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Identification and assessment of digital competences in primary education

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Voorwoord

Het doel van dit proefschrift is het uitbreiden van de bestaande kennis over het meten van ICT-competenties van leerlingen alsook over de factoren die gerelateerd zijn aan verschillen in ICT-competenties. Net als het onmogelijk is een allesomvattend overzicht te bieden van alle factoren die samenhangen met ICT-competenties van leerlingen, is het onmogelijk alle personen te bedanken die op één of andere manier een invloed hebben gehad op de uitwerking van dit proefschrift. Deze dissertatie is ontstaan in interactie met, en via de hulp en steun van heel wat collega's, beleidsmakers, actoren uit de onderwijspraktijk, en vrienden en familie. Een aantal van hen wens ik hier in het bijzonder te bedanken.

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Gent, januari 2015

Koen Aesaert

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General introduction

"All that is taught in college amounts to very little;
but if we can send students out self-reliant in their investigations,
we have accomplished very much".

- OTIS ROBINSON (1876) -

Parts of this chapter are based on:

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Chapter 1

General introduction

Abstract

This chapter serves as a general introduction and delineates the context in which the subsequent chapters of this dissertation are situated. The first section of this chapter presents the research context and the general theoretical background: ICT competences, measuring ICT competences, factors related to ICT competences, and ICT competences in Flemish education. The second section describes the research objectives. The general objective of this dissertation is to identify relationships that exist between differences in primary school pupils' ICT competences and differences in pupil, classroom and school level characteristics. Reaching this aim implied 1) developing a conceptual model that can be used to identify pupil, classroom and school level factors related to pupils' ICT competences; 2) constructing a standardized and performance-based assessment instrument that can be used to measure pupils' ICT competences in a direct and valid way; and 3) identifying important pupil, classroom and school level characteristics that are related to pupils' ICT competences. Furthermore, the second section also provides information on the design of the different studies and the outline of the dissertation, in which the content of the different chapters and their interrelatedness is presented. The third section of this introductory chapter provides information on the theoretical, empirical and practical relevance of this dissertation.

1. Research context

The past 30 years, technology and especially information and communication technologies are at the core of the educational, economic and social transformations that characterize our present knowledge society (Kozma, 2008; Mioduser, Nachmias, & Forkosh-Baruch, 2008) i.e. a society where ideas or knowledge function as commodities (Anderson, 2008). Technologies of digitization, computation and information processing and transmission through digital communication networks, have intensively changed the meaning of social relationships and how work and job related activities are conducted (Behrens, Mislevy, DiCerbo, & Levy, 2012). As the relevance of certain competences is determined by the social, economical, intellectual and physical context in which we behave, these changes ask for the identification and acquisition of competences individuals need for active and successful participation in the knowledge society (Ananiadou & Claro, 2009; Voogt & Pareja Roblin, 2012). In the literature, these competences are known as 21st century skills. In general, 21st century skills can be characterized as transversal (i.e. they are not restricted to a specific subject or field but apply to many fields) and multidimensional (i.e. they refer to units of knowledge, skills and attitudes). Moreover, they do not refer to basic skills or fact knowledge, but rather to higher-order skills that are needed to deal with complex problems and unpredictable situations (Markauskaite, 2006; Voogt & Pareja Roblin, 2012). General themes that reappear in frameworks on 21st century skills refer to abilities in collaboration, communication, critical-thinking, problem-solving, creativity, citizenship, and also ICT literacy or ICT competence (ISTE, 2007; NCREL, 2003; P21, 2011). Similarly, the European Commission (2007) sets out ICT competence as one of eight key competences for lifelong learning, and defines it as "*the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet*" (p. 7). Although it is acknowledged that the acquisition of ICT competences is important for pupils, large scale research conducted in the area of ICT competences is limited (van Deursen and van Dijk, 2011). Moreover, most studies are targeted at university and college students rather than pupils of primary and secondary education (Meelissen, 2008).

In general, research in the field of ICT competences – often operationalized as specific computer or Internet skills - can be divided into three main groups: 1) a group of researchers that aims to conceptualize what comprise ICT competences that pupils need in their everyday life; 2) a group of researchers that focuses on the assessment of ICT competences itself and tries to capture a pupil's level of ICT competence; and 3) a group of researchers that tries to link the measured level of ICT competence to other factors such as gender or socioeconomic status (Litt, 2013).

The first research community is occupied with defining and describing the concept of ICT competences, and also with the operationalization of the construct in ICT competence frameworks. In this research literature, a diversity of terms has been used to describe ICT related capacities such as ICT literacy (ETS, 2002), digital literacy (Søby, 2003), IT fluency (NRC, 1999), digital competence (European Commission, 2007) , digital age skills (ISTE, 2007), etcetera. Although these terms have specific and (sometimes slightly) different meanings, they are interchangeably used in different contexts (Markauskaite, 2006). In this dissertation, the term ICT competence is used. Below, we briefly present the conceptualization of ICT competence as it should be understood in this dissertation.

The second group of studies focuses on the measurement of the construct of ICT competence. As such, these studies try to identify pupils' proficiency in using computers and the Internet for specific purposes. In these studies, different assessment methods are used to measure levels of ICT competences, such as surveys that refer to self-perceived measures of ICT competence or ICT self-efficacy (Compeau & Higgins, 1995; Torkzadeh & Van Dyke, 2002; Tsai & Tsai, 2010). Other researchers try to measure ICT competences in a more direct way and use methods of observation (Hargittai, 2002; Hargittai, 2005) or performance-based assessment (Claro et al., 2012; van Deursen & van Diepen, 2013). In studies on the measurement of ICT competences, the research interest is mainly directed towards self-perceived measures of ICT competences and ICT self-efficacy (Hargittai, 2005; van Deursen & van Dijk, 2011). Although these self-reported measures are often used, they suffer from validity problems of self-reported bias (Merritt, Smith, & Di Renzo, 2005). Below, some of the assessment methods that are used to measure pupils' ICT competences are presented and discussed.

The third research group in the field of ICT competences aims at identifying factors that are related to differences in the level of pupils' ICT competences, such as pupils' ICT experience (Tsai & Tsai, 2010), gender (Bunz, Curry, & Voon, 2007; Li & Kirkup, 2007) and socioeconomic status (Claro et al., 2012; Vekiri, 2010). Most of this research is directed towards factors that can be situated at the pupil level and does not take into account the educational context in which these pupil level factors are embedded, i.e. classroom and school level factors. However, educational effectiveness research clearly indicates that educational outcomes - such as ICT competences – are often explained by the combined effects of factors at the pupil, classroom and school level (Creemers & Kyriakides, 2008). Below, we describe the most frequently investigated factors that seem to be related to pupils' ICT competences.

1.1. ICT competences

In a study on the design of an integrated analytic framework of ICT literacy, Markauskaite (2006) states that many different terms are interchangeably used to describe various sets of ICT related capabilities. This different terminology includes terms such as digital literacy (Søby, 2003), ICT literacy (ETS, 2002), Internet skills (van Deursen & van Diepen, 2013), digital competence (European Commission, 2007; Søby, 2003), computer mediated communication competence (Spitzberg, 2006), computer and Web fluency (Bunz et al., 2007), ICT proficiency (ETS, 2003) etcetera. In this dissertation, the term ICT competence is deliberately used for two reasons. First, the term ICT competence best fits this dissertation's intention of investigating ICT related capabilities that go beyond basic and technical ICT skills, i.e. those that require more profound and higher-order thinking processes. In this context, Westera (2001) states that a competence refers to a higher-order skill or behavior employed in complex situations. A competence includes knowledge, skills, attitudes, strategic thinking and metacognition. Second, the term ICT competence is preferred over terms such as digital or ICT literacy, as the ICT related capabilities under investigation are perceived as separated competences that are measurable. ICT literacy is perceived as more than a set of ICT competences. It is seen as a life skill - just like numeracy or literacy – and not a threshold that guarantees familiarity with ICT once acquired. ICT literacy depends on the needs of the situation, and may change as the needs of the situation change. In order to be ICT literate, one must be able to deploy ICT competences that are required in that specific situation (Martin, 2006). In a nutshell, this means that ICT literate people can deploy ICT competences in authentic life situations, and that the content of these ICT competences is subject to change, as it depends on the situation itself and on the rapidly evolving technology.

Although the standardization of ICT competences into educational ICT curricula, ICT frameworks and ICT attainment targets is only a recent phenomenon, the need for schools and education systems as a whole to deliver ICT competent pupils has existed for more than half a century. Since the 1960s, the specific types of ICT competences schools focus on have gone through a three-phase evolution, i.e. a mastery stage (1960s to the mid-1980s), an application stage (mid-1980s to the late 1990s) and a reflection stage (late 1990s until present) (Martin, 2006). In the *mastery phase*, ICT competence was perceived as simple computer science i.e. knowledge of how the computer works, skills in how to master it, and rudiments of computer programming (Martin, 2006). The teaching and learning of ICT related capabilities focused on developing a fundamental understanding of the components of the machine, of its history, of the basic application, and on acquiring hands-on skill in programming language (Tannenbaum & Rahn, 1984). This means that in the mastery phase, the development of ICT competent pupils was limited to learning about information technology and basic ICT skills rather than learning with or through computers (Carleer, 1984; Voogt, 2008).

At the end of the 1980s, the focus shifted from learning to use ICT to using ICT to learn. Several authors such as Collis (1988) recognized the potential of ICT for learning and teaching. Moreover, software applications and operating systems became more user friendly, easier to use, more powerful and as such, products of mass usage at that time. Parallel to these two evolutions, ICT competences shifted into a more *application* oriented *phase* (till the late 1990s). Rather than on technical operating skills and specialist knowledge, ICT competences referred to practical basic skills to apply common software in education, work and leisure (Martin, 2006). The skills incorporated in both the mastery and application stage have a technical-procedural dimension. In the third and at present dominant *reflective* phase, the mastery of these technical-procedural skills is considered as insufficient to cope with the changes and challenges of the information society (Anderson, 2008; ETS, 2002; Voogt, 2008) i.e. the acquisition of technical-application oriented skills is not enough to develop proficient ICT competences. In the context of the reflective stage, ICT competences do not refer to basic skills and use of ICT applications, but rather to a more evaluative and critical use of computers and the Internet. For instance, retrieving data from the Internet not only requires knowledge of search engines, but also the ability to distinguish relevant from irrelevant data (Eshet, 2002).

In this context, several educational frameworks on 21st century skills have incorporated ICT competences as important skills for lifelong learning. Rather than mastering basic ICT skills, ICT competences are concerned with problem solving, information processing, critical thinking, and creative and innovative ICT use (European Commission, 2007). For example, ISTE's National Educational Technology Standards for Students are organized into the following six categories: 1) Creativity and Innovation; 2) Communication and Collaboration; 3) Research and Information Fluency; 4) Critical Thinking, Problem Solving, and Decision Making; 5) Digital Citizenship; and 6) Technology Operations and Concepts (ISTE, 2007). Although the reflective phase puts focus on ICT competences as higher-order learning-process competences, the technical and application ICT skills are still considered as important. The skills of the mastery and application phase are subordinate to the reflective phase (Martin, 2006) i.e. the technical and application ICT skills are instrumental to the higher-order ICT competences. In their operationalization of Internet competences (a subdomain of ICT competences), van Deursen and van Dijk (2011) stress this hierarchical structure of ICT competences. These authors make a distinction between two types of higher-order ICT competences (i.e. information Internet competences and strategic Internet competences) and two types of medium related types of ICT skills (i.e. operational or navigation Internet skills, and formal or orientation Internet skills). They stress that the content related ICT competences depend on the medium related ICT skills. This means that one needs to master the basic technical and application skills in order to even come to performing the higher-order ICT competences. Similarly, Markauskaite (2007) refers to an ICT competence as the interactive use of 1) general cognitive capabilities, and 2) technical capabilities in order to successfully complete cognitive information and ICT-based tasks.

In this dissertation, ICT competences can be situated within the context of the reflective phase. As such, an ICT competence is perceived as a multilayered and complex construct. An ICT competence refers to a higher-order learning-process oriented competence that is used in complex, authentic and unpredictable situations, and is underpinned by technical and application ICT knowledge and skills. The construct of ICT competence covers a wide range of competences, such as locating digital information, being creative with computers, actively producing digital media, etcetera (Ito et al., 2008). Within the context and timeframe of this dissertation it is impossible to measure the total construct of ICT competence in a valid way. As such, retrieving, processing and saving appropriate digital information and communicating in a safe, sensible and appropriate way using ICT, were selected as the two ICT competences under investigation. In Chapter 4, we elaborate on the selection of both these ICT competences.

1.2. Measuring ICT competences

In general, research on the assessment of ICT competences can be divided into studies using indirect measures and studies using more direct measures to assess pupils' proficiency in successfully completing computer and Internet based tasks. In the case of indirect assessment, the measurement of a pupil's ICT competence level is based on the analysis of the pupil's own judgment of his ICT competences or ability to successfully complete ICT related tasks (Nitko & Brookhart, 2007). In this context, several survey instruments of self-reported ICT competences and ICT self-efficacy have been developed in recent years (Livingstone & Helsper, 2010; Meelissen , 2008). In general, these instruments comprise the two big domains of ICT competences i.e. computer related and/or Internet related competences. Whereas some instruments are used to measure ICT competences in general, others have a more specific approach and measure specific aspects of ICT competences. For example, Compeau and Higgins (1995) developed the general computer self-efficacy scale, which is used to measure *"an individual's perception of his or her ability to use a computer in the accomplishment of a job task"* (p.193). Liang and Tsai (2008) developed two instruments to measure certain aspects of pupils' Internet related ICT competences and pupils' Internet related ICT competences in general, i.e. the Communicative Internet Self-Efficacy scale (CISE) and the General Internet Self-Efficacy scale (GISE). The Computer-Email-Web fluency scale of Bunz (2004) measures pupils' self-perceived ability in general computer use, e-mail use, Web navigation and Web editing. The Internet Self-Efficacy Scale of Tsai and Tsai (2010) was developed to measure one's self-perceived ability in the dimensions of navigating and searching for information on the internet (online exploration), and communicating via the internet (online communication).

A big advantage of indirect (survey) measures of ICT competence and ICT self-efficacy is that they are easy to deploy on large samples and are not resource-consuming (Litt, 2013). However, as these indirect measures suffer from validity problems of self-reported bias, they are less appropriate for measuring pupils' actual ICT competences (Hakkarainen et al., 2000; van Deursen & van Dijk, 2011). As pupils can over- or underestimate their own ICT competences, the results of self-reported, indirect measures may not always be an accurate representation of their actual performance level. For example, Ballantine, McCourt Larres and Oyelere (2007) found that pupils significantly tend to overestimate their computer competences. Similarly, results of Bradlow, Hoch and Hutchinson (2002) indicate an overestimation in knowledge of the Internet and an underestimation in computer terminology and data management. This validity problem of self-reported bias is reinforced by the fact that most studies on the assessment of ICT competences are directed towards these indirect measures of ICT self-efficacy and self-reported abilities (Meelissen, 2008).

Direct assessment of pupils' ICT competences is considered as a way to tackle these shortcomings of self-reported, indirect measurements. In the case of direct assessment, the measurement of a pupil's ICT competence level is based on the analysis of directly performed and observed actions (Nitko & Brookhart, 2007). Direct measures are less widespread than indirect measures and involve performance-based and observation measurement techniques, which imply pupils performing hands-on actions on a computer (Litt, 2013). For example, van Deursen and van Dijk (2011) developed a performance-based test to measure adolescents' ability in operational internet skill, formal internet skill, information internet skill and strategic internet skill. All tasks of this test were closed-ended and fact-based, and participants' ability level for each type of internet skills was determined by the number of tasks solved successfully and the time spent on these tasks. Being a pioneer in direct assessment of ICT competences, Hargittai (2002) used observations and thinking-aloud protocol to assess adults' proficiency in finding certain information online. Although there are only few, these direct measures have high validity and provide robust accounts of human behavior, in this case pupils' actual ICT competences (Litt, 2013). In this context, Messick (1994) states that performance-based tasks are valuable because they guarantee direct and authentic appraisals of complex competences. According to Wirth (2008) real tasks or simulation-based tasks that come close to reality, are more authentic and therefore more valid than conventional item designs such as survey measures based on a multiple choice design.

However, besides the advantage of being more valid, these direct measures suffer from practical disadvantages such as being time consuming, expensive, more difficult to replicate and more difficult to conduct on large samples. Moreover, most of the studies that use direct measures address post-primary education. In this dissertation, we try to tackle some of these shortcomings of ICT competence measurement, by developing a standardized performance-based ICT competence test that can be deployed in large scale samples of primary school pupils.

1.3. Factors related to ICT competences

In general, research exploring factors related to ICT competences can be divided into studies investigating how ICT competences affect other factors and studies focusing on factors that might influence pupils' ICT competences. This dissertation can be situated in the latter category as it investigates which factors are related to differences in primary school pupils' ICT competences, i.e. ICT competences are considered as outcome and dependent variable.

In the context of research directed towards ICT competences as outcome or dependent variable, differences in ICT competences are mostly studied from the perspective of gender, age, socioeconomic status and ICT experience and use (Litt, 2013; Meelissen, 2008; Volman, van Eck, Heemskerk, & Kuiper, 2005). Although other factors have also been investigated, e.g. ICT attitudes (Pamuk & Peker, 2009), we limit ourselves in this introductory chapter to a description of the four most intensively studied factors as mentioned above. With regard to gender, research reports inconsistent results. Whereas some studies have identified a positive association between gender and ICT competences in favor of boys (Kuhlemeier & Hemker, 2007; Li & Kirkup, 2007), other studies did not find any significant relationship at all (Durndell & Haag, 2007; Pamuk & Peker, 2009). However, what has become clear is that more nuanced measures that focus on specific types of ICT competences lead to more detailed results than general measures. For example, the results of Bunz et al. (2007) indicate that girls rate themselves higher at communication and online relation competences, whereas gender is positively associated with technical ICT abilities in favor of boys. Jones, Ramanau, Cross and Healing (2010) found a significant relationship between gender and certain ICT activities such as using spreadsheets, graphics, audio/video, computer maintenance and security, in favor of boys. However, this relationship was not found for other ICT activities such as writing and commenting on blogs and wikis and using online library resources.

Similar to gender, consistent findings with regard to how age is related to ICT competences are lacking. For example, Hargittai and Schafer (2006) found that younger adults outperform older adults at finding content online. Similarly, the results of McCoy (2010) indicate that adults of college age (18-25 years old) have higher levels of technology proficiency than other adults. Liang and Tsai (2008) found that older college students reported lower communicative Internet competence than their younger colleagues. The results of Loos and Mante Meijer (2012) indicate that older people are less competent in online navigation than their younger counterparts, but that these generational differences become smaller when the older users have more online experience. Although these studies illustrate a negative relationship between age and ICT competence, some studies conducted with only adolescents and younger adults provide opposite results. For example, the results of Appel (2012) show that older secondary-school students have better theoretical and practical computer knowledge than their younger secondary-school colleagues. Van Deursen and van Dijk (2011) elaborated on these results by investigating the relationship between age and different types of Internet competences. Their results indicate that younger adults have better developed technical ICT skills (i.e. formal and operational Internet skills) than older adults, but that there are no significant differences between younger and older adults with regard to more complex higher-order ICT competences (i.e. information and strategic Internet competences). However, other studies did not provide any evidence for a positive or negative relationship between age and ICT competences. For example, Hargittai and Hinnant (2008) did not find a significant association between young adults' age and their knowledge of Internet-related terms.

Most research that has investigated the relationship between socioeconomic status (SES) and ICT reports a positive relationship between both factors. Results of Claro et al. (2012) show that the higher the economic goods at secondary students' home, the higher they score at an ICT competence test measuring their ability in locating and processing digital information, effective communicating, and interacting and collaborating in virtual environments. Measuring SES in terms of highest educational level, Hargittai and Hinnant (2008) found that students with a college degree know significantly more about the Internet than students having a lower educational level. Vekiri (2010) found that primary school pupils with parents having a lower rated education and occupation, report lower levels of ICT self-efficacy. Further, it seems that pupils from an ethnic-minority background consider themselves to have less developed ICT competences with regard to word-processing, Internet, illustrations, e-mail, presentation software, Windows and bookmarking favorites (Volman et al., 2005). Although the studies above indicate a positive relationship between SES and ICT competences, some studies provide evidence that this relationship is too weak to conclude that lower SES contributes to lower levels of ICT competences (van Braak & Kavadias, 2005; Tondeur, Sinnaeve, Van Houtte, & van Braak, 2011).

Finally, numerous studies have explored the relationship between ICT competences on the one hand, and ICT experience and ICT use on the other. ICT experience often refers to how long a person has been using a computer or the Internet in general, or to the frequency of daily/weekly time spent using a computer or the Internet (Tsai & Tsai, 2010; van Deursen & van Dijk, 2011). ICT use is a less general measure than ICT experience, as it refers to the time that a person spends on using specific types of computer and online applications. In both cases of ICT experience and ICT use, studies have found a positive relationship with pupils' ICT competences (Claro et al., 2012; Fagan, Neill, & Wooldridge, 2003; Liang & Tsai, 2008; Livingstone & Helsper, 2007). For example, the results of Kuhlemeier and Hemker (2007) indicate that 13 to 15 year-old pupils' level of Internet competences is related to the extent to which they chat online, use e-mail and word-processing software, but not by the extent to which they use computers for games and music. Hargittai and Hinnant (2008) found that young adults who have been computer and Internet users for fewer years and who go online less than once daily, have lower levels of Internet knowledge. Although the results above seem conclusive, not all studies provide evidence for a significant relationship between ICT competence and ICT use/ICT experience (Ballantine et al., 2007; Sam, Othman, & Nordin, 2005).

It should be stressed that the studies mentioned above, all made a significant contribution to the knowledge base on factors affecting pupils' ICT competences. However, most of these studies are conducted from a single-level perspective and do not take into account the complexity of the context in which pupils behave and interact (i.e. pupils nested in classrooms, which are in turn nested in schools). Although educational effectiveness research has repeatedly shown that pupils' educational outcomes are multilevel in nature (Creemers & Kyriakides, 2008), almost no studies exist in which differences in pupils' ICT competences are attributed to factors at different levels such as the pupil, classroom and school level. Moreover, most of these studies have focused on the traditionally used pupil level factors such as gender, SES and ICT use (Claro et al., 2012). Zhong's study (2011) can be considered as an exception in the research field as the author investigated whether the ICT penetration rate of a country and its educational expenditure (context level), the school type and ICT access at school (school level), and the gender, socioeconomic status, ICT experience and ICT access at home of a pupil (pupil level) were associated with secondary school students self-reported digital competences. Furthermore, it seems remarkable that all of these studies were conducted in secondary and higher education, or with adults. In this dissertation, we try to tackle some of these shortcomings by developing and validating a multilevel model that identifies pupil, classroom and school level factors that are related to primary school pupils' ICT competences.

1.4. ICT competences in Flemish education

This last section of the research context presents the Flemish context in which this dissertation is embedded. ICT competences were already described as abilities to be mastered in order to cope with the social, economic and educational challenges of our contemporary society. As ICT competences are essential for successful participation in this knowledge society (Anderson, 2008), and as they are considered as learned abilities that can be developed and enhanced through education (Litt, 2013), national and international educational policy makers are increasingly paying attention to ICT competences. In the past ten years, this attention for ICT competences in educational policies resulted in a booming establishment of several ICT competence frameworks (European Commission, 2007; ISTE, 2007). In this context, some national governments have introduced ICT competences into their national curriculum, i.e. national governments are administering a formal and compulsory ICT curriculum to their schools (Vanderlinde, van Braak & Hermans, 2009). These ICT curricula distinguish themselves from traditional curricula in terms of addressing the development of ICT related knowledge, skills, attitudes and competences that are needed in the information society (Aesaert, Vanderlinde, Tondeur, & van Braak, 2013). ICT curricula can be considered as a blueprint for developing ICT competences through the use of ICT at school and in the classroom, i.e. they are the official teaching and learning experiences administered by national governments in order to design learning environments in which pupils can acquire and develop ICT competences. The introduction of an official ICT curriculum has two major consequences with regard to educational ICT use. First, a compulsory character is added to the educational ICT use of teachers. As a consequence, the teaching of ICT competences no longer depend on the willingness and interest of the individual teacher. All schools and teachers have the responsibility of providing all children with equal opportunities to develop ICT competences (Vanderlinde et al., 2009). Second and more important in the context of this dissertation, the introduction of an official ICT curriculum formalizes the status of ICT competences as educational outcomes in their own right. In this regard, Thomas and Knezek (2008) state that ICT competence standards and attainment targets define the achievement expectations for students, and as a consequence ICT competences are considered as educational outcomes.

In September 2007, the Flemish government administered an official ICT curriculum to its primary schools, operationalized as eight cross-curricular attainment targets. The cross-curricular character of the attainment targets stresses the orientation of the ICT curriculum on transfer, i.e., instead of referring to a specific subject content, the attainment targets can be developed and learned across different subjects. The eight attainment targets are perceived as minimum final objectives. They refer to the ICT competences the government considers necessary and feasible for all pupils to master by the end of primary education (Vandenbroucke, 2007; Vanderlinde et al., 2009). The eight ICT competences of the Flemish ICT curriculum for primary education are presented in Table 1. The ICT competences of the Flemish ICT curriculum focus on learning process oriented competences such as searching and processing information, communicating using ICT, being creative with ICT, etcetera (De Craemer, 2008). Technical and application oriented ICT skills are considered as necessary but instrumental to the learning process oriented competences. This means that pupils need the learning process oriented ICT competences as well as their underlying technical and application oriented ICT skills in order to solve computer related tasks and problems. Although they are considered as important, the technical and application oriented ICT skills are not integrated as separated attainment targets in the Flemish ICT curriculum. Considering this instrumental perception of ICT competences, the attainment targets of the Flemish ICT curriculum can be situated in the integrated and hierarchical view on ICT competences, used in this dissertation.

1	Pupils have a positive attitude towards educational technology, and are willing to use educational technology to support their own learning process.
2	Pupils use educational technology in a safe, responsible and effective way.
3	Pupils can work independently in a learning environment enriched by educational technology.
4	Pupils can learn independently in a learning environment enriched by educational technology.
5	Pupils can use educational technology to elaborate their ideas in a creative way.
6	Pupils can use educational technology to search for, process and store digital information that is appropriate for them.
7	Pupils can use educational technology to present information to others.
8	Pupils can use educational technology to communicate in a safe, responsible and effective way.

Table 1. The eight attainment targets of the Flemish ICT curriculum for primary education

The establishment of the Flemish ICT curriculum formalized the status of ICT competences as official educational outcomes. Consequently, all Flemish schools and teachers have the responsibility of creating learning environments in which pupils can acquire and develop the eight attainment targets of the Flemish ICT curriculum. However, little is known about the degree to which pupils benefit from the establishment of the Flemish ICT curriculum in terms of ICT competence development, i.e., no information is available about primary school pupils' mastery of the Flemish ICT curriculum. In this context, valid ICT competence assessment tools can be considered as important instruments for studying ICT curriculum implementation, i.e. valid assessment tools are needed to investigate whether formal ICT attainment targets written down in official curriculum documents (intended curriculum) are actually mastered by pupils (attained curriculum) (see also van den Akker, Fasoglio, & Mulder, 2010). At this moment, no standardized instruments are available that can be used to explore the degree to which primary school pupils master the attainment targets of the Flemish ICT curriculum. In this dissertation, we tried to tackle this problem by developing and implementing a performance-based test that can be used to measure the degree to which primary school pupils master the attainment targets of the Flemish ICT curriculum.

2. Research design and overview of the dissertation

2.1. Research objectives

Building on the shortcomings that are stated earlier in the research context of this chapter, the main aim of this dissertation is to gain insight into primary school pupils' ICT competences. More specifically, the aim of this dissertation is to identify relationships that exist between differences in primary school pupils' ICT competences and differences in pupil, classroom and school level characteristics. This general aim is divided into three general research objectives that directed the different studies of this dissertation.

Research objective 1 (RO1): To develop a conceptual model that can be used to identify pupil level, classroom level and school level conditions that are related to primary school pupils' ICT competences.

Research objective 2 (RO2): To construct a standardized and performance-based assessment instrument that can be used to measure primary school pupils' ICT competences in a direct and valid way.

Research objective 3 (RO3): To identify important pupil, classroom and school level characteristics that are related to primary school pupils' ICT competences.

2.2. Design of the studies

In order to tackle the three research objectives, qualitative and quantitative methods were used. However, in this dissertation considerably more emphasis is laid on the quantitative component. The qualitative methods are restricted to document analyses in order to get a richer understanding of the educational policy context in which ICT competences are integrated as well as for the design of different instruments.

The results presented and discussed in this dissertation are based on six studies (see Table 2): one qualitative study (a document analysis), two studies in which a literature review was combined with a quantitative analysis, and three quantitative studies. The five quantitative studies are based on data collected with a performance-based test and/or a pupil, parent, teacher and ICT coordinator questionnaire. In total, the performance-based data and the questionnaire data were respectively gathered in 67 and 96 Flemish schools. The stratification variables for school selection were related to school size (small school<180 pupils; large school≥180 pupils), type of educational network and location (region). Table 2 presents an overview of the research goals, methodology, research design, data collection and analysis methods adapted in each study, and the research objectives (RO1, RO2, and RO3) being focused on.

Research objective 1 is tackled using a document analysis (study 1) and a study in which a literature review and survey study (pupil, parent, teacher survey) were combined (study 2). The primary research goal of the document analysis was to present the educational policy context in which the ICT competences of primary school pupils are embedded. For this purpose, a cross-case analysis of the content features of national ICT curricula was conducted. The constant comparative method was used for data analysis (Maso & Smaling, 1998; Merriam, 1998). The results of this study were used for the selection of ICT competences to be measured in the subsequent analyses of this dissertation. Study 2, in which a literature review and survey study were combined, had two research goals. The primary research goal of the literature review was to create an extensive and multilayered conceptual model in which pupil, classroom and school level characteristics that are possibly related to pupils' ICT competences were integrated. The main research goal of the survey part of study 2 included the development and validation of a set of reliable scales that can be used to measure the characteristics of the developed conceptual model. Data were collected from 2413 pupils in 96 schools, their parents (n=2267) and their teachers (n=134). Exploratory (EFA) and confirmatory (CFA) factor analyses were used to analyze the data. In order to check the stability of the EFA solutions, several replication analyses were conducted.

Research objective 2 is tackled with a study in which a literature review and the analysis of the results of a performance-based test are combined (study 3), as well as with a study that focuses on the psychometric characteristics of the same performance-based test (study 4). The main research goal of the literature review of study 3 was the development of a theoretical test framework that guided the further development of the performance-based test. The developed framework contains the different ICT competences that were assessed in this dissertation. The second aim of study 3 was to identify differences in pupils' ICT competences and how these relate to gender and socioeconomic status. For this purpose, different methods are used to analyze the answers of 378 pupils on a performance-based ICT competence test i.e. classic item analysis, chi-square tests, nonlinear EFA, ordinal reliability analysis, ANOVA. With regard to study 4, item response theory was used to investigate the item and test characteristics of the developed performance-based ICT competence test. As such, the major goals of study 4 are to examine the reliability and validity of the test, and to construct and validate an ICT competence scale that is based on direct measurement. The test was administered to 560 pupils finishing primary school.

Research objective 3 is tackled using two correlational design studies (study 5 and study 6). The main goals of study 5 were to explore pupils' general level of ICT competence and identify pupil, classroom and school level characteristics that are related to this level of ICT competence. Data were collected using the performance-based ICT competence test (*n*=378) and a pupil (*n*=378), parent (*n*=378), teacher (*n*=83) and ICT coordinator (*n*=56) questionnaire. Multilevel analysis was used for data-analysis (Snijders & Bosker, 2012). The major aim of study 6 was to examine how differences in primary school pupils' ICT self-efficacy are related to differences of certain pupil, classroom and school level characteristics. Questionnaires were used to collect data from the pupils (*n*=2421), their parents (*n*=2256), their teachers (*n*=141) and the ICT coordinator of their school (*n*=86). Multilevel modelling techniques were used to analyze the data.

Research objective	Research goals	Methodology	Research Design and data collection	Analysis methods	Output
RO1	- To present the educational policy context in which ICT competences are embedded. - To present content features (visions and rationales, ICT competences, instruction related aspects) of ICT curricula.	QL	Document analysis	Cross-case analysis using the constant comparative method	Chapter 2 (study 1)
RO1	- To develop a multilayered, extensive conceptual model that integrates pupil, classroom and school level factors that are likely related to primary school pupils' ICT competences. - To develop and validate a range of quantitative research instruments that can be used to measure the factors integrated in the developed conceptual model.	L QN	Literature review Survey design - pupil survey (*n*=2413) - parent survey (*n*=2267) - teacher survey (*n*=134)	Literature review EFA, CFA, internal replication study (SPSS, AMOS)	Chapter 3 (study 2)
RO2	- To delineate the construct of ICT competence into a test framework - To outline the design of a performance-based test that can be used to measure primary school pupils' ICT competences in a direct and valid way - To identify differences in pupils' ICT competences and how these relate to gender and socioeconomic status.	L QN	Literature review Survey design - pupil performance-based test (*n*= 378)	Literature review Classic item analysis, chi-square tests, nonlinear EFA, ordinal reliability analysis, ANOVA (BILOG-MG, SPSS, NOHARM, R)	Chapter 4 (study 3)
RO2	- To examine the reliability and validity of a new performance-based ICT competence test. - To construct and validate an ICT competence scale that is based on direct or performance-based measurement.	QN	Survey design - pupil performance-based test (*n*= 560)	Item Response Theory (IRT) (BILOG-MG, NOHARM)	Chapter 5 (study 4)
RO3	- To explore primary school pupils' general level of actual ICT competence (cfr. Chapter 4). - To explore which pupil, classroom and school level characteristics are predictors of primary school pupils' actual ICT competences.	QN	Correlational design - pupil performance-based test (*n*= 378) - pupil survey (*n*=378) - parent survey (*n*=378) - teacher survey (*n*=83) - ICT coordinator survey (*n*=56)	Multilevel Analysis (BILOG-MG, MLwiN)	Chapter 6 (study 5)
RO3	- To explore which pupil, classroom and school level characteristics are related to primary school pupils' ICT self-efficacy.	QN	Correlational design - pupil survey (*n*=2421) - parent survey (*n*=2256) - teacher survey (*n*=141) - ICT coordinator survey (*n*=86)	Multilevel Analysis (MLwiN, R)	Chapter 7 (study 6)

Table 2. Research goals, methodology, research design, data collection, analysis methods and output for the different research objectives

RO= Research objective; L=Literature review; QL=Qualitative study ; QN=Quantitative study

2.3. Outline of the dissertation

In total, the dissertation is structured into eight chapters. Apart from the General introduction (Chapter 1) and the General conclusion and discussion (Chapter 8), the dissertation can be split up into three parts. The first part is theoretical in nature and represents the contextual-conceptual phase of the dissertation. In this phase the educational policy context in which ICT competences are embedded was investigated. Furthermore, this phase also focuses on the development of the conceptual model (EDC-model) that guided the studies in the subsequent phases of this dissertation. The output of the contextual-conceptual phase is registered in Chapter 2 and Chapter 3. The second part is labeled as the developmental phase of this dissertation. The studies in this phase deal with the development and validation of the performance-based computer test that was used to measure primary pupils' ICT competences in a direct and valid way. The output of the studies in the developmental phase was written down in Chapter 4 and Chapter 5. The third phase of this dissertation is more empirical in nature. The studies in this phase investigated the relationships between pupil level, classroom level and school level characteristics, and directly and indirectly assessed ICT competences. The results of the studies of the empirical phase were written down in Chapter 6 and Chapter 7. Besides the General introduction and the General conclusion and discussion, all chapters are based on papers that have been published in international peer-reviewed A1-journals listed in the Social Science Citation Index. Figure 1 provides an overall picture of this dissertation i.e. of the different chapters and the relationships between them.

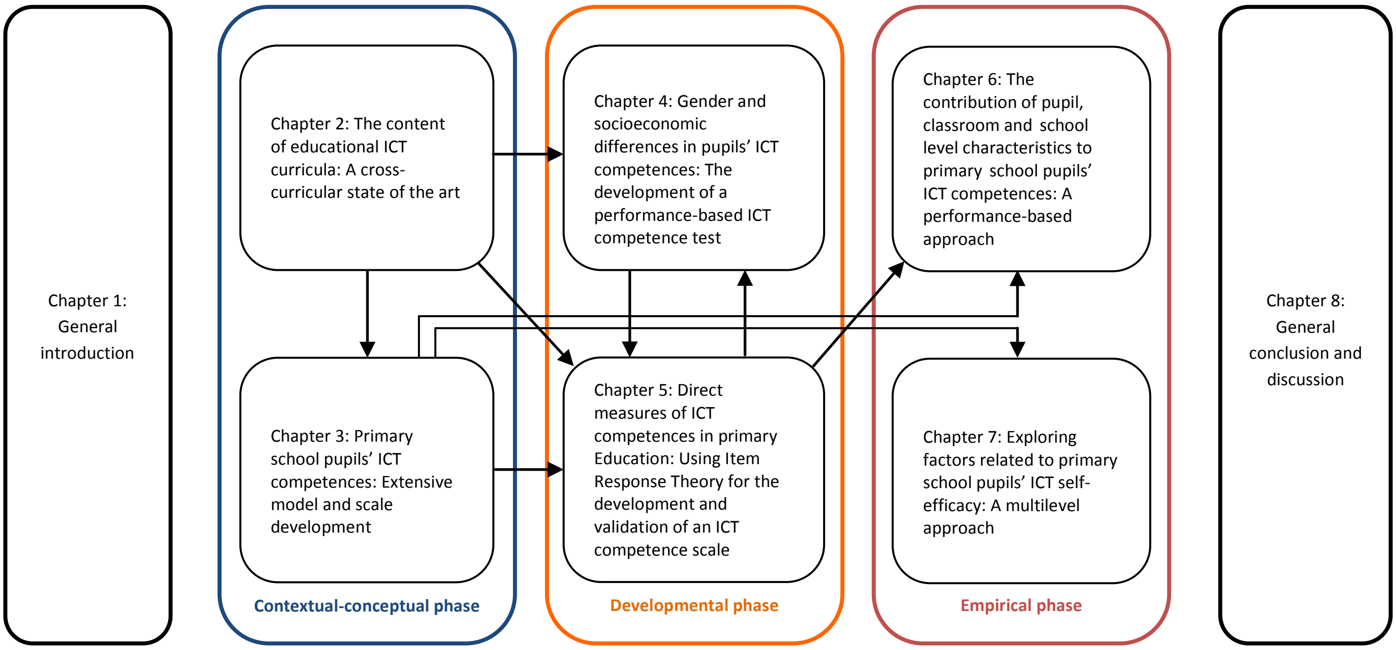

Figure 1. Overview of the dissertation chapters

Chapter 1 provides a general introduction for this dissertation. First, it describes the present research context of assessment of ICT competences. Second, an overview is given of the different studies and chapters integrated in this dissertation. Finally, the theoretical, empirical and practical relevance of this dissertation for the current literature on the assessment of ICT competences is discussed.

Chapter 2 'The content of educational ICT curricula: A cross-curricular state of the art' presents the results of a document analysis performed on national ICT curricula. ICT curricula can be described as the official teaching and learning experiences administered by national governments in order for schools to design learning environments in which pupils can develop their ICT competences. As such, the content of ICT curricula can be considered as a blueprint for learning ICT competences at school and in the classroom. A cross-case content analysis was conducted on the national ICT curricula of Norway, Flanders and England and their underlying policy documents. The level of centralization or decentralization was the major criterion for curriculum selection as this parameter has a great influence on the content of national curricula (Resh & Benavot, 2009). The six curriculum components of Madaus and Kellaghan (1992) were adapted to suit the specific context of ICT curricula and used as an analysis framework (i.e. context, broad curriculum aims, specific curriculum objectives, curriculum materials, transactions and processes, assessment and results). The major aim of the study was to identify similarities and differences in the content features of national ICT curricula. Furthermore, the study also aims to shed light on the educational policy context in which ICT competences are embedded. This chapter is based on an article that was published in 2013 in *Educational Technology Research & Development.*

Chapter 3 'Primary school pupils' ICT competences: Extensive model and scale development' focuses on the development of a conceptual model that can be used to guide future studies that explore differences in primary school pupils' ICT competences. The model can be considered as the conceptual foundation of this dissertation as it provides the input for the empirical studies described in Chapter 6 and Chapter 7. It is argued that the present frameworks on ICT competences do not take into account the broader classroom and school context in which pupils are embedded. Therefore, this chapter presents the Extensive Digital Competence model (EDC-model), a multilayered conceptual model that tries to explain differences in primary school pupils' ICT competences. The factors of the model were retrieved from a literature review and are located at the pupil, classroom and school level. Within the model, ICT competences are considered from the perspective of direct and indirect assessment, i.e. actual ICT competences and ICT self-efficacy respectively). Besides model development, Chapter 3 also focuses on instrument development. More specifically, reliable scales were developed for those factors of the EDC-model for which there are currently no validated scales available to use in primary education. For this purpose, replication exploratory and confirmatory factor analyses were conducted on a representative sample of primary school pupils (*n*=2413), their parents (*n*=2267), and their teachers (*n*=134). Chapter 3 is based on an article that was published in 2015 in *Computers & Education*.

Chapter 4 and *Chapter 5* try to tackle the problem of self-reported bias that comes together with indirect measurement of ICT competences. In both chapters, it is stated that the main research interest on ICT competences is conducted from the perspective of indirect or self-reported measurement. As these indirect measures cope with validity problems, the focus of chapter 4 and chapter 5 is on the development and implementation of a performance-based ICT competence test to diagnose primary school pupils' digital information processing and communication competences in a direct and valid way. Chapter 4 and chapter 5 can be considered as the instrumental foundation of this dissertation as they provide a standardized research instrument to investigate which pupil, classroom and school level characteristics are related to pupils' actual ICT competences, as was done in chapter 6. Chapter 4 *'Gender and socioeconomic differences in pupils' ICT competences: The development of a performance-based ICT competence test'* first outlines the design of the computer based assessment test i.e. the design of the underlying test framework, the items and the preliminary studies conducted. Second, chapter 4 also describes the results of the test and how these results are related to differences in pupils' SES and gender. Performance-based and questionnaire data were collected from a representative pupil sample (*n*=378) in 58 schools. These results elaborate on previous research on the relationship between gender, SES and ICT competences, as they are based on direct performance-based measurement, rather than on self-reported measures. Chapter 4 is based on an article that was published in *Computers & Education*. *Chapter 5 'Direct measures of ICT competences in primary Education: Using Item Response Theory for the development and validation of an ICT competence scale',* describes the construction and validation of a performance-based ICT competence scale based on Item Response Theory (IRT). The validity and reliability of the developed ICT competence scale are discussed in detail in this chapter. For this purpose, the developed test was administered to a representative sample of 560 sixth-grade pupils in 67 schools. This chapter is based on an article that was published in 2014 in *Computers & Education.*

In *Chapter 6 'The contribution of pupil, classroom and school level characteristics to primary school pupils' ICT competences: A performance-based approach',* multilevel analysis was used to explore which pupil, classroom and school level characteristics are related to primary school pupils' actual ICT competences. The dependent variable ICT competence, was measured using the performance-based ICT competence scale developed in Chapter 4 and Chapter 5. The independent variables were the pupil, classroom and school level characteristics of the EDC-model (Chapter 3). The major aims in this study concern 1) the exploration of primary school pupils' general level of actual ICT competence; and 2) the exploration of pupil, classroom and school level characteristics related to primary school pupils' ICT competences. With regard to data collection on pupils' actual ICT competences, the performance-based test was administered to a representative sample of 378 sixth graders from 83 classes in 58 schools. To investigate the effect of the factors at the EDC-model, questionnaires were administered to the 378 pupils that conducted the performance-based test (pupil level), their parents (*n* =378, pupil level), their sixth grade teacher (*n*=83, classroom level) and the ICT coordinator (*n* =58, school level). The results of this chapter are presented in an article that was published in *Computers & Education.*

Chapter 7 'Exploring factors related to primary school pupils' ICT self-efficacy: A multilevel approach' investigates the degree to which the pupil, classroom and school level factors of the EDC-model are associated with primary school pupils' self-perceived competence in digital information processing and communication, i.e. ICT self-efficacy. The ICT self-efficacy scale for primary education of Aesaert et al. (2014) was used to measure primary pupils' ICT self-efficacy (Chapter 3). Data on pupils' ICT self-efficacy and the pupil level factors were gathered through a pupil questionnaire (*n*=2421) and a parent questionnaire (*n*=2256) in 92 Flemish primary schools. A teacher questionnaire (*n*=141) and an ICT coordinator questionnaire (*n*=86) were used to gather information on classroom and school level factors. The results in this chapter elaborate on previous research as the relationship between ICT self-efficacy and its associated characteristics is investigated from a multilevel perspective. Chapter 7 refers to an article that was published in 2014 in *Computers in Human Behavior.*

In chapter 8, a general conclusion and discussion synthesizes the most important findings from this dissertation. It provides an overview of the main results with regard to the research objectives and aims formulated above. These results provide input for a discussion around five general themes related to the assessment of ICT competences that reoccurred in this dissertation. Finally, the chapter ends with the limitations of this dissertation, directions for future research and theoretical and practical implications.

3. Relevance of the dissertation

The studies conducted in this dissertation try to make a contribution to the knowledge on assessment of ICT competences in several ways.

The theoretical relevance of this dissertation is reflected in the attempts to develop two conceptual models. First, a model was created which gathers pupil, classroom and school level characteristics that are possibly related to pupils' ICT competences. This model theoretically adds to the research literature on ICT competences as it provides a multilayered framework that can act as a blueprint when studying pupils' teaching and learning of ICT competences. The second conceptual model developed in this dissertation is the test framework that guided the design of the performance-based ICT competence test. As the test framework is developed from the reflective perspective on ICT competence, it brings together higher-order learning-process oriented ICT competences as well as technical ICT skills. The theoretical advantage of the test framework is its operationalization of digital information searching, processing and communication into specific technical ICT skills and higher-order learning-oriented ICT competences. As such, it can be used by other test developers that wish to assess primary school pupils' ICT competences.

Besides theoretical relevance, this dissertation adds to the research literature through the development and disposal of validated instruments at the research community on ICT competences. First, a reliable and standardized measure was developed to assess primary school pupils' ICT competences in a direct and valid way. Although previous research has already set up direct assessment initiatives, these are often based on observation, making them expensive, harder to replicate, and harder to conduct on large samples. As such, the development of the computer and performance-based test in this dissertation provides future researchers with an instrument to measure primary school pupils' ICT competences in a valid and standardized way with large-scale samples. Besides a direct measure of ICT competence, a reliable measure of ICT self-efficacy was developed. This measure distinguishes itself from other measures of ICT or computer self-efficacy as it can be used in primary education.

From an empirical point of view, this study provides data on factors that are related to primary school pupils' ICT competences. Multilevel studies were conducted in order to identify which pupil, classroom and school level characteristics are related to pupils' actual and self-reported ICT competences. Together with the theoretical models that were created, these results are a first attempt in unraveling the complex process of ICT competence development and the role that pupils, parents, teachers and schools play in it.

Finally, this dissertation also attempts to contribute to educational practice and policy. In this context, the most important contribution is the development of the performance-based ICT competence test. Although the test is initially developed for research purposes, adaptations could be made to make it usable for teachers in their classroom. Teachers could use pupils' individual test results to identify specific shortcomings in pupils' ICT competences and adapt their instruction according to these needs. In the context of educational policy, the test can be used to measure the degree to which primary school pupils master the Flemish ICT curriculum. The results of the test can be used to inform policy makers and curriculum developers about specific ICT competence areas that need to be (re)addressed in the ICT curriculum.

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2

The content of educational ICT curricula: A cross-curricular state of the art

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Chapter 2

The content of educational ICT curricula: A cross-curricular state of the art

Abstract

The purpose of this study is to analyze the content features of educational ICT curricula for primary education developed by national governments. A qualitative cross-case document analysis of the national educational ICT curriculum of Norway, Flanders and England was conducted. The analysis focuses on the underlying visions, specific aims and instruction related aspects that are integrated in the national educational ICT curricula of the three cases under investigation. The results indicate that specific aims mainly focus on the critical use of ICT; safe and responsible use of ICT; information retrieval, processing and production; communication by use of ICT; and use of ICT for subject learning. It is possible that a discrepancy exists between the concepts of digital literacy and the specific aims that are addressed in educational ICT curricula. Moreover, the rationales that underlie educational ICT curricula represent a catalytic and social point of view rather than an economic one. The implications of our findings for curriculum developers and researchers are discussed.

1. Introduction

Nowadays, it is widely accepted that ICT plays a significant role in the educational, economic and social changes that characterize our present knowledge society (Kozma, 2008). Within the context of technological interactionism (De Mul, 2002), ICT not only enables these societal changes, but people also depend on ICT in order to cope with them. Often labeled as digital natives, evidence mounts that students' ICT use is much more limited in scope than originally portrayed in the literature (Judson, 2010; Nasah, Costa, Kinsell, & Seok, 2010). Consequently, teachers and schools have to organize learning environments in which pupils can develop ICT competences. Teachers and schools can rely on national educational ICT curricula to design and organize these learning environments. These curricula add a compulsory dimension to educational ICT use, making it less dependent on the willingness and individual initiatives of teachers.

They provide teachers with guidelines on what their government expects from them with regard to educational ICT use (Vanderlinde, van Braak, & Hermans, 2009). However, there is no consensus about the features of such ICT curricula (Fraillon & Ainley, 2010). The aim of the present study is to identify similarities and differences between national educational ICT curricula. The identification of these similarities and differences is essential because they can be considered as a lever for the development of pupils' ICT competences.

2. Theoretical background

2.1. ICT literacy and ICT competences

It is globally accepted that children need to possess a set of new skills, often referred to as 21st century skills, to tackle the challenges of our present information society. These skills are perceived as a set of generic competences for lifelong learning that enable children to adapt to change. Voogt and Pareja Roblin (2010) state that ICT competences are an essential set of 21st century skills, next to collaboration, communication, and social and cultural competences. Worldwide, frameworks are recently being developed, acting as a blueprint for the acquisition of 21st century skills and ICT competences, including the National Educational Technology Standards (ISTE, 2007) and the Framework for 21st Century Learning (P21, 2011) in the United States. Within the European context, the European Parliament sets out ICT literacy as one of the eight key competences for lifelong learning. This involves the "confident and critical use of Information Society Technology (IST) for work, leisure and communication" (ECEC, 2007, p. 7).

The concept of ICT literacy has many diverging, and even conflicting understandings (Bawden, 2008). While some authors define ICT literacy as the ability to use digital applications and software, others conceive it as a special kind of mindset. For instance, retrieving data from the Internet not only requires knowledge of search engines, but also the ability to distinguish relevant from irrelevant data (Eshet, 2002). Gilster (1997) defines ICT literacy as similar to our traditional idea of literacy, but in the digital age. In this sense, ICT literacy refers to "the ability to read, write and otherwise deal with information using the technologies and formats of the time" (Bawden, 2008, p. 18), and thus comprises an essential life skill. In this broad view, ICT literate pupils can thoughtfully deploy ICT competences in authentic life situations (Martin, 2006). It therefore seems that ICT competences are conceptualized more broadly than ICT skills. While ICT skills refer to technical and procedural computer use, ICT competences are conceptualized as the integrated and functional use of ICT related knowledge, skills and attitudes (Ananiadou & Claro, 2009). This means that ICT competences seem to include ICT skills. Markauskaite (2007) states that students' well-rounded ICT literacy–and thus also their ICT competences – needs to be developed across curricula. Within this context, Tondeur, van Braak and Valcke (2007) consider ICT literacy as a general aim of educational ICT curricula. Nevertheless, the literature on how the concepts of ICT competence and ICT literacy are perceived and integrated in curricula remains scarce. Within the context of this study, attention is paid to differences and similarities between the conceptualizations of ICT literacy and competences in educational ICT curricula as administered by national governments. The study of these conceptualizations is grounded on the fact that clear and univocal definitions aid the implementation of a curriculum (Virkus, 2003).

2.2. Educational ICT curricula

National educational ICT curricula can be situated within the context of the intended curricula at the macro level (Vanderlinde et al., 2009). They represent the visions and intentions held by national and state governments of educational ICT use and ICT competences. In other words: educational ICT curricula are the official learning and teaching experiences administered by national governments in order to design and organize learning environments in which children can develop ICT competences.

Although the need for education systems to deliver pupils with ICT competences exists since the 1960s (Martin, 2006), the establishment of educational ICT curricula is a relatively new trend in national educational policies. Yelland (2006) considers it problematic that educational ICT use is often still mapped onto traditional curricula that were developed in a non-computer age. Although the goals of these traditional curricula are still desirable, they seem inadequate and insufficient to prepare pupils for the challenges of the 21st century society (Dede, 2000). According to Voogt and Pelgrum (2005) coping with these challenges requires curricular adaptations. In this context, Vanderlinde et al. (2009) note that it is only recently that "some national governments are broadening their scope by administrating technology curricula as a specific form of educational policy making" (p. 573–574). Educational ICT curricula can be distinguished from traditional curricula in terms of addressing the generation of knowledge, skills, attitudes and competences that are related to the information society. Furthermore, they have a clear pedagogical foundation (Vanderlinde et al. 2009), which implies that they are more concerned with educational visions, content and processes than with 'boxes and wires'. By integrating ICT curricula into educational policy making, a compulsory character is added to the educational use of ICT by teachers. Moreover, the content of these ICT curricula can be seen as a blueprint for the ICT competences that pupils must acquire through ICT use at school. According to Fraillon and Ainley (2010), large variations exist between educational ICT curricula of different countries. It can be expected that these variations result in different educational ICT use and the ICT competences that are strived for.

2.3. Curriculum analysis

Curriculum scope is a major factor to be studied when analyzing curricula and has been defined by Hewitt (2006) as "what is included in the curriculum, what is covered" (p. 90). Madaus and Kellaghan (1992) divide the scope of a curriculum into six components: 1) context, 2) broad curriculum aims, 3) specific curriculum objectives, 4) curriculum materials, 5) transactions and processes, 6) assessment and results (see Table 1). Similar to a study of Rasinen (2003), these six major curriculum components were used as a blueprint for the development of the analysis framework in this study. While the first two components refer to underlying visions, the third covers the aims that can be integrated into a national educational ICT curriculum. The three remaining categories refer to instructional aspects that can be used to teach the specific curriculum aims. These three umbrella clusters of underlying visions, aims and instructional aspects refer to the three major curriculum planning elements of Walker (1990), which are purpose, content and organization of learning (van den Akker, Fasoglio, & Mulder, 2010). In order to have an indication of more concrete aspects that are possibly present in national educational ICT curricula, we linked these six curriculum components to the common themes of ICT literacy frameworks identified by Rosado and Bélisle (2007). These authors performed a comparative analysis of the characteristics of ten frameworks concerning policies that address the integration of ICT and ICT competences in education. The themes that applied to the six curriculum components were used as initial concretizations of the analysis framework. The concretizations can be found in the third column of Table 1. It should be stressed that this list of concretizations is not exhaustive.

The component 'broad curriculum aims' was operationalized by the four rationales for educational ICT use, distinguished by Hawkridge in 1990 (Tondeur et al. 2007). These four rationales drive national educational ICT policies and are strongly related to the dominant rationales of curriculum development. Tondeur et al. (2007) describe these four rationales as follows: An economic rationale is stressed when pupils must develop ICT competences for their future jobs. Within the context of an educational rationale, ICT is seen as a supportive tool to improve the learning of pupils. A social rationale focuses on the acquisition of ICT competences for all pupils and citizens in order to be able to fully participate in society. Within the context of a catalytic rationale ICT is seen as a medium for educational change and improvement.

Umbrella cluster of curriculum planning	**Curriculum component**	**Includes concretizations such as …**
Underlying visions (purpose)	*Context*: factors that should be taken into account when implementing a curriculum	• required (ICT related) prior knowledge/skills/attitudes/ competences • vision on ICT education • vision on ICT literacy • vision on ICT competence • etc.
	Broad curriculum aims: rationales underlying the curriculum	ICT related rationale of the curriculum: economic, social, educational, catalytic
Curriculum aims (content)	*Specific curriculum objectives:* translations of the broad aims into specific aims that can be used to develop instructional activities	• ICT related knowledge to be acquired • ICT related skills to be acquired • ICT related attitudes to be acquired • ICT related competences to be acquired • underlying structure of ICT competences, knowledge, skills, attitudes • formulation of skills, knowledge, attitudes and competences to be acquired • etc.
Instruction related curriculum aspects (organization of learning)	*Curriculum materials:* materials that can be used to learn and teach the specific objectives	• books • etc.
	Transactions and processes: procedures that teachers use to achieve the objectives	• transactions described for the macro level • transactions described for the meso level • transactions described for the micro level • content used for teaching the specific aims • etc.
	Assessment and results: performance measurement of the curriculum objectives	• what is being assessed • by whom is it being assessed • following which assessment procedure • using which assessment indicators • etc.

Table 1. Curriculum components according to Madaus and Kellaghan (1992) and umbrella clusters of curriculum planning according to Walker (1990)

3. Research aim

Few studies have compared content features of national educational ICT curricula in a systematic way. The identification of such content features is essential because they can be considered as a lever for the further development of primary pupils' level of ICT competences. Moreover, this content is an important starting point for the achievement of the strategic educational ICT-policy rationales that national governments formulate. The identification of similarities and differences between national educational ICT curricula in primary education can provide curriculum designers (e.g. departments of curriculum development, specialized standards development organizations) with ideas when developing a new or adapting an existing national educational ICT curriculum. In doing so, the consistency of a national educational ICT curriculum can be improved, making them less difficult for teachers to interpret.

The three umbrella clusters of curriculum planning shown in Table 1 provided the input for the research questions and outline of this study:

- Which visions (e.g. context, general aims) underlie educational ICT curricula?
- Which curriculum aims are integrated in educational ICT curricula?
- Which instruction related aspects (e.g. materials, transactions and processes, assessment) are integrated into educational ICT curricula?

4. Research design

A comparative document analysis of national curricula and their underlying policy documents was chosen as research design to develop empirical knowledge of the similarities and differences between educational ICT curricula. Merriam (1998) states that document analysis may often be the only realistic approach for historical and cross-cultural studies (Bowen, 2009). Consequently, the cross-national character of this study validates the use of document analysis as a stand-alone method.

4.1. Curriculum selection

No assumptions were made in advance about the curriculum content, such as the integration of specific ICT competences. By doing so, the selection of the curricula was not based on their content. This inclusive approach reduced the risk of predetermined curriculum selection and thus biased conclusions. Instead, three general criteria determined the selection of the curricula: 1) To guarantee a common international foundation, European member country was the first selection criterion; 2) The countries of the selected cases had to possess a well-documented national educational ICT policy; and 3) The level of centralization or decentralization of the education policy was taken into account, as this parameter has a great influence on the curriculum content on the macro level (Resh & Benavot, 2009).

The curriculum of Flanders (the Dutch speaking part of Belgium), Norway and England were finally selected as units of analysis because the centralization of the education system in these European countries is different. While school autonomy is a cornerstone of the Flemish education policy (Denis, Valcke, & van Braak, 2009; Vanderlinde et al., 2009), the education systems of Norway and England have a long tradition of a unitary and centralized policy. However, the autonomy of Norwegian and English schools concerning decision-making is growing (Erstad & Quale, 2009; Higginson & Cuddy, 2009; Kuiper, van den Akker, Letschert, & Hooghoff, 2007; Norwegian Ministry of Education and Research, Eurydice Unit, 2010). Moreover, the educational ICT curriculum of each of these countries has recently been adapted or established. However, during this study a new UK Government took office and on June 7th 2010 it was decided not to proceed with the previous Government's proposed new primary curriculum (QCDA, 2010a). This new primary curriculum was intended to be integrated into schools from September 2011. Consequently the English curriculum of 1999 was used in this study, which was developed within the heavily centralized education policy of that time (Kuiper et al., 2007). Additionally, other ICT policy documents and documents that describe the educational system of the three cases were analyzed during this study. An overview of these documents can be found in Appendix A.

4.2. Analysis

The data analysis consisted of two phases. First, for each country a within-case analysis was performed "to describe, understand and explain what has happened in a single, bounded context" (Miles & Huberman, 1994, p. 172). The analyzed data of each curriculum are presented in a descriptive text based on the structure of the analysis framework. This fixed structure (see Table 1) enabled us to make a comparison of the different texts in the subsequent cross-curricular analysis phase of this study. In order to guarantee the internal validity of the study each descriptive text was sent to the corresponding Curriculum Development Departments. Representatives of the curriculum departments were able to make corrections and ask questions about their descriptive text. In addition to the descriptive text, the departments also received open-ended questions about the main findings of their curriculum. They were asked to answer these questions in a critical manner. Based on their remarks or reference to alternative documents, each descriptive text was then revised and adapted in order to be used during the second phase of the analysis.

Second, during the cross-case analysis the technique of constant comparative analysis (Maso & Smaling, 1998) was used to filter the common themes and recurring patterns in the three descriptive texts. In practice, the cross-case analysis refers to a cyclic iteration of reading, interpreting and controlling the data of the three descriptive texts. The major curriculum components of the analysis framework were the point of departure for conducting the cross-case analysis. The identified content-related similarities and differences were then presented in a text that was structured by the subjects of the three research questions.

5. Country Overview

Below we give a brief overview of the current education system, the historical-cultural foundation and the curriculum for each country. Following this the major cross-curricular findings are presented.

5.1. Norway

Norwegian compulsory education is divided into primary school (grades 1–7) and lower secondary school (grades 8–10). Children start primary education the year they become six (Norwegian Ministry of Education and Research, Eurydice Unit, 2010). The last two decades the educational ICT policy can be divided into three chronological phases. Whereas the first phase (1996–1999) was mainly focused on implementing ICT infrastructure into schools, the following two phases took the educational context more into account. During the second phase (2000–2003) ICT was considered as a way to change the school and learning environment. In the third phase (2004–present) educational ICT policies emphasize pupils' acquirement of ICT literacy (Erstad & Quale, 2009). It is within the context of this last phase that the Ministry of Education and Research introduced the general school and curriculum reform Knowledge Promotion in 2006. This latest reform in compulsory school education and training established a new national curriculum for primary education. This national curriculum for Knowledge Promotion consists of five parts: the Core Curriculum; the Quality Framework; subject curricula; distribution of teaching hours per subject; and individual assessment (Berge, Hatlevik, Kløvstad, Ottestad, & Skaug, 2009). The new curriculum is perceived as a central curriculum that puts emphasis on a common content of knowledge, skills and values regardless of pupils' background and personal characteristics. Within the context of the recent decentralized education policy, the adaptation of the common content of the curriculum––according to local and personal specificities and differences––is considered a main principle (EACEA, 2010). The curriculum focuses on the cultivation of five basic skills, which are integrated into all subjects. The idea is that these basic skills contribute to the development of the subject competences while also being a part of them. One of these five basic skills is 'being able to use digital tools' (Norwegian Ministry of Education and Research, 2007). The other four refer to being able to express oneself orally, being able to express oneself in writing, being able to read, and being able to do mathematics in the different subjects.

5.2. Flanders

Compulsory education in Flanders comprises primary education (6 years) and secondary education (6 years). Children start primary education the year they become six. The use of final objectives in primary education is considered an important curriculum principle (EACEA, 2009). They are perceived as minimum objectives or attainment targets that indicate which knowledge, skills and attitudes the government considers necessary and feasible for pupils to have by the end of primary education. They can be divided into subject-specific attainment targets and cross-curricular attainment targets. The cross-curricular objectives refer to "minimum targets relating to knowledge, insight, skills and attitudes that do not specifically belong to a subject, but are sought after by means of various courses, educational projects, and other activities" (FME, 2010a, para. 4). In 2007, the Flemish Government introduced eight cross-curricular final objectives for educational ICT use. These final objectives set up a formal educational ICT curriculum which replaced the existing but non-binding ICT guidelines (Vanderlinde & van Braak, 2011) i.e. before the introduction of the ICT curriculum, educational ICT use depended on initiatives of mostly skilled and personally interested teachers. The educational ICT curriculum should be interpreted within the recent policies of the Flemish government that focus on providing school's with a decent ICT infrastructure, delivering training and supporting schools (Denis et al., 2009).

5.3. England

Compulsory education covers primary (6 years) and secondary (5 years) education. Primary education is divided into key stage 1 (ages 5–7) and key stage 2 (ages 7–11) (Higginson & Cuddy, 2009). In the early years (1970s–1980s) ICT use in schools was mainly mapped on a voluntary basis. It wasn't until the introduction of the national curriculum in 1988 that ICT was formally introduced as a subject and integrated in other subjects. As mentioned above, the present ministers confirmed that they will not proceed with the newly developed curriculum proposed by the previous Government (QCDA, 2010a). Consequently, the core of the national curriculum of England remains unchanged since its establishment in 1999. Although new educational ICT policy documents have been published since then, it is within the context of the heavily centralized education policy at the end of the nineties that the original national curriculum document should be interpreted. The national curriculum contains four categories. The first part describes the aims, values and purposes underlying the curriculum. In the second part, a programme of study sets out what pupils should learn at each key stage for each subject. The programme of study for each subject is written down in a separate booklet. In the third part attainment targets are formulated for each subject. The fourth part describes the general teaching requirements that apply across the different programmes of study. It should be mentioned that ICT is integrated into the national curriculum in two ways. On the one hand, the national curriculum contains a separate programme of study for ICT. On the other hand, the use of ICT as a general teaching requirement is integrated into the other subject-specific programmes of study. In this study we refer to these two components as 'ICT as a subject' and 'ICT in subjects'.

6. Cross-curricular findings

Based on a cross-case comparison of the three descriptive texts the most relevant findings for the three research questions underlying this study are presented below.

6.1. Underlying visions

6.1.1. Context: ICT literacy and ICT competences

The curricula documents indicate that between the studied curricula as well as within the individual curricula different terms refer to the concept of ICT literacy, such as digitally skilled, digitally literate, digitally competent (Norway), ICT capability (England) and ICT competence (Flanders). Moreover, these concepts contain different semantic meanings. The Norwegian curriculum describes ICT literacy as a complex competence "that ranges from basic skills to more generalized insights that foster discerning digital usage" (Norwegian Ministry of Government Administration and Reform (MGAR), 2006, p. 29). Basic ICT skills consist of being able to apply software and to locate and transform information. Discerning digital usage is characterized by a more critical and creative dimension. It requires the ability to critically evaluate, acquire, analyze and use important information, media content and genres (Erstad & Quale, 2009). Although ICT capability is not defined in the English curriculum, policy documents describe it as the "technical and cognitive proficiency to access, use, develop, create and communicate information appropriately, using ICT tools" (DCSF, 2009, p. 30). In Flanders ICT competence is described in a general way as a problem solving capacity that exceeds technological and procedural skills (FME, 2007; Vandenbroucke, 2007). Besides Flanders, the two definitions of ICT literacy seem to stress the importance of acquiring and processing information by using ICT. Each of the three definitions seems to contain both a technical and cognitive dimension. The technical dimension refers to basic ICT skills such as button and application knowledge, whereas the cognitive dimension refers to higher order skills such as evaluating information, choosing the right application or using metacognitive skills. While the Flemish and Norwegian definitions suggest that technical proficiency is instrumental to cognitive proficiency, the English curriculum does not assign a hierarchical structure to these two dimensions.

None of the studied curricula refers in a consistent way to the concept of ICT competence. The curricula of Norway and England, for example, do not contain information about how they conceptualize their goals as ICT skills, knowledge, attitudes or competences. In the Flemish curriculum ICT competence is perceived as a multilayered construct, rather than a separate set of ICT knowledge and ICT skills. It refers to a learning-process oriented competence that integrates ICT knowledge and ICT skills and has underlying complex (metacognitive) skills and attitudes. Technological and procedural ICT knowledge and ICT skills are considered important, but instrumental to the more complex ICT competences (De Craemer, 2008; FME, 2007). However, none of the ICT competences formulated in the Flemish curriculum refers to the specific technological ICT skills, ICT attitudes or ICT knowledge necessary to acquire the complex ICT competence. Within this context, none of the curricula outline the prior ICT knowledge, skills or attitudes required to develop the specific aims of the curricula.

6.1.2. General aims

Although growth in the economic work force and the use of ICT for the purpose of improving learning are present as general aims in all three curricula, more recent policy documents indicate the importance of ICT use for the pursuit of equity and educational reform. With regard to equity, the three governments describe the lack of ICT competences as a major contribution to digital exclusion and digital divides. Consequently, in Norway the development of ICT literacy for all is elaborated by integrating the use of digital tools as a basic skill into the new curriculum for Knowledge Promotion (MoM, 2005). Similarly, the Flemish Government notes that the use "of final objectives to put each pupil in contact with ICT education ensures that all pupils, course participants and students receive an equally valid basic training" (Vandenbroucke, 2007,

p. 13). The English curriculum supports this vision. More specifically, the government wants to create equal opportunities for developing ICT capabilities by integrating general recommendations and ideas to overcome potential barriers into learning in the 'ICT as a subject' curriculum, such as "some pupils may require specialist software [...] to be able to exchange and share information with others through the use of ICT" (QCA, 1999, p. 34). The government also stresses the importance of using technology in schools to "improve access to learning for pupils with a diverse range of individual needs, including those with special educational needs and disabilities" (DfES, 2003, p. 6). Considering the pursuit of educational reform, the three curricula give a different interpretation to the catalytic rationale. As an innovative tool, the Norwegian government describes ICT as "a catalyst for adaptation and change processes in education. ICT is to stimulate the use of new working methods and increase interaction between teachers and learners" (Norwegian Ministry of Education and Research, 2004a, para. 4). Besides this pedagogical-didactical dimension, the Flemish Ministry of Education adds a curricular dimension to the innovative use of ICT. More specifically, its curriculum intends to address those ICT competences that pupils are not spontaneously confronted with in an outside-school context (FME, 2010b). In England the catalytic function of educational ICT use is embedded within a context of whole school improvement, in which ICT is perceived as a tool to perform and reform leadership and management. Making better use of ICT at the institutional level should "free up teachers their time and the whole-school approach to improvement, which are essential to create capacity for reform" (DfES, 2003, p. 8). For example, school leaders should focus more on sustainable ICT investment and develop an educational ICT vision for whole school improvement, etcetera (DfES, 2003). This focus on the social and catalytic rationale within the curricula is not exclusive. Rather, both rationales are related to underlying economic and educational motives. In Norway, for example, the pursuit of ICT literacy for all is in place to let all citizens participate fully in working life and social activities (Erstad & Quale 2009). The same goes for England where the whole school improvement initiative has the final goal of performance progression in subject learning and participation in today's economy and society.

6.2. Specific curriculum aims

The specific aims of the studied curricula address the same central themes, i.e., critical use of ICT; safe and responsible use of ICT; information retrieval, processing and production; communication by use of ICT; and the use of ICT for subject learning and practice. The Flemish curriculum adds 'the development of a positive ICT attitude' and ‘creative expression by using ICT’ to these central themes. In general, these central themes seem to focus on higher-order skills using ICT and information processing rather than the technical use of ICT. It is remarkable that the three countries seem to strive for similar themes through their specific aims, while they use different terms for ICT literacy and attribute different meanings to them. This could possibly indicate a discrepancy between the aims that are formulated in national educational ICT curricula and their conceptualizations of ICT literacy. This could mean that the goals that are formulated in national educational ICT curricula are not or only partly mapped onto its underlying visions and definitions.

Furthermore, the specific aims, their degree of integration in other subject aims, and the specificity of their formulation are different for the three countries, going from a cross-curricular to a fully integrated subject-specific curriculum. In the Norwegian curriculum educational ICT aims are integrated into each subject in two ways. First, a curriculum section ‘basic skills’ describes how the basic skill ‘being able to use digital tools’ can be integrated and adapted in order to promote learning in the specific subject. Second, an ICT dimension is directly inserted into some of the subject-specific goals, such as “photograph and manipulate images digitally and reflect upon the use of motifs and sections” (DoE, 2006). Consequently, ICT competence is automatically linked up with the subject content. In the Flemish curriculum the specific aims encompass eight generally formulated cross-curricular final educational ICT objectives, such as “being able to use ICT to communicate in a safe, sensible and appropriate way”. The cross-curricular character of the objectives stresses their orientation on transfer. Consequently, the objectives themselves do not refer to any subject content or teacher and learner roles during the learning process. To make the objectives more understandable for teachers, each of them is accompanied by a theoretical clarification and examples that illustrate possible activities and roles of learners and software. The possible roles of the teacher are not mentioned. This is consistent with the Flemish decentralized educational policy. The Flemish Agency for Education Development (DVO) of the Ministry of Education develops the attainment targets. However, they are neither allowed to elaborate the attainment targets in a localized curriculum nor are they permitted to provide any pedagogical guidance (Kuiper et al., 2007) such as illustrations of teacher roles.

The English educational ICT curriculum can be seen as semi-integrated. In the ‘ICT as a subject’ curriculum, the specific aims are generally formulated and organized around four educational ICT attainment clusters for each key stage; 1) finding things out, 2) developing ideas and making things happen, 3) engaging and sharing information, and 4) reviewing, modifying and evaluating work as it progresses (QCDA, 2010a). All of the aims are concretized by key words that refer to possible activities or sorts of software that teachers can use. Moreover, some aims are linked with the attainment clusters of other subject specific curricula. The educational ICT aim “how to develop and refine ideas by bringing together, organizing and reorganizing text, tables, images and sound as appropriate”, for example, is linked to the attainment cluster “planning and drafting” of the English curriculum. Besides ‘ICT as a subject’, there is also the ‘ICT in subjects’ curriculum. For each subject the four attainment clusters of the ‘ICT as a subject’ curriculum are translated into specific statutory requirements to use ICT in subject teaching, which are directly integrated in the subject specific aims; for example “pupils could use sensors to record temperature changes”.

In the Norwegian and English curricula, educational ICT aims are not always integrated into the subject-specific aims to the same extent. Whereas some of the goals clearly describe the ICT competence and subject content pupils must acquire, other goals seem to pay less attention to the ICT dimension. “Place and describe positions in grids, with and without digital tools”, for example, says more about the mathematical dimension of the aim than about the ICT competence that students must acquire. The ICT dimension here is reduced to the add-on ‘with and without digital tools’.

6.3. Instruction related curriculum aspects

6.3.1. Curriculum materials

Apart from England, none of the studied countries dedicates a separate part of its educational ICT curriculum to instructional aspects. With regard to materials that can be used to teach ICT competences the curriculum of Norway and Flanders sporadically mention types of software and hardware that can be used. In contrast, the English curriculum contains an elaborated section ‘curriculum in action’ which translates the different programmes of study into real classroom activities. For ‘ICT as a subject’, activity descriptions and goals refer to the software and hardware that can be used and how pupils and teachers can use it during the activity. Information is also provided about the ICT-related capacities that the child has acquired during the activity of using certain types of software and hardware. The online version of the curriculum also provides teachers with screenshots as illustrations of ‘items of work’.

6.3.2. Transactions and processes

With regard to transactions and processes, the curricula of Norway and Flanders do not provide teachers with any information on how to implement the curriculum goals in their classroom activities. This is consistent with the features of a politically determined decentralized education system, which is used in both of these countries. Such an education system stresses school autonomy and enables schools and teachers to organize their learning environments in their own way. Although the English education system is also becoming more decentralized nowadays, it was the curriculum of 1999 that was used in this study. In this curriculum the section 'curriculum in action' provides "real examples of pupils' work for key stages 1 and 2" (QCDA, 2010b). For each subject, each example offers a chronological description of the overall actions of the pupils and teachers, the technology resources to be used, a line-up of the activity's objectives, and a description of the actions that pupils have to perform with technology during the activity. When ICT is the subject, the objectives are ICT related and the ICT performance level of the task, as well as what teachers could do to promote future progress, is added. Furthermore, a category 'items of work' contains images of learning products and of how ICT can be used during the learning process.

6.3.3. Assessment and results

The Norwegian and Flemish curricula do not contain guidelines or prescriptions on the assessment of their specific ICT aims. In England, however, a detailed attainment target for ICT is integrated into the national educational ICT curriculum. It sets out the expected standards of pupils' performance for ICT at the end of key stages 1 and 2. More specifically, the attainment target consists of eight levels of increasing difficulty. These show progression in the four educational ICT attainment clusters. For each level a general description is provided to outline how and why ICT is used. The description also refers to typical performance of pupils that concretize the ICT use at that level. The curriculum contains a section that provides information on how teachers must use the different level descriptions when deciding on the pupil's level of performance. The national curriculum advises teachers to use the attainment targets as input for the development of learning environments. "Teachers' planning for schemes of work should start from the programmes of study and the needs and abilities of their pupils. Level descriptions can help to determine the degree of challenge and progression for work each year at each key stage (QCDA, 2010b)".

7. Discussion and Conclusion

The aim of this study was to provide a state of the art of content features of three national educational ICT curricula in primary education. The results add to the current literature on educational ICT curricula in general and ICT competences in particular.

The first research question addressed the possible visions that underlie educational ICT curricula. Special attention was given to the conceptualization of ICT literacy and ICT competences within the studied curricula. The results indicate that national governments define ICT literacy in their curricula in different and sometimes diverging ways. Different terms refer to the concept of ICT literacy, such as digitally skilled, digitally competent, digitally literate, ICT competent and ICT capable. Not only are different terms used, each of their definitions contains different semantic meanings, ranging from the use of basic ICT skills to complex problem solving abilities. This permissive use of concepts in national educational ICT curricula supports Markauskaite's (2006) view that the notion of ICT literacy is poorly understood in formal education and many terms are used to describe various sets of ICT related capabilities. Moreover, no clear descriptions are given about the interpretation of curriculum objectives as skills, competences, knowledge or attitudes. Within this context, Virkus (2003) states that "agreeing definitions not only aid the implementation of curriculum innovations, but also help schools to clarify their educational position" (para. 21). Although ICT skills, attitudes, knowledge and competences are interconnected, each concept has its own characteristics resulting in specific teacher and pupil behavior when they are taught i.e. skills can be situated at an operational level whereas knowledge does not require a pupil's act of performance. Consequently, it should be investigated whether this tangled ball of concepts hampers the interpretation and implementation of national educational ICT curricula. Resh and Benavot (2009) note that the between-school variation in curriculum implementation tends to be greater under conditions of an increased decentralized education policy. Within such a decentralized education policy schools are offered a high degree of freedom and autonomy to interpret the curriculum. Within the context of the Flemish decentralized education policy, the results of Vanderlinde, Braak and Dexter (2011) indicate that especially schools with a low school capacity for educational ICT curriculum development, such as their school improvement conditions, have difficulty interpreting and implementing the national educational ICT curriculum. On an international level it would be interesting to investigate how the content and concepts of a national educational ICT curriculum are related to the relationship that exists between a schools capacity for educational ICT curriculum development and curriculum implementation. This greater between-school variation in curriculum implementation in schools embedded within decentralized education policies does not mean that education policy should be centralized. Rather, it emphasizes the need for precise and well considered development and interpretation at all curriculum levels. Fullan (2001) states that large scale change, such as the implementation of a national ICT curriculum, could be effective, but requires a certain degree of top–down initiative at the beginning followed by greater attention paid to local conditions (Tondeur, Van Keer, van Braak, & Valcke, 2008). Vanderlinde, Dexter, and van Braak (2011) describe the development of a school-based ICT plan as a way to support schools in strengthening their capacity to improve local conditions, e.g. vision building, team collaboration, etc. More specifically, such an ICT plan acts as a lever that could facilitate the implementation of intended national educational ICT curricula. For the development of such an ICT plan, schools need to interpret the specific national educational ICT curriculum and translate it according to their own particular school context. However, it is likely that schools will experience translation problems if the final goal of ICT literacy is not conceptualized in a concrete and univocal way within the top-down initiative of a national educational ICT curriculum. The next step is to conduct further research on how the schools of the selected countries implement their ICT curriculum. With regard to the Flemish case for example, Vanderlinde et al. (2009) present two levers that facilitate the realization of national educational ICT curricula. Firstly, ICT coordinators should act more as curriculum managers and secondly, schools should jointly establish an ICT policy plan. Besides this implementation process, future research should also focus on the evaluation of the final objective of educational ICT curricula i.e. pupils' ICT competences should be assessed in a valid manner.

This study indicates that the general aims of educational ICT curricula especially pursuit equity and educational reform. Equity is hereby perceived as the development of ICT competences in order to let all people participate in working life and social activities. Educational reform refers to: a) pedagogical-didactic changes, b) curriculum changes that focus on the development of ICT competences necessary to function in the knowledge society, and c) whole school improvement by the use ICT. These results slightly expand the view of Voogt (2008) that mainly educational and social rationales were very prominent in the introduction of ICT in the primary school curriculum. Moreover, the results indicate that the four rationales cannot be distinguished as separate factors driving the development of educational ICT curricula; these rationales are clearly intertwined. This is in line with Kozma's (2008) argument that policy rationales are not mutually exclusive, rather they reinforce each other. For example, reforming the curriculum (catalytic) to provide students with information processing and communication skills will also prepare an excellent future workforce (economic)

(Kozma, 2008). Future research should examine whether the visions that underlie national educational ICT curricula have shifted during the past decade and how this may have affected the development of educational ICT curricula. Moreover the four rationales presented here need to be revised and refined. In this study alone, for example, three different interpretations of the catalytic rationale were identified.

The second research question addressed the nature of the specific aims that are integrated in educational ICT curricula. The results of this study indicate that the aims of national educational ICT curricula focus on higher-order thinking skills and information processing rather than technological and procedural ICT use. This reinforces Law's (2009) statement that the perceived role of ICT in the curriculum has moved through different phases since the early 1990s. The author distinguishes three paradigms that represent three policy foci: technological literacy (basic ICT skills), knowledge deepening (in terms of complex problem solving in subject areas), and knowledge creation (perceived as 21st century skills). The curriculum aims of the cases in this study can be clearly classified under the last two categories.

Based on the degree of integration of ICT competences in subject related aims, the three cases of this study represented a cross-curricular, a semi-integrated and a fully integrated national educational ICT curriculum. Whereas a cross-curricular ICT curriculum contains generally formulated aims, the aims of the integrated and semi-integrated ICT curricula are made more specific by referring to possible teacher and learner roles, or content that can be used to realize the aim. This content can be derived from the subject aim and attainment targets that are linked with the ICT competence. At present there exists little knowledge about the relationship between the specificity of the aims of national educational ICT curricula and the ICT competences that pupils develop in school. This is in line with the old but still ongoing debate between authors that claim that specific objectives improve instruction and learning, while others state that this specificity hampers the ends of instruction (Jenkins & Deno, 1971). Future research should focus on the relationship between the specificity of aims formulated in ICT curricula, the implementation of the ICT curriculum, and the ICT competences that pupils acquire. Whatever the outcome of such research may be, curriculum developers––especially those of integrated ICT curricula––should take into account that educational ICT aims must be formulated in a way that leaves room for teacher and school interpretation, as "detailed, prescriptive lists are in danger of alienating or marginalizing teachers by imposing curricular limitations onto classroom teaching" (Ryberg & Georgsen, 2010, p. 90). Moreover, when ICT related goals are integrated into other subject curriculum goals, both ICT and subject dimensions must be fully operationalized.

The third research question of this study focused on the instruction related aspects that are integrated into educational ICT curricula. Only one of the three countries dedicated a separate part of its educational ICT curriculum to instructional and organizational aspects. It is worth mentioning that it is particularly the curriculum of England that contains these instructional aspects, a country that is considered as having a heavily centralized educational policy. In this context, Resh and Benavot (2009) note that centralized education systems mostly formulate a detailed curriculum which results in a greater overlap between the content of the official curriculum and the organization and contents of subjects in schools. Although the curriculum of England is the most detailed and describes all components of the analysis framework, research indicates that a conflicting use of ICT as a subject and the use of ICT in other subjects results in a poor delivery of the educational ICT curriculum in many schools (Cox, 2009). This implies that a very detailed curriculum does not automatically result in a greater overlap between the content of the official curriculum and the organization and contents of subjects in schools. Consequently, the question arises as to what degree the specificity and volume of a national educational ICT curriculum is related to the implementation of that curriculum in the class and the level of ICT competences pupils acquire. However, regardless of the specificity of the curriculum, the different curriculum components, such as underlying visions, concepts and aims, should always be described in a univocal way and should be perfectly tuned to each other. Using the metaphor of a spider web, van den Akker (2003) stresses the importance of balance and consistency between curriculum components for effective curriculum improvement and implementation.

Future research should investigate the educational ICT curricula of other countries––including those outside Europe––in order to verify whether the results of this study are a general educational trend or an occasional phenomenon. Moreover, future research should focus on documents and stakeholders’ perceptions on a regional and practice level. Critical qualitative analyses of regional documents and opinions of teachers, principals, parents and school boards could reveal judgments that oppose the dominant views based on this study’s analysis of national policy documents. Such qualitative research and different points of view are necessary in order to clearly structure and map out the complexity of educational ICT curriculum development and implementation in the future. Further, it is necessary to investigate educational ICT curricula in relation to other curriculum fundamentals, such as sequence, balance and continuity (Hewitt, 2006). The results of this study indicated that there are differences between the concepts and the specificity of national educational ICT curricula. Too little attention is being paid to the relationship between these differences and the implementation of national educational ICT curricula. This underlines the fact that the development of a practical and unequivocal national educational ICT curriculum remains a difficult but fascinating endeavor.

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Appendix A

Norway

Title	Authors/institution and year
Education in Norway– from Kindergarten to Adult Education	Norwegian Ministry of Education and Research (2007)
Structures of Education and Training Systems in Europe – Norway – 2009/2010 Edition	Norwegian Ministry of Education and Research, Eurydice Unit (2010)
The digital challenges of school and teacher education in Norway: Some urgent questions and the search for answers	R. Krumsvik (2006)
Educational technology, epistemology and discourses in curricula in Norway	R. Krumsvik (2008)
ICT competencies for the next generation of teachers	A.G. Almäs, & A.G. Nilsen (2006)
Organization of the education system in Norway 2009/2010	Education, Audiovisual & Culture Executive Agency (EACEA)/Eurydice (2010)
National Curriculum for Knowledge Promotion in Primary and Secondary Education and Training	Directorate for Education(2006)
Programme for Digital Competence 2004-2008	Norwegian Ministry of Education and Research (2004)
An Information Society for All	Norwegian Ministry of Government Administration and Reform (2006)
Culture for Learning	Norwegian *Ministry of Education and Research* (2004)
Digital Competence: from ICT skills tot digital “bildung”.	M. Søby (ITU) (2003)
National Curriculum for Knowledge Promotion in Primary and Secondary Education and Training – The Quality Framework	Directorate of Education (2006)
ITU-Monitor 2009: The digital State of Affairs in Norwegian Schools 2009	O., Berge, O.E., Hatlevik, V., Kløvstad, G., Ottestad, & J.H., Skaug (ITU)(2009)
eNorway 2009 - the digital leap	Ministry of Modernisation (2005)
Knowledge Promotion: Information for pupils and parents/guardians: What is new in the 10-year compulsory school and upper-secondary schools from the autumn of 2006?	Norwegian Ministry of Education and Research (2006)
National Policies and Practices on ICT in Education. Norway	Erstad, O., & Quale, A. (2009)

Flanders

Title	Authors/institution and year
Educational Structures and Education Systems for Vocational Training and Adult Education in Europe. Belgium – Flemish Community -2009	Flemish Ministry of Education, Eurydice Unit (2009)
National Policies and Practices on ICT in Education: Belgium.	Denis, B., Valcke, M., & van Braak, J. (2009)
Competences for the knowledge society. The Flemish policy on ICT in education.	J. De Craemer (2008)
Lager Onderwijs: Uitgangspunten voor de eindtermen van het lager onderwijs.	Flemish Ministry of Education (2007)
Competences for the knowledge society. ICT in education initiatives 2007-	F. Vandenbroucke (2007)

2009	
Computer in de klas. Ben je klaar voor de ICT-eindtermen?	Flemish Ministry of Education (2007)
Information for teachers and schools. Developmental aims and final objectives of the mainstream primary education	Flemish Ministry of Education (2010)
ICT-eindtermen in het gewoon en buitengewoon basis- en secundair onderwijs: karwei of opportuniteit?	D. Delcour (2008)
Organisation of the Education System in the Flemish Community of Belgium 2008/2009	Education, Audiovisual & Culture Executive Agency (EACEA)/Eurydice (2009)
Core Curriculum	Flemish Ministry of Education (2010)

England

Title	Authors/institution and year
Structures of Education and Training Systems in Europe; United Kingdom – England 2009/10	C. Higginson, & N. Cuddy (2009)
Privatisation, Decentralisation and Education in the United Kingdom: The Role of the State	D. Turner (2004)
About the primary Curriculum	Qualifications and Curriculum Development Agency (1999)
The National Curriculum for England. Information and communication technology Key stages 1-4	Department for Education and Employment & Qualifications and Curriculum Authority 1999)
Assessing pupil's progress. Assessment at the heart of learning.	Qualifications and Curriculum Authority (2008)
Assessment and Reporting Arrangments. National curriculum assessments 2010: Key stage 1	Qualifications and Curriculum Development Agency (2010)
Assessment and Reporting Arrangments. National curriculum assessments 2010: Key stage 2	Qualifications and Curriculum Development Agency (2010)
Technology in the primary curriculum (April 2010)	British Educational Communica-tions and Technology Agency (BECTA) (2010)
Fulfilling the Potential. Transforming teaching and learning through ICT in schools	Department for Education and Skills (2003)
Beyond Engagement. The use of ICT to enhance and transform learning at Key Stage 2 in literacy, mathematics and science.	Department for children, schools, and families (2009)
Excellence and Enjoyment: A strategy for primary schools	Department for Education and Skills (2003)
The National Curriculum. Handbook for primary teachers in England. Key stages 1 and 2.	Department for Education and Employment & Qualifications and Curriculum Authority (1999)
National Grid for Learning: Connecting the Learning Society.	Department for Education and Employment (1997)
Quality principles for digital learning resources	British Educational Communications and Technology Agency (BECTA) (2007)
National Policies and Practices on ICT in Education: England.	M.J. Cox (2009)

3

Primary school pupils' ICT competences: Extensive model and scale development

This chapter is based on:

Aesaert, K., van Braak, J., Van Nijlen, D., & Vanderlinde, R. (2015). Primary school pupils' ICT competences: Extensive model and scale development. *Computers & Education, 81*, 326-344

Chapter 3

Primary school pupils' ICT competences: Extensive model and scale development

Abstract

In search of factors that affect pupils' ICT competences, research has developed and empirically validated several conceptual frameworks. Although these frameworks are valuable ways of initially identifying factors related to pupils' ICT competences, they do not take into account the broader classroom and school context in which pupils are embedded. Moreover, most frameworks and their corresponding instruments focus on post-primary education. This study first presents a multilayered model that can be used to guide future studies that try to explain why some primary-school pupils are more effective in acquiring ICT competences than others. Factors are situated on the pupil, classroom and school level. Second, this study provides future research with a range of reliable measurement instruments to identify factors related to primary school pupils' ICT competences. These factors were drawn from the developed multilayered model. A survey was conducted in a large sample of primary school pupils (n = 2413), their parents (n = 2267) and their teachers (n = 134). The results of the replication exploratory and confirmatory factor analyses indicate a good factorial validity and reliability of the developed scales.

1. Introduction

ICT plays an important role in developing a person's skills of collaboration, social interaction, information retrieval and civic participation (Zhong, 2011). As such, people (in particular, learners) should master advanced ICT competences (Aesaert, Vanderlinde, Tondeur, & van Braak, 2013). In the context of the 21st century skills movement, the European Commission defined the use of ICT as one of the eight key competences for lifelong learning (i.e., a competence that people need for personal fulfillment, active citizenship, social cohesion and employability in a knowledge society (European Commission, 2008)). Recent research indicates that the variability in ICT competences is related to the degree to which people benefit from the use of computers (Hargittai & Hinnant, 2008). For example, people who lack ICT competences tend to use online public services less frequently than those who are digitally skilled (van Deursen & van Dijk, 2009). Hargittai and Hinnant (2008) found that people with higher self-reported levels of knowledge of online-related terms are more likely to visit websites that can have a substantial influence on the development of their human and financial capital. Consequently, the disparity in ICT competence might exacerbate existing social inequalities (van Deursen & van Dijk, 2011). These studies indicate the importance of mastering ICT competences and underline their importance as educational outcomes next to traditional curriculum content and attainment targets. Recently, certain national governments have recognized this importance and have designed and issued ICT curricula for their schools. Thus, gaining ICT competences is becoming a compulsory educational outcome and schools and teachers are being entrusted with the responsibility of providing pupils with equal opportunities for developing them (Vanderlinde, van Braak, & Hermans, 2009).

Next to national governments, research on ICT in education has also been paying more attention to this notion of ICT competences. However, in such research two problems seem to arise. First, studies that have identified factors related to ICT competences mostly focus on the pupil level and do not take into account the larger educational and social context (i.e., the context in which pupils develop such competences) (Bunz, Curry, & Voon, 2007; Hargittai & Shafer, 2006; van Deursen & van Dijk, 2011). However, nowadays it is widely accepted that research investigating the impact of certain factors on educational outcomes – such as ICT competences – should be multilevel in nature (Creemers & Kyriakides, 2008), reflecting a pupil, classroom, school and overall context level. At present, research on ICT competences, is mainly directed towards pupil level factors (e.g. sex, ICT attitude, out of school ICT experience (Kuhlemeier & Hemker, 2007; Wu & Tsai, 2006; van Deursen & van Dijk, 2011)) and less towards factors at the classroom level (e.g. ICT experience in the classroom, ICT competences of the teacher (Evers, Sinnaeve, Clarebout, van Braak, & Elen, 2009; Claro et al., 2012)), school level (e.g. availability of an ICT coordinator, a school's policy on educational ICT use (Berge, Hatlevik, Kløvstad, Ottestad, & Skaug, 2009; Vanderlinde, Dexter, & van Braak, 2012)) and general or overall context level (e.g. ICT penetration rate of a country, educational expenditure (Zhong, 2011)). The second problem is that most studies are conducted in the context of post-primary education (Meelissen, 2008). However, in terms of national and international curricula for early childhood and primary education, research indicates that ICT competences should already be taught at an early age (Aesaert et al., 2013). Therefore, this study focuses on ICT competences in the context of primary school. As such, the purpose of this study is twofold:

- First, to develop a multilayered, extensive conceptual model that integrates school, classroom, and pupil level factors that are likely related to primary school pupils' ICT competences. The conceptual nature of our model is emphasized as well as its need for empirical validation in future research.

- Second, to develop and validate a range of quantitative research instruments that can be used to measure the factors integrated in the said conceptual model.

2. ICT competences

The notion of 'competence' has been conceptualized in different ways in the literature, and can be categorized as those which follow a theoretical perspective and those which follow an operational perspective (Westera, 2001). From a theoretical perspective, a competence is defined as a basic cognitive structure that is distinguished from, but facilitates specific behaviors or performances. From an operational perspective, competences refer to higher-order skills or behaviors employed in complex and unpredictable situations. According to Westera (2001), these competences include knowledge, skills, attitudes, metacognition and strategic thinking.

Markauskaite (2007) considers ICT literacy and ICT competences from an operational perspective. The author defines them as the interactive use of 1) general cognitive abilities, and 2) technical abilities which function to successfully complete cognitive-information and ICT-based tasks. ICT competence scales largely focus on subcategories of computer and internet use, such as web navigation and web editing skills (Bunz, 2004), hardware operating skills (Donker & Reitsma, 2007), higher-order information processing skills, online communication skills (Liang & Tsai, 2008), online exploration (Tsai & Tsai, 2010), and basic and maintenance skills (Verhoeven, Heerwegh, & De Wit, 2010). van Deursen and van Dijk (2011) consider ICT competences from the perspective of a range of internet skills, including operational internet skills (basic skills), formal internet skills (navigation and orientation), information internet skills (locating required information) and strategic internet skills (taking advantage of the internet). The authors particularly stress the hierarchical structure of these categories, i.e., information and strategic internet skills, which are content related and depend on the operational and formal internet skills, which are considered medium related. This means that one needs to possess the medium-related skills in order to properly employ the content related skills.

In this study, ICT competences are considered from an operational perspective, where the integrated, hierarchical structure of skills is taken into account. This means that ICT competences refer to higher-order learning processing competences that integrate technical and application skills (Aesaert et al., 2013). The technical and application skills refer to the use of basic software, such as saving a text, sending an e-mail, word processing, etc. (Volman, van Eck, Heemskerk, & Kuiper, 2005). The higher-order learning processing skills refer to the ability to be creative, innovative, solve problems and think critically with a computer, such as communicating and searching, synthesizