)***	30.34(14.99)*	45.82(18.86)***	42.10(15.10)**
Level 1 – teacher $\sigma^2_{\varepsilon 0}$	557.6(36.70)***	485.2(31.87)***	456.0(30.01)***	420.90(27.60)***	465.8(30.59)***	325.6(21.39)***

Note. Per cell: regression coefficient and standard error
*$p < .05$ **$p < .01$ ***$p < .001$

First, we consider the effects of *contextual school characteristics* on the three types of computer use. The variable "availability of computers" is positively related to the adoption of ICT in view of basic Computer Skills (CS), whereas the "availability of computers in the classroom" is positively related to the adoption of ICT as a Learning Tool (LT). The "availability of computers with Internet connection" is, of course, associated with the adoption of ICT as an Information Tool (IT).

Taking the *schools' cultural characteristics* into account, three variables have a significantly positive effect on CS: "openness to change", "perceptions school policy" and "ICT training". In contrast, no cultural school characteristics have a significant impact on IT. Significant determinants of LT are "openness to change" and "perceptions school policy". The significant effect of "supportive leadership" and "goal-orientedness" disappear when controlling for the "schools' innovativeness".

Subsequently, *structural teacher characteristics* were added to the model. The results highlight the significant effect of "gender" on the adoption of ICT as an IT. Male teachers report the use of computers as an IT more often than opposed to their female colleagues. Also a significant positive effect was also observed for "computer experience" on CS. No significant effect on LT was found, based on structural teacher characteristics.

Of the *cultural teacher characteristics*, "constructivist teaching beliefs" has a significant effect on the adoption of the three types of computer use. The effect on CS and LT is rather small. Only in the adoption of ICT as an IT is the positive impact of "constructivist teaching beliefs" high. Conversely, "traditional teaching beliefs" have a significantly negative impact on IT. Finally, "teachers' innovativeness" has a positive effect on LT and IT and seems to mediate the effect of "computer attitudes".

It was assumed that the effects of characteristics from the outer circles could be explained by means of characteristics from the inner circles. However, the input order in which the independent variables were added to the model did not affect the results. Finally, it has to be noted that no interaction effects were found

Discussion

In this study, we explored a variety of teacher and school variables to explain the differences in computer use by primary school teachers. From a methodological perspective, the results demonstrate the need to adopt multilevel modelling in this type of research: we discovered a significant amount of variance attributed at school level to explain differences in the types of computer use. Additionally, the multilevel approach allowed identifying the impact of teacher characteristics in conjunction with school characteristics. In this respect, the study corroborates previous findings (Tondeur et al., in press) that have shown the importance of also verifying the influence of characteristics at school level. While there is still much to learn with respect to the impact of school characteristics, the findings presented here indicate that ICT integration does not only depend on the position and behaviour of the individual teachers.

Furthermore, the results confirm the importance of examining ICT integration from a multidimensional approach (O'Dwyer et al., 2004; Tondeur et al., 2007). A clear example is seen with respect to the role of infrastructure. Although infrastructure is an important condition for ICT integration in general, our findings suggest that the location of computers in the school and the availability of an Internet connection are only associated with one type of computer use: to develop pupils' technical computer skills. In contrast, the availability of computers in the classroom is positively related to the use of computers as a learning tool. This finding supports the idea that the specific positioning of computers in the school can foster or hinder ICT integration in learning activities (Salomon, 1990). In addition, the provision of computers with an Internet connection is needed to foster the use of computers to research and process information. These results have clear policy implications for schools wishing to promote specific types of educational computer use.

In a comparable way, cultural school characteristics are also associated with specific types of computer use. Several of these characteristics are significant predictors for "basic computer skills" and "computers as a learning tool". But no cultural school characteristics were detected to explain the use of "computers as an information tool". A possible reason for the latter is that "computers as an information tool" is considered the most innovative type of computer use and related to learning goals pursued at higher grade levels (Tondeur et al., 2007). It therefore appears that the adoption of this type of computer use still depends largely on individual teacher characteristics.

In contrast, the results show the importance of ICT school policies for the use of computers to develop computer skills and as a learning tool. It should be stressed, however, that only the teachers' perceptions about their schools" ICT policy have a significant impact. In other words, successful ICT integration becomes much more likely when teachers share the values expressed within the school policy and understand their implications (Kennewell et al., 2000; Tondeur et al., in press). This falls in line with research findings suggesting that successful ICT integration depends upon the development of a shared vision (Hughes & Zachariah 2001; Otto & Albion 2002). The models also show that ICT training is a significant predictor of only one type of educational computer use: "basic computer skills". To build on this positive effect, a school would need to keep professional development at the center of its ICT policy. However, next to the importance of technical skills development, the analysis of the models urges to adopt a training programme that centres on a wider integration of ICT into the curriculum.

A school's willingness to be innovative is positively related to "the use the computer as a learning tool", meaning that schools with cultures that are open to innovations move forward with their use of ICT. It is interesting to note that the effect of "leadership" disappears when controlled for the "schools' innovativeness". More research is needed to better understand the relationship between these school characteristics. The absence of an effect of innovativeness (at school level) on "the use of computers as an information tool" might be surprising. An innovative school culture is not associated with the use of computers as an information tool, while, at the same time, teacher innovativeness (at class level) is a

significant predictor for this type of computer use. These finding demonstrate the complexity of ICT integration.

At the individual teacher level, we see gender-related differences with regard to the "use of computers as an information tool". Shapka & Ferrari (2003) stipulate that gender differences might still exist in the use of less familiar computer applications. This could partially explain why gender differences only exist in the adoption of this type of computer use. One of the cultural teacher characteristics to which we can attribute a strong positive effect is "constructivist teaching beliefs". The models presented here suggest that "constructivist teaching beliefs" is a significant predictor for the three types different types of computer use – mostly "the use of computers as an information tool". This confirms research findings that constructivist teachers are more likely to use computers in more challenging ways (Becker, 2001). According to Ertmer (2005), teachers adopting strong traditionalist beliefs are less likely to use computers in the classroom at all. Our results suggest, however, that strong traditionalist beliefs decrease only one type of computer use: "the use of computers as an information tool". As a result, a multidimensional approach provides more insight into the characteristics affecting computer use.

Although the present study has been helpful to study in depth the impact of an interrelated set of teacher and school variables to explain the differences in computer use, it also reflects some shortcomings. With respect to the data analysis, future studies could adopt a multivariate, multilevel analysis. An important benefit of the multivariate model is that it is possible to investigate whether predictor variables have a different effect on the dependent variables by doing a significance test (Snijders & Bosker, 1999). Second, the results cannot simply be generalized to other educational levels. Some variables were specifically measured in the context of primary education. Another limitation of the study is the quantitative nature of our survey. Additional qualitative studies, based on interviews and/or observations are needed to further explore the reasons why and how teachers integrate computers in their classrooms. Finally, future studies are needed to verify how schools are responding to new ICT standards recently legislated by the Flemish government. It will be interesting to explore how these standards affect school policies and, in turn, ICT integration.

Conclusions

The focus of the present study on the multidimensional interaction of both teacher and school characteristics has been helpful in developing a richer understanding of the complex process of ICT integration. The effect of school characteristics highlights the potential impact of actions and policies at school level, such as the development of a school-wide vision, school-based, in-service training and precise considerations as to the nature of computer access. The results also indicate that the differential impact on specific types of computer use should be considered. Variables at teacher and/or at school level are related to different types of computer use.

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Chapter 7
General discussion and conclusion

Abstract

In this final chapter, we integrate and discuss the results of the different studies reported in the previous chapters. We relate these findings to the research questions and the general research problem of the dissertation, elaborated in Chapter 1. In addition to the findings, we spell out limitations of the studies, directions for future research and practical implications for different types of audiences. Lastly, we present our general conclusions.

Overview of the research questions and the results

The central aim of this dissertation is to understand how ICT is being used by primary school teachers and to examine the many characteristics that are associated with the use of ICT in the classroom. In the introduction, we present four objectives that arose from the analysis of earlier relevant research. Those objectives are: (a) the study of how ICT is integrated in the context of primary education; (b) the identification of teacher characteristics associated with ICT integration; (c) the exploration of school characteristics associated with ICT integration; and (d) the development of a model that integrates both teacher and school characteristics associated with ICT integration. These objectives form the basis for two preliminary and eight research questions formulated in this dissertation:

(PQ1) Can we develop an instrument that measures the integration of computers for supportive and class use?
(PQ2) Can we develop an instrument that integrates different types of computer use in class?
(RQ1) To what degree have Flemish primary school teachers integrated computers for supportive use and class use?
(RQ2) To what degree have Flemish primary school teachers integrated different types of computer use in class?
(RQ3) What set of teacher characteristics are associated with the use of computers in class?
(RQ4) To what degree are teachers' educational beliefs related to how computers are used in class?
(RQ5) To what degree are local school policies related to the use of computers in class?
(RQ6) What is the impact of school culture characteristics on the use of computers in class?
(RQ7) What is the combined impact of teacher and school characteristics on computer use in class?
(RQ8) What is the differential impact of teacher and school characteristics on specific types of computer use in class?

We tackled these research questions in four studies that we reported and discussed in the five preceding chapters. In this section, we bring together the results of these chapters.

Teacher characteristics related to supportive and class use of computers

The purpose of the study in Chapter 2 was to develop a reliable and valid instrument that measures the integration of supportive use and class use of computers (PQ1). Using data reduction techniques, a measure has been constructed to identify educational computer use in the classroom (e.g., computers as a tool for presentation, encouraging pupils to improve skills, instructing pupils in the possibilities of computers) and for supportive tasks (e.g., administration, preparing worksheets for pupils and looking for information on the Internet for lesson preparation). This instrument helps to identify different computer applications and the teaching approaches they support (Table 1, p. 33).

The instrument also measures the frequency of the types of computer use (RQ1). In this way, administration of the instrument in a first study helped to determine the actual situation with respect to supportive and class use in the context of Flemish primary education. All teachers in the sample of the first study reported to be in some way familiar with computing. Computers are more intensively used for professional support and to a lesser extent for class use. Most of the teachers use the computer between one and two hours a week in their classrooms. This implies that computers have found their way into classrooms, but the quantity of use in the class is rather limited.

Additionally, Chapter 2 tries to answer research question 3, which refers to the factors influencing both types of computer use. We applied path modelling in order to identify which teacher characteristics predict supportive and class use of computers. Teacher characteristics were categorised in three sets: demographics (age and gender), computer experience (computer training, computer experience expressed over time, intensity of computer use) and attitude measures (general computer attitudes, attitudes toward computers in education, technological innovativeness). We found that supportive use and class use of computers are not related to the same set of variables. Supportive computer use was mainly predicted by computer experience and general computer attitudes (Fig. 1, p. 38). Strongest predictors of class use were technological innovativeness and gender (Fig. 2, p. 40). The total explanation of computer use in class, however, is considerably lower compared to supportive computer use. The latter finding introduces a discussion about the level of complexity when trying to account for computer use in class; especially when relying on variables measured at the individual teacher level. This brings us to the central focus and results of the next study.

Teacher and school characteristics related to computer use in class

Chapter 3 studies computer use in class from a broader perspective, in particular by analysing the relationship between local school policies and the actual use of computers in the classroom. This chapter integrates the results of studies 1 and 2 and helps to formulate a more comprehensive answer to research question 5. To answer the research questions, a representative sample of 53 primary school principals was interviewed (study 2). In addition, the interview data were supplemented with survey data of 574 teachers from the same 53 schools (study 1). Also, teachers' perceptions about the ICT school policy were examined in

order to investigate whether these perceptions play a vital role for successful implementation of this school policy. Taking into account the hierarchical structure in the large set of variables (teacher level and school level), we opted for multilevel modelling, since these models are specifically geared to the statistical analysis of data with a clustered structure (Goldstein, 1995).

The findings suggest that successful ICT integration is clearly related to variables at the school level. What emerged from the analyses was that teachers' perceptions about school-related policies, such as an ICT plan, ICT support and ICT training have a significant impact on class use of ICT. Nevertheless, findings from the interviews indicate that school policies are often underutilised, and it is clear that most schools have not yet integrated ICT in a systemic or systematic way. Findings about the impact of teacher characteristics confirm results reported in Chapter 2.

Typology for computer use in class

Chapter 4 investigates to what degree Flemish primary school teachers integrate different types of computer use in class (RQ2). It focuses on a better understanding of the variety in computer use in view of supporting learning and instructional processes. Therefore, we developed an instrument to measure different types of class use of computers (PQ2). The instrument development built on a comprehensive review of the literature. The review helped to construct a questionnaire to study the typology of computer use in primary education. In addition, the questionnaire was enriched by statements from experts in this field.

The questionnaire was presented to a sample of 352 primary school teachers (study 3). The input from a first sub-sample was used to carry out an exploratory factor analysis; the other sub-sample was used to verify the identified factor structure via confirmatory factor analysis. We identified a three-factor structure of computer use in primary education: "the use of computers as an information tool", "the use of computers as a learning tool" and "learning basic computer skills" (Table 1, p. 72). The three-factor structure was confirmed when applying the confirmatory factor analysis (Fig 2, p. 73). The results underpin a number of meaningful differences in the current practice of computer use in primary education.

Teacher beliefs related to different types of computer use in class

The central research question in Chapter 5 focuses on studying teachers' educational beliefs in relation to how computers are used in class (RQ4). Therefore, the research first examines whether profiles can be developed that reflect a set of beliefs adopted by teachers, based on the extent to which they adopt traditional and constructivist teaching beliefs. A survey of 574 elementary school teachers was conducted (study 4) that focused both on teachers' traditional or constructivist beliefs about education and on different types of computer use (Chapter 4).

Cluster analysis resulted in four distinct teacher profiles, reflecting relatively homogeneous scale scores, based on varying levels of traditional and constructivist beliefs

teachers hold about education. Overall results indicate that teachers with relatively strong constructivist beliefs who also have strong traditional beliefs report a higher frequency of computer use. In addition, results point to a specific relationship between teachers' beliefs profiles and how computers are used in the classroom. Teachers with a traditional teaching profile, for example, are less likely to use computers as an information tool where the emphasis lies on the autonomous interaction between the pupil and the subject domain content. They are much more likely to use "computers as a learning tool" as compared to using "computers as an information tool". For this group of primary teachers, drill-and-practice activities on the computer are more common. These results confirm the importance of examining ICT integration from a multidimensional approach.

Model for ICT integration in education

Chapter 6 integrates the findings from the studies reported in the previous chapters. This study brings us to the main aim of the dissertation: the development of a model about the teacher and school characteristics associated with the integration of ICT in Flemish primary schools. In particular, the article documents the types of computer use by elementary school teachers and examines teacher and school characteristics that are associated with these types of computer use (RQ8). In addition, this chapter also analyses the impact of school culture characteristics on the use of computers in class (RQ6). In order to answer the research questions, a survey was conducted involving 527 teachers from 68 primary schools. A separate questionnaire was administered to ICT coordinators to gather additional information about cultural and contextual school characteristics. The combined impact of both teacher and school characteristics (RQ7) was explored through a multilevel analysis. Table 1 presents an overview of the results:

Table 1
Summary of the results

	Computer skills	Learning tool	Information tool
Contextual school characteristics			
Availability of computers	0.82(0.15)***	-	-
Computers with Internet connection	-	-	0.61(0.13)***
Computers in the classroom	2.57(0.80)**	3.47(0.72)***	-
Computers in the classroom with Internet connection	-		5.855(0.68)***
Cultural school characteristics			
Openness to change	0.49(0.18)**	0.53(0.15)**	-
Perceptions of ICT school policy	0.14(0.05)**	0.19(0.05)***	-
ICT training (extent)	2.19(0.79)**	-	-
Structural teacher characteristics			
Gender	-	-	12.73(2.15)***
Computer experience	0.70(0.23)**	-	-
Cultural teacher characteristics			
traditional teaching beliefs	-	-	-0.15(0.07)*
constructivist teaching beliefs	0.19(0.08)*	0.17(0.08)*	0.35(0.07)***
Innovativeness	-	0.12(0.05)*	0.15(0.05)**
Level 2 – school $\sigma^2_{\mu 0}$	57.30(21.48)**	30.34(14.99)*	42.10(15.10)**
Level 1 – teacher $\sigma^2_{\varepsilon 0}$	485.16(31.87)***	420.90(27.60)***	325.58(21.39)

Note. Per cell: regression coefficient and standard error
*$p < .05$ **$p < .01$ ***$p < .001$

When we consider the effects of contextual school characteristics on the three types of computer use, the results show that the "availability of computers" is positively related to the adoption of ICT in view of basic Computer Skills (CS), whereas "availability of computers in the classroom" is positively related to the adoption of ICT as a Learning Tool (LT). The "availability of computers with Internet connection" is, of course, associated with the adoption of ICT as an Information Tool (IT). Taking the schools' cultural characteristics into account, three variables have a significantly positive effect on CS: "openness to change", "perceptions of school policy" and "ICT training". In contrast, no cultural school characteristics have a significant impact on IT. Significant determinants of LT are "openness to change" and "perceptions of school policy". The results with respect to structural teacher characteristics highlight the significant effect of "gender" on the adoption of ICT as an Information Tool (IT). Male teachers report the use of computers as an IT more often than their female colleagues. Also a significant positive effect was observed for "computer experience" on BS. No significant effect on LT was found, based on structural teacher characteristics. Of the cultural teacher characteristics, "constructivist teaching beliefs" has a significant effect on the adoption of the three types of computer use. The effect on CS and LT is rather small. Only in the adoption of ICT as an Information Tool (IT) is the positive impact of "constructivist teaching beliefs" considerable. "Traditional teaching beliefs" have a significantly negative impact on IT. "Teachers' innovativeness" has a positive effect on LT and IT and seems to mediate the effect of "computer attitudes".

In line with the findings reported in Chapter 3, the results confirm that ICT integration cannot be attributed to teacher characteristics alone. Besides the importance of school characteristics, the results point to differential effects on specific types of computer use. A general discussion of these overall findings will be presented in the next section.

General discussion

In this section, we link the most important results summarised above and discuss (a) the multidimensional nature of computer use, (b) the importance of an educational vision to ground and direct ICT integration, (c) the potential of an ICT school policy and (d) the search for a more holistic approach to explain differences in ICT integration.

A multidimensional approach to measure computer use

The results of chapters 2, 5 and 6 confirm findings from previous studies (Becker, 2001; O'Dwyer, Russell, Bebell, & College, 2004) about the importance of examining ICT integration from a multidimensional perspective. The first study reported in Chapter 2 points out that supportive and class use of computers are influenced by a varying set of characteristics and rejects the view that educational computer use can be studied as an isolated variable in the learning environment. For this reason, in Chapter 4 we present an instrument to measure different types of computer use in the classroom. Three types of educational computer use could be identified: "basic computer skills" (to develop pupils' technical skills), "computers as an information tool" (to research and process information) and "computers as a learning tool" (to practice knowledge and skills). This instrument goes beyond studying percentages of time teachers or pupils spend with computers. The instrument rather focuses on the question about how computers are used in view of supporting learning and instruction. Many studies provide a long list of dimensions to distinguish between types of computer use (e.g., Baylor & Ritchie, 2002; Kozma, 2003), but a too large number is less helpful in identifying relevant usage patterns. This illustrates an apparent tension between the need for simplicity and the need to present an overall picture of the varying ways computers are used by teachers in the classroom.

In educational practice, it is often less easy to differentiate between different types of computer use. For example, the distinction between "basic computer skills" and educational computer use can be blurred because educational use of computers does involve the application of some technical skills. This complicates the problem of evaluating computer use. Nevertheless, the overall results in this dissertation emphasise the need to be specific as to the type of computer use. "Gender issue" is a good example. In the first study, teacher gender seems to have a significant effect on computer use in class. Male teachers report integrating computers more often. But when we examine the effect of gender on types of computer use, we only see gender-related differences with regard to the use of "computers as an information tool". Shapka & Ferrari (2003) stipulate that gender differences might still exist in the use of less familiar computer applications. This could partially explain why

gender differences only exist in the adoption of this type of computer use – because it is considered the most innovative type of use and related to learning goals pursued at higher grade levels.

In the same way, the study in Chapter 6 illustrates how other teacher and school characteristics are associated with specific types of computer use. To summarise, a multidimensional approach provides more insight into the characteristics affecting computer use.

It's about "education"

One of the teacher characteristics that has as strong impact on the level of ICT integration is "teaching beliefs". The results in Chapter 5 and 6 suggest that "constructivist teaching beliefs" is a significant predictor for ICT integration in education. Teachers with stronger constructivist beliefs tend to show a higher frequency of computer use in the classroom. This finding is in accordance with earlier research about the impact of beliefs on ICT integration in classroom practice (Becker, 2001; Granger, Morbey, Lotherington, Owson, & Wideman, 2002). It could be argued that computers serve as a valuable instructional tool in classrooms in which teachers hold personal beliefs aligned with constructivist pedagogy (Becker, 2000).

However, it is important to be more specific as to the type of educational computer use in this context. Our results suggest that "constructivist teaching beliefs" has a significant effect on the adoption of the three types of computer use, but the effect on the use of "computers as a learning tool" and "computer skills" is rather small. Only in view of the adoption of "computers as an information tool" there is a positive impact of "constructivist teaching beliefs". This confirms research findings that constructivist teachers are more likely to use computers in challenging ways (Becker 2001).

Similarly, traditionalist beliefs are associated with more specific types of computer use. According to Ertmer (2005), teachers adopting strong traditionalist beliefs are less likely to use computers in the classroom. Our results in Chapter 6 suggest, however, that traditionalist beliefs decrease only one particular type of computer use: "computers as an information tool". Interestingly, the results from Chapter 5 indicate that a teacher profile comprising of relatively high constructivist beliefs and high traditionalist beliefs leads to the most frequent adoption of all types of computer uses. One possible explanation is that, since teachers use computers in ways that are consistent with their personal beliefs, a broader spectrum of educational beliefs might result in a more diverse use of ICT.

Clearly, the issue of ICT integration cannot be restricted to mere technology-related factors. The role computers play in education depends on choices about the nature of teaching and learning processes that teachers prefer and want to realize. A computer does not embody one single pedagogical orientation; it has the potential to support a spectrum of different approaches towards teaching and learning. As a consequence, an understanding of teacher beliefs is an important factor in supporting further ICT integration in education. According to Pajares (1992), teachers interpret innovations according to their personal beliefs. In other

words, teachers accept more easily innovations that are in accordance with their personal conceptions of teaching and learning. ICT integration in education is therefore unlikely to succeed unless we understand teachers' personal educational beliefs and their relationship with teaching practices.

Need for a shared vision at school level

Throughout the subsequent studies, we observed significant differences in the way ICT is currently implemented in the classroom setting. Some teachers are intrinsically motivated to use computers in educational practice, while others do not share this affinity with computers. For this reason, many researchers have centered on critical teacher related characteristics associated with educational computer use, such as "innovativeness" (Marcinkiewicz, 1993; van Braak, 2001), "computer attitudes" (Albirini 2006; Dementrias, Barbas, Molohides, Palaigeorgiou, Psillos, Vlahavas, et al., 2003; van Braak & Goeman, 2003) and "computer experience" (Becker, 2001; Bovée, Voogt, & Meelissen, 2007; Williams, Coles, Wilson, Richardson, & Tuson, 2000). The impact of these factors falls in line with our research findings suggesting that ICT integration depends in large part on the willingness and attitudes of individual teachers.

In order to complete existing research by including school related characteristics, we examined ICT integration from a school improvement approach. This leads to a strong focus on the school as a unit of change and pays additional attention to the internal conditions at school level. The results demonstrate the need to and the success of adopting this perspective: we discovered that a significant degree of variance in computer use could be explained by variables at school level. In this respect, the study in Chapters 3 and 6 corroborates previous findings (Baylor & Ritchie, 2002; Kennewell, Parkinson, & Tanner, 2000; Tang & Ang, 2002) that have shown the importance of also verifying the influence of characteristics at school level. While there is still much to learn with respect to the impact of school characteristics, the findings presented in the different studies indicate that ICT integration depends on more than teacher related variables.

First, the studies in Chapters 3 and 6 show that teachers in schools with an explicit ICT school policy that stresses shared goals, use ICT more regularly in their classrooms. This confirms results of other studies that successful ICT integration depends on the development of a shared vision (Hughes & Zachariah, 2001; Otto & Albion, 2002). However, it is to be stressed that in our study only "teacher perceptions regarding the content of the ICT school plan" and not the actual content of the ICT plan appears to have a significant impact on classroom use of ICT. As a consequence, an ICT policy seems to be an important incentive to foster the integration of ICT use in class, but only when teachers are aware of its content. In other words, successful ICT integration is much more likely when teachers share the values expressed within the school policy and understand their implications. Nevertheless, as could be derived from the interviews (Chapter 3), teachers were often overlooked during the development of the school's ICT policy. The results point at a lack of communication between principals and teachers. This reinforces the fact that policy decisions and change

models do not always acknowledge the pivotal role of the teacher in effecting change (Olson, 2000).

Next to the importance of a shared vision about ICT, three other significant school characteristics - reported in Chapter 3 - influence ICT integration: teachers that attended in-service trainings, the availability of school-internal ICT support and infrastructure. First, it appears that teachers reporting a high degree of ICT-related support incorporate ICT in their practice more often. This confirms research findings that teachers need considerable support in view of ICT integration (e.g., Galanouli, Murphy, & Gardner, 2004; Lai & Pratt, 2004). From the interviews with principals it became clear that the most support is supplied by ICT coordinators. Coordinators, however, primarily provide schools with technical expertise, while their impact on educational or policy-related issues seems limited. As Somekh (1996) noted, the need for technical support tends to take precedence over curriculum support. According to Lai and Pratt (2004), the main responsibility of the ICT coordinator should rather be to guide computer integration in teaching and learning (curriculum support). Principals in our study indicate a lack of time as an obstacle for providing teachers and the school with such curriculum-related support.

Building on the positive effect of the "number of in-service ICT training sessions" on higher levels of ICT class use (Chapter 3), professional development should stay at the centre of an ICT policy. The final models presented in Chapter 6 also show that ICT training is a significant predictor, but only in view of one type of educational computer use: "basic computer skills". Next to the importance of technical skills development, the analysis of the models in Chapter 6 urges the adoption of training programmes that centre on a wider integration of ICT into the curriculum.

Next, our results confirm what is general acknowledged: infrastructure is an important condition for ICT integration. A more important result perhaps is the location of computers and the availability of an Internet connection (Chapter 3 and 6). The availability of computers *in the classroom*, for instance, is only positively related to the use of "computers as a learning tool". These results have clear policy implications for schools wishing to promote specific types of educational computer use.

In this respect, it has to be stated that school policies are often underutilised, and it is clear that ICT integration is not yet achieved in a systemic or systematic way in most of the schools. Very few schools can be labelled as "learning organisations" with a shared commitment to ICT integration. Similar to other studies (Janssen Reinen, 1996), the available data gathered in Flemish primary schools do not present sufficient evidence to be able to conclude that teaching and learning with computers has reached the phase of institutionalization in primary education. As ICT continues to drive changes in society and in education, we contend that school policies need to define their organisational vision and actions more clearly in view of planned change. We elaborate on this issue in the "practical implication" section.

Search for a more holistic approach

Researchers are now beginning to face the critical characteristics associated with educational computer use but succeed only partly in explaining differences in ICT integration. One of the reasons for this might be that most researchers have investigated the influence of just a few characteristics on the ICT integration process. In this dissertation, we explored a variety of factors in combination in order to obtain a more complete empirical understanding of the complex process of ICT integration (Chapters 2, 3 and 6). In this way, our results provide a basis for the statement that the influencing factors must be studied from a system of variables that interact in determining the success or failure of ICT in education; the status of one factor is continuously affected by the status of many others.

From our results it is clear that there are many factors influencing computer use in education. A frame of reference that helps to structure this variety in processes and variables was therefore needed. We adopted a framework (Veenstra, 1999, 2004; Meelissen, 2005) to structure the variety in variables (Chapters 1 and 6). This particular framework was well-suited for this research because it allowed also to develop a deeper understanding of the relationships between the influencing variables. Existing school improvement theories and findings from each subsequent chapter offered guidelines as to which variables had to be included in our final model.

This conceptual model also guided the analysis of both teacher and school variables through multilevel analysis. Multilevel models are specifically geared to the statistical analysis of clustered data (Goldstein, 1995). In the present study, data from teachers (level 1) are not considered as wholly independent due to the school context shared by the teachers in this school (level 2). It is not a custom in educational computing research to combine teacher and school characteristics in a multilevel model. However, as stated earlier, we discovered a significant amount of variance to be attributed to variables at school level when explaining differences in educational computer use.

Our final model demonstrates that a substantial proportion of the variation in educational ICT use is due to school improvement related variables (Chapter 1 and 3). However, we would like to stress that the set of variables incorporated in the final model as presented in Chapter 6 still does not depict the full complexity of ICT integration in education. Further development of the model is needed when setting up future research. This brings us to the next section.

Limitations of the studies and directions for future research

Although the studies in this dissertation have been helpful to study the impact of an interrelated set of teacher and school variables explaining differences in computer use in primary education, they also reflects a number of limitations. The following concerns apply to most studies: (a) the generalisability of the results, (b) the quantitative nature of the studies, (c) the innovative use of ICT, (d) the effectiveness of ICT use and (e) alternative measures to explain ICT integration. Moreover, we suggest some directions for future research in order to

corroborate the findings or to study new research questions that arise from the results. These new issues refer both to the content of the study and to the methodological approach.

Generalisability of the results

First, the results of this dissertation cannot simply be generalised to other educational levels. Some variables were specifically measured in the context of primary education; this is especially true when it comes to studying school culture, school policies and school development approaches. In secondary and higher education, computer use might be integrated in different ways. Furthermore, we have to assume that ICT integration in education can be different outside the Flemish educational context. In this respect, an earlier study (Tondeur, van Braak, & Valcke, 2007) stressed the importance of national ICT policies by subsidising an appropriate infrastructure, providing in-service training, etc. Several other studies have pointed at the critical importance of national ICT policies to promote the potential of ICT in learning processes (Olson, 2000; Tawalbeh, 2001; Valcke, Rots, Verbeke, & van Braak, 2007; ten Brummelhuis, 1995). This indicates that further refinement and evaluation of the instrument might be needed outside the Flemish educational context.

Apart from the evaluation of ICT at other educational levels and outside the Flemish context, there is also the question of different stages of ICT integration. The study of Janssen Reinen (1996) indicates that within the broad process of ICT integration, one could distinguish different stages or sub-phases of development, each influenced by a different set of variables. Also at school level, ten Brummelhuis (1995) concluded that variables identified by the theories of educational change do not have equal impact during all stages of the innovation process of computer use in education. The stages of development in a process of implementing change are defined by Fullan (1991) in terms of adoption, implementation and institutionalisation. The results of the study reported in Chapters 3 and 6 indicate that Flemish primary schools have not yet reached the phase of "institutionalisation". However, in this study we did not distinguish between different sub-phases of development. A future study should also include indicators as to the current phase of computer diffusion (Itzkan, 1995). Additionally, for a better understanding of computer use, comparisons should be made over time. This makes it possible to identify influencing factors at different stages of development.

Another remark with respect to validity (especially of our instruments to measure ICT use in the classroom): our data have been gathered through self-reporting surveys. Although these instruments have been extensively trialled and validated and reflect a long history of development work, the fact remains that they are self-report measures. A potential problem with these types of instruments is that they are an indirect measurement and do not reveal what teachers actually do with ICT. On the other hand, self-reported measures are efficient in view of obtaining generalisable research findings. These measures can be gathered by involving large samples. In Chapters 3 and 6 we made an attempt to develop a basic triangulation approach by adopting a multilevel approach in our data collection and also by building on data acquired from other actors involved in the ICT integration process. In Chapter 3 data from teachers were supplemented with interview data from school principals.

In study 6, some characteristics were measured by both questioning the ICT coordinator and the teachers. Examination of these findings revealed that perceptions of school principals and ICT coordinators are not always in line with the perceptions of teachers. It is therefore important to complement with data from different perspectives. In future research, alternative approaches could be adopted to meet the limitation discussed above: e.g., class observations, and retrospective techniques such as stimulated recall. That brings us to the next section.

The quantitative nature of the studies

A crucial limitation of the present study concerns the quantitative nature of our survey. It has to be stressed that ICT integration in education is a complex phenomenon and that it is not easy to gather information about this complex phenomenon on the base of a survey and building on questionnaires. Therefore, future studies need to undertake qualitative interpretative research. Future researchers might wish to collect more in-depth information through interviews to explore why teachers integrate (or refuse to integrate) computers in their classrooms. A problem with interpretative research, however, is that teachers are inclined to report external hindering factors such as a lack of adequate infrastructure (Williams, Coles, Wilson, Richardson, & Tuson, 2001), which can mask individual factors, such as experience and attitude.

Future research should include more detailed and qualitative discourse analysis. For example, in this dissertation we focus on teacher beliefs, but, if we want to understand how computers relate to learning activities and instructional methods, it is necessary to really look at what is actually going on in classroom practice. Another issue requiring interpretative research, is the influence of school characteristics on teachers' capacity to apply ICT in daily classroom practice. In view of the latter, case studies could be set up. This would be helpful to study e.g., the suggestion that "school culture" is an important consideration in terms of ICT integration (e.g., Lim, 2002; Tearle, 2003). Case studies could help to investigate how these "informal policies" affect formal policies and, in turn, ICT integration.

Nevertheless, it is advisable to relate both quantitative and qualitative research. The relevance and usefulness of such an approach is illustrated in Chapter 3 where data from teacher surveys were combined with interviews. This study exemplified that interview findings provide in-depth information about the way certain school characteristics influence computer use, while the survey findings provide a knowledge base about educational ICT use and a starting point for the interviews.

Innovative ICT use

A further limitation of the present studies is related to the "innovative" use of ICT. The three dimensions presented in Chapter 4 synthesise actual types of computer use in Flemish primary education, but, since types of computer use that have barely been observed in current education have been excluded from our instrument, innovative computer-based activities could have been ignored (e.g., mind mapping, the use of computers for problem

solving, the use of collaborative workspaces, such as Wiki's). Educational authorities, including the Flemish government, emphasise the importance of ICT as a catalyst to innovate teaching and learning approaches: "ICT can boost the creation of an optimal teaching/learning environment. This learning organisation will evolve over the course of time from schools into open learning centres and multimedia learning environments. ICT must be viewed as a means to support teaching aspects such as an extension of the special needs provision, participation, internationalisation, lifelong learning and intercultural education" (Ministry of the Flemish Community, 2002, p. 16). Also, Hawkridge (1990) stresses the educational innovation potential of ICT use (catalytic rationale). With respect to this catalytic rationale, ICT is expected to accelerate educational innovations. The central finding of the OECD/CERI study (Venezky & Davis, 2002) is that ICT rarely act as a catalyst by itself for schooling change yet can be a powerful lever for realising planned educational innovations.

At the present time, most teachers do not adopt the full potential of ICT when developing learning environments (Smeets & Mooij, 2001; Smeets, 2005). Thus computers are used mainly to complement rather than change existing pedagogical practices. It is clear that ICT may not be expected to contribute to creating innovative, pupil-centred learning environments unless teachers pay attention to the broader potential of ICT. This raises the question about factors promoting innovative ICT applications. In this study, the "use of computers as an information tool" is considered to be the most innovative type (Chapter 4). Our results illustrate that this type of computer use is especially associated with teacher characteristics, such as constructivist educational beliefs. Also Drent (2005) concluded that educators who are able to use ICT innovatively in their own learning processes are characterised by a specific combination of knowledge, skills and attitudes, including personal entrepreneurship and a student-oriented pedagogical approach. Following these results, the teaching-learning process should be the starting point of future research, and the question then becomes whether the computer becomes a substitute for current practice or contributes to changes and improvements in teaching and learning processes. This introduces the discussion presented in the next section.

Efficacy of ICT use: impact on learning performance

In our studies we did not take into account the complex interplay between ICT use and student outcomes. There is, however, a great desire among policymakers to examine the concrete impact of ICT on student learning. As argued in the introduction, we think that it is rather critical to study first how ICT is being used and to examine the characteristics that are associated with the use of ICT in the classroom. Therefore, we studied ICT integration from a school-improvement point of view. School improvement is mainly concerned with the quality of change, with less immediate attention being paid to the consequences at the level of pupil outcomes. In contrast, the school-effectiveness approach reflects an outcome focus looking at the impact on student achievement and characteristics correlated with achievement (Creemers, 2002; Hulpia & Valcke, 2004; Reynolds, Teddlie, Hopkins, & Stringfield, 2000).

During the last decades, a large number of studies have systematically examined the impact of the educational use of ICT on student outcomes (e.g., Kulik, 1999; Schacter, 2001; Waxman & Connell, 2002). Although the overall results of these meta-analyses show a positive effect of teaching and learning with ICT, the knowledge base is not consistent. There are still many unanswered questions about the expected positive effect of ICT use. It is, for instance, unclear how to integrate and use ICT in an appropriate way. But despite the difficulties, such a study is important, as educational outcomes are considered to be an important stimulus for a teacher to implement computers in the teaching process. Notwithstanding, the effectiveness approach was beyond the scope of this study.

Model building

Our last critical issue is related to the final model presented and evaluated in this study framing the complex interplay of variables influencing ICT integration (Chapter 6). First, not all possible variables have been studied. We did for instance not center on variables at the level of the pupil. In this dissertation, decisions to incorporate particular variables in the research model were based on theoretical considerations and the results of the empirical studies. It is important to recognise that the present model is but a first projection of a theoretical explanation to describe this complex reality. In addition, the empirical evidence put forward supports the present model, but does actually not "proof" the model (Cf. Tuijnman & Keeves, 1994). The static nature of the data, gathered to develop the model, also pose difficulties to grasp the dynamic and evolving nature of ICT integration in education (ten Brummelhuis, 1995). Future research should therefore adopt an iterative approach in developing the model to explain ICT integration in education. As discussed above, ICT use is difficult to grasp as a static concept. The scales to measure types of computer use, for example, are based on data from the beginning of 2006. Rapid ICT developments mean that new computer applications can also be considered within the framework of our instruments. To further study ICT integration, these applications should be added on to the types of computer use.

Following the line of argumentation of Itzkan (1994), comparisons should also be made over time. This was not possible in the context of this study. It would be interesting, for instance, to verify whether the influencing factors in the final model reported in Chapter 6 change according to different stages of development. But this would also imply to keep some variables constant over time. Since the field of computer use is changing so rapidly, keeping variables constant over time could result in obtaining less valid results. According to Janssen Reinen (1996) it is difficult to solve this dilemma; the importance of longitudinal comparison on the one hand and doing justice to changes over time on the other hand should be closely and carefully considered.

The model, studied in this dissertation can also be criticized from an additional point of view. We already indicated that next to teacher and school related variables, we should also consider the level of the individual pupil. Even in doing the latter, we still neglect the macro-level that influences ICT-use and school policies. At the national level, educational authorities

heavily influence education; despite the importance of school autonomy. It would therefore be of interest to study how schools respond to e.g., new ICT standards that have recently been introduced by the Flemish government. How will these standards affect school policies and, in turn, ICT integration at classroom level? In the present study (Chapter 3), principals report that their personal impact on the current level of ICT integration is rather limited because of the fact that ICT was not yet included in the formal curriculum. To respond to this problem, the Flemish government has recently put forward ICT standards that determine what should be attained by the majority of pupils at the end of primary education and at the start of secondary education. A study about the impact of these standards would help clarify whether class use of ICT changes more rapidly when a school policy is firmly established and pushed by macro-level variables.

Practical implications

The research presented in this dissertation was not only helpful to develop a theoretical base and to provide stepping stones for future research. The results also offer insights that have clear implications for educational practice. In this section we discuss the most important practical implications mentioned throughout the different chapters, and that build on the following set of results: (a) the findings that teacher's educational beliefs play a key role, (b) the potential of an ICT school policy, (c) the focus on curriculum support and (d) the importance of monitoring ICT integration.

Addressing the importance of teachers' educational beliefs

Although it is not possible to identify single variables determining ICT integration, it can be inferred from the results that "teacher educational beliefs" is a crucial characteristic that also affects the success of this educational innovation. Our results stress the central role of teachers in the integration process. From a teacher's perspective, the role of ICT is primarily determined by how appropriate the use of computers fits their educational beliefs.

Considering this finding, how do we support teachers to integrate ICT in their classroom? It might be useful to design professional development approaches that at least take into account educational beliefs. How to facilitate and support this in a pre- or in-service training approach is less clear, especially for staff developers who are familiar with the development of technical ICT skills. Although some argue that the optimal use of ICT demands a new learning paradigm, we think that staff developers might consider introducing ICT to accomplish that which is already valued. According to Zhao and Cziko (2001), the further a new teaching practice is from the existing practice, the less likely it will be implemented successfully. Moreover, once a certain type of ICT use is integrated, the emphasis in its use can evolve to achieve additional aims, including those that are supported by broader or different educational beliefs (Ertmer, 2005).

The belief-action relationship must be seen as bi-directional: beliefs lead to actions, which, in turn, lead to new, reconstructed or reaffirmed beliefs (Haney, Lumpe, Czerniak, &

Egan, 2002). That means that teachers' practices and belief profiles are continually shaped by their ongoing teaching experience. It can be argued, then, that to include the use of computers, teachers must have models of how computers work in the classroom and must be supported to reflect on their own role in the learning process. Observing successful ICT use by colleagues and in practice might increase teachers' perceived awareness of or their need for change as well as to assure them that the required changes are feasible. This approach to the development of new ICT based educational practices is hardly found in the context of Flemish education. Nevertheless, there is no doubt that teachers must be personally convinced of the benefits of ICT and see the utility of using a particular application. This might explain why in-service approaches that build on good practices are appreciated and valued by teachers (Lam, 2000).

Towards an ICT school policy

In line with the implications mentioned above, it could be argued that if teachers feel pressured to change their educational beliefs in order to integrate ICT, they are likely to resist adopting it. This is where variables at the school level play a key role. It is in the workplace that the model should be situated, that opportunities for learning provided and that positive reinforcement and support should be offered. According to Antonietti and Giorgetti (2006), problems can arise if teachers, working within the same project, have different conceptions about the role of ICT. It is therefore recommended that school principals work closely together with the teachers to address their beliefs and concerns about ICT and provide an influential level of personal support and provide additional resources.

However, as derived from the interviews, teachers in the present study felt often overlooked during the development of the school's ICT policy. The results point at a clear lack of communication between principals and teachers. This reinforces the fact that policy decisions and change models currently do not (always) acknowledge the pivotal role of the teacher in effecting change. Olson (2000) suggests that a dialogue should be established between principals, teachers and other stakeholders. Moreover, engaging teachers in the development of an ICT policy plan gives them the opportunity to reflect on their particular educational use of ICT. It fosters the subjective meaning making process of individual teachers as to how and why they will respond to ICT use in class.

Findings from the interviews with principals (Chapter 3) also suggest that ICT school policies are often underutilised in the context of Flemish primary education. It is clear that ICT integration is not yet achieved in a systemic or systematic way in most of the schools. Very few schools can be labelled as 'learning organisations' with a shared commitment to ICT integration. To illustrate the latter, only a small number of schools reported to have developed an extensive ICT plan. But, as ICT continues to drive changes in society and in education, ICT school policies will also need to define their organisational vision and actions more clearly in view of planned change. In this respect, the literature about school improvement stresses the importance of leadership in developing a commitment to change. Their capacity to develop and articulate, in close collaboration with other actors from the

school community, a shared vision about ICT use and integration is considered a critical building block in this process. An important implication, therefore, is that also the training of principals should become a priority in developing ICT-related professional training. The study from Dawson and Rakes (2003) underpins the former: the more training principals receive, the more ICT integration at school level is observed. Their findings suggest that without well-trained, ICT-capable principals, the integration of ICT into school curricula will remain deficient.

Focus on curriculum support

When it comes to the incorporation of computers in educational practice (education rationale, see Chapter 1), more attention should be given to curriculum support. ICT coordinators in our study primarily provide schools with technical expertise, while their impact on educational or policy-related issues remains limited. As such, the need for technical support tends to take precedence over curriculum support. According to Lai and Pratt (2004), the main responsibility of ICT coordination is to guide ICT integration in teaching and learning (curriculum support). Principals in our study, however, indicate lack of time as an important obstacle for providing curriculum-related support. It would, therefore, be recommended to distinguish between "technical coordinators" providing schools and teachers with technical support and "educational coordinators" who focus primarily on educational support in view of integrating ICT into the curriculum.

In addition, the analysis of the theoretical model that helped to explain ICT use in education, stresses the adoption of a training programme that centres on a wider integration of ICT into the curriculum. The models show that ICT training is a significant predictor, but only in view of one type of computer use: "basic computer skills". Building on this result, professional development should stay at the centre of an ICT policy. However, next to the importance of technical skills development, the emphasis can switch to, as mentioned above, in-service approaches that build on good practices, appreciated and valued by teachers.

Another implication in relation to curriculum support is the impact of the pupil/pc-ratio. Although infrastructure is an important condition for ICT integration in general, our findings suggest that the availability of computers *within the classroom* is positively related to the use of computers as a learning tool; and this in contrast to computers in a computer lab. In this context, Salomon (1990) states that computer labs are less effective because the separation between computer and classroom reduces the straightforward integration of ICT use in learning activities. In-classroom provision seems to maximise usage potential, in contrast to computer labs where computer use depends on time-allocation mechanisms. This finding supports the idea that the specific positioning of computers in the school might foster or hinder ICT integration in learning activities.

Several studies have pointed at the critical importance of national ICT policies to promote the potential of ICT into learning processes. Tawalbeh (2001) for example, has argued that the highly centralised nature of the French and Jordanian educational system, in combination with a comprehensive ICT policy, has highly fostered the integrated use of ICT

in schools. However, the question is whether a top-down implementation process alone is desirable. An interesting issue in the context of this discussion is the balance between the extrinsic and intrinsic forces that drive the integrated use of ICT by teachers. Imposing policy decisions is often less responsive to teacher perspectives and often neglects workplace constraints. A way forward is stressing the responsibilities of local schools to develop a school-based ICT plan. In a best-case scenario, an ICT plan makes ICT competencies visible for all parties involved and stimulates the dialogue among school managers, teachers and parents about ICT use in the curriculum. In the context of this dialogue, the following questions can be explored: How can ICT be integrated and tested in classroom practice? What feedback can be derived from classroom practice? What type of feedback is considered critical from a classroom perspective?

Monitoring ICT integration

While the present studies stress the importance of support at school level, it is also crucial that the implementation of a complex innovation such as ICT-integration is not completely left to the school. The results of our studies also challenge educational authorities (macro level) in a number of ways: the dissemination of "good practices", awareness campaigns, providing in-service training, subsidising infrastructure, etc.

A final implication for educational authorities at macro-level is related to the importance of "monitoring" ICT integration in education. A transparent understanding of actual computer use can result in adequate management measures of policy developers to foster the integration of computers in the classroom. The results of a monitor such as those compromising our model (Chapter 6) could also encourage individual schools to reflect on the educational use of computers at school level. A better understanding of computer use stimulates the discussion about the adoption of specific computer-related school policies. Computer use will – as a result – become linked to teacher, classroom and school variables. Accurate, reliable and up-to-date information about the use of ICT at the different educational levels in Flanders is scarce and fragmented. The government in Flanders is aware of this problem and has therefore ordered a study to develop an adequate monitoring system (Ministry of the Flemish Community; Department of Education, 2007). This monitor will, hopefully, serve as an instrument to evaluate and elaborate local and national ICT policies.

To conclude

The research presented in this dissertation aimed at understanding how computers are being used by primary school teachers and how ICT use is influenced by and related to a number of teacher and school related variables. This research aim embodies the idea that ICT integration should be seen as a specific case in the wider field of school improvement. The school-improvement perspective and findings from each subsequent chapter resulted in the development of a model of ICT integration in primary education. The model adds to the holistic approach when explaining ICT integration in education because teachers are not

considered as completely independent, but sharing their school context. Although ICT integration still seems to depend for a large part on the willingness and attitudes of individual teachers, an important conclusion arising from our studies is that school-based policies have the potential to become a vehicle to promote ICT integration.

In this final chapter, we especially focused on the iterative construction of a model that describes and explains ICT integration in class. Although future research is needed to further develop this model, we nevertheless hope that the conclusions presented throughout this dissertation are already helpful for those actively involved in the difficult task of managing the complex process of ICT integration. It must be stressed over and over again that, even when teachers recognise ICT as a beneficial tool, the integration of computers in daily classroom practice remains a complex and long-term enterprise.

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Samenvatting (summary in Dutch)

Het hoofddoel van dit doctoraat is de ontwikkeling van een model voor de integratie van informatie- en communicatietechnologie (ICT) in het Vlaamse lager onderwijs. In het domein van educatief ICT-gebruik zoeken zowel praktijkmensen als onderzoekers naar de factoren die deze innovatie bevorderen of belemmeren. Dit proefschrift wil bijdragen aan deze zoektocht en richt zich meer specifiek op een verkenning van de samenhang tussen leerkrachtkenmerken, schoolkenmerken en ICT-integratie in de klaspraktijk. De studies die in de verschillende hoofdstukken beschreven worden, steunen voornamelijk op kwantitatief onderzoek waarin zowel leerkrachten, directies als ICT-coördinatoren betrokken worden.

In het eerste hoofdstuk worden de onderzoekscontext en de probleemstelling van dit proefschrift geïntroduceerd. We starten met een korte bespreking van de maatschappelijke veranderingen ten gevolge van de snelle technologische ontwikkelingen. Deze veranderingen hebben geleid tot de opkomst van de "informatie- of kennismaatschappij", een maatschappij waar kennis en creativiteit centraal staan en waarbij ICT niet meer weg te denken is. Ook het onderwijs staat voor de uitdaging om ICT te integreren in onderwijsleerprocessen. Volgens tal van onderwijsoverheden is het leerplichtonderwijs de plaats bij uitstek om ervoor te zorgen dat alle jongeren over de nodige ICT-competenties beschikken die van belang zijn in onze informatie- of kennismaatschappij. Naast sociaal-economische motieven kan ICT echter ook van belang zijn voor het onderwijs zelf. ICT kan enerzijds ingezet worden ter ondersteuning van bestaande onderwijsleerprocessen en anderzijds als katalysator voor nieuwe vormen van leren en instructie.

De vraag stelt zich dan ook in welke mate scholen en leerkrachten ICT integreren in hun onderwijspraktijk. Onderzoek wijst uit dat in de meeste scholen ICT slechts in beperkte mate ingeschakeld wordt binnen onderwijsleerprocessen. In het tweede deel van hoofdstuk 1 geven we een overzicht van het onderzoek dat op zoek gaat naar de mogelijke oorzaken hiervan. Vanuit de leemtes in bestaand onderzoek worden de algemene onderzoeksdoelen van dit proefschrift geformuleerd:

1. Het onderzoeken van op welke wijze ICT gebruikt wordt in de klaspraktijk.
2. Het identificeren van een breed spectrum leerkrachtkenmerken die ICT-integratie beïnvloeden.
3. Het exploreren van schoolkenmerken die van belang zijn bij de integratie van ICT in de klas.
4. Het ontwikkelen van een verklaringsmodel voor ICT-integratie waarin zowel individuele leerkrachtkenmerken als schoolkenmerken worden opgenomen.

Hoofdstuk 1 gaat vervolgens dieper in op het theoretisch kader van het proefschrift. Met dit onderzoek bestuderen we het vraagstuk van ICT-integratie als een uitdaging in termen van schoolontwikkeling. Het schoolontwikkelingsperspectief kan samengevat worden als een

praktijk- en beleidsgeoriënteerde benadering gericht op het vermogen van scholen om met vernieuwing om te gaan. Twee fundamentele vragen staan centraal binnen het schoolontwikkelingsperspectief: “Hoe ontwikkelen scholen zich?” en “Wat zijn belangrijke elementen van schoolontwikkelingsstrategieën?”.

Nadat de uitgangspunten van de schoolontwikkelingsbeweging geënt worden op condities die van belang zijn bij ICT-integratie, wordt het conceptueel raamwerk van het proefschrift voorgesteld. Doordat ICT-integratie in het onderwijs beïnvloed wordt door een groot potentieel aan factoren loopt het onderzoek het risico onoverzichtelijk te worden. Het conceptueel raamwerk van Veenstra geeft structuur aan deze exploratie door leerkracht- en schoolkenmerken te ordenen binnen een structuur van vijf concentrische cirkels, met name: (1) contextuele schoolkenmerken, (2) culturele schoolkenmerken, (3) structurele leerkrachtkenmerken, (4) culturele leerkrachtkenmerken, en (5) de afhankelijke variabele “ICT-gebruik in de klas”. Tenslotte worden de verschillende onderzoeksvragen die doorheen het proefschrift aan bod komen, opgesomd en gelinkt aan het conceptueel raamwerk.

Het tweede hoofdstuk focust op de invloed van leerkrachtkenmerken op het gebruik van ICT (onderzoeksdoel 2). Daarbij worden twee types ICT-gebruik onderscheiden (onderzoeksdoel 1), enerzijds het gebruik van ICT in de klas (bv. het gebruik van de computer om vaardigheden in te oefenen, het gebruik van de computer als demonstratietool, enz.) en anderzijds het gebruik van ICT ter ondersteuning van het onderwijs (bv. het opstellen van een agenda op de computer, opzoeken van informatie op Internet om een les voor te bereiden, enz.). De resultaten van de padanalyses tonen aan dat beide types ICT-gebruik door verschillende leerkrachtkenmerken verklaard worden. Zo wordt ondersteunend computergebruik verklaard door oa. “algemene computerattitudes”, “computerervaring” en de “intensiteit van computergebruik”, terwijl het gebruik van computers in de klas verklaard wordt door oa. “opvattingen over computers in het onderwijs”, “technologische innovativiteit” en “gender”.

Door de data van de leerkrachtenbevraging (hoofdstuk 2) te koppelen aan data van interviews met directies uit dezelfde scholen, kon de impact van schoolkenmerken op ICT-gebruik in de klas bestudeerd worden (onderzoeksdoel 3). In het derde hoofdstuk ligt de klemtoon meer specifiek op de rol van het ICT-beleid van de school. Uit de resultaten van de multilevelanalyses blijkt dat het ICT-beleid van een school alleen een invloed heeft op het gebruik van ICT in de klas via de percepties van leerkrachten. Zo heeft de aanwezigheid van een ICT-plan op zich geen impact op het ICT-gebruik, maar wel het feit of leerkrachten al dan niet op de hoogte zijn van de inhoud ervan. Dezelfde redenering kan gevolgd worden voor ICT-gerelateerde ondersteuning en ICT-nascholing. Niettemin wijzen de resultaten van de interviews uit dat het schoolbeleid het potentieel aan beleidsinstrumenten vaak onbenut laat.

Het doel van de studie in hoofdstuk 4 bestaat uit de validering van nieuwe schalen die leiden tot een fijnere maat voor ICT-gebruik in de klas (onderzoeksdoel 1). Op die manier kunnen we een beter zicht krijgen op de wijze waarop ICT wordt ingeschakeld in de klas.

Factoranalytisch worden drie types ICT-gebruik onderscheiden: (1) het gebruik van de computer om technische vaardigheden aan te leren (bv. leren werken met de muis en het toetsenbord), (2) het gebruik van de computer als "informatietool" (bv. opzoeken en selecteren van informatie op de computer), en (3) het gebruik van de computer als "oefentool" (bv. leerstof inoefenen). Deze typologie stelt ons in staat om ICT-gebruik op een multidimensionele manier te bestuderen.

Hoofdstuk 5 onderzoekt de relatie tussen de types ICT-gebruik (hoofdstuk 4) en de opvattingen van leerkrachten over "goed onderwijs" (onderzoeksdoel 2). Deze opvattingen over "goed onderwijs" bevatten twee dimensies: traditionalistische en constructivistische opvattingen. Op basis van de scores op deze twee dimensies worden via clusteranalyse vier leerkrachtprofielen onderscheiden. Uit de resultaten blijkt dat een leerkrachtprofiel met zowel een hoge mate van traditionalisme als constructivisme resulteert in meer ICT-gebruik in de klas. De resultaten tonen eveneens aan dat specifieke profielen gerelateerd zijn aan specifieke types ICT-gebruik. Dit bevestigt de noodzaak om ICT-integratie op een multidimensionele manier te bestuderen.

Hoofdstuk 6 leidt, op basis van de bevindingen uit de vorige hoofdstukken, tot een model voor de verklaring van verschillende types ICT-integratie in de klas (hoofdstuk 4). De leerkracht- en schoolkenmerken worden geordend binnen de concentrische cirkels volgens het conceptueel raamwerk van Veenstra dat eerder werd beschreven. Centraal bevinden zich de drie types ICT-gebruik in de klas (zie hoofdstuk 3), de afhankelijke variabelen binnen deze studie. Via multilevelanalyses kan de invloed van zowel leerkracht- als schoolvariabelen op deze types ICT-gebruik bestudeerd worden. De resultaten wijzen op het belang om naast leerkrachtkenmerken ook schoolkenmerken op te nemen in een model voor ICT-integratie in het onderwijs. Verder tonen de resultaten aan dat de verschillende types ICT-gebruik worden beïnvloed door specifieke leerkracht- en schoolkenmerken. Dit ligt in het verlengde van de resultaten uit hoofdstuk 5. Zo wijzen de resultaten op een significant gendereffect met betrekking tot het gebruik van de computer als informatietool. Mannelijke leerkrachten zullen deze toepassing meer integreren in hun onderwijspraktijk in vergelijking met hun vrouwelijke collega's. Voor de ander types ICT-gebuik treffen we geen gendereffect aan. Dit bevestigt de noodzaak om ICT-gebruik op een multidimensionele manier te bestuderen.

Hoofdstuk 7 bestaat uit een algemene discussie en conclusie waarin de resultaten die doorheen de vorige hoofdstukken werden gepresenteerd met elkaar in verband gebracht worden. Algemeen kunnen we besluiten dat de integratie van ICT in het lager onderwijs een complexe aangelegenheid is waarbij verschillende culturele en structurele kenmerken met elkaar in verband gebracht moeten worden. De klemtoon mag daarbij niet enkel op ICT-gerelateerde kenmerken liggen. Zo blijkt uit hoofdstuk 5 en 6 dat opvattingen van leerkrachten over "goed onderwijs" een belangrijke impact hebben met betrekking tot ICT-integratie. Daarbij moet, zoals reeds gezegd, een onderscheid gemaakt worden in het type ICT-gebruik. ICT-gebruik omvat immers een breed spectrum aan mogelijke toepassingen.

Ook het belang van het schoolontwikkelingsperspectief komt in hoofdstuk 7 uitgebreid aan bod.

Verder worden de beperkingen van de studies besproken en worden suggesties voor verder onderzoek geformuleerd. De beperkingen en suggesties zijn gerelateerd aan de generaliseerbaarheid van de resultaten, de methodologische keuzes, de operationalisering van ICT-gebruik en de primaire focus van het onderzoek. Met betrekking tot dat laatste kan vervolgonderzoek verder ingaan op de innovatieve kracht van ICT en de effecten van ICT op het leerrendement.

Tenslotte worden op basis van de resultaten een aantal praktische implicaties vermeld voor een verdere integratie van ICT in het onderwijs:

1. Gegeven het belang van een gemeenschappelijk ICT-schoolbeleid, zou meer werk kunnen gemaakt worden van het potentieel aan beleidsmaatregelen, zoals de ontwikkeling van een ICT-leerlijn, de adequate inzet van hard- en software, het voorzien van de nodige ondersteuning, enzovoort.
2. Bij de ontwikkeling van een visie over de integratie van ICT binnen onderwijsleerprocessen is het van belang om te vertrekken vanuit een visie over "goed onderwijs". In een volgende stap kan nagegaan worden hoe ICT kan bijdragen tot de realisatie van deze visie. ICT kan immers op verschillende manieren helpen onderwijsleerprocessen mee vorm te geven.
3. Zowel huidige als toekomstige leerkrachten moeten naast technische ondersteuning ook voldoende ondersteund worden op didactisch vlak. De resultaten wijzen uit dat vooral dat laatste nog meer aandacht verdient. Het volstaat immers niet om ICT-vaardig te zijn om ICT ook op een doeltreffende manier te gebruiken in de onderwijspraktijk.
4. Het monitoren van ICT-integratie is van groot belang; een beter begrip van ICT-integratie kan resulteren in gepaste beleidsmaatregelen ter ondersteuning van een verdere integratie van ICT in ons onderwijs.

We besluiten het proefschrift door terug te koppelen naar het doel ervan: de ontwikkeling van een model voor ICT-integratie in het onderwijs. Met het model, zoals voorgesteld in hoofdstuk 6, krijgen we meer inzicht in de manier waarop leerkracht- en schoolkenmerken zich verhouden tot verschillende types ICT-gebruik. Het laatste hoofdstuk benadrukt de iteratieve constructie van dit model en wijst op het belang om het model in toekomstig onderzoek verder te ontwikkelen. Toch hopen we dat de bevindingen van dit proefschrift nu reeds van belang kunnen zijn voor iedereen die betrokken is in de complexe taak van ICT-integratie in het onderwijs.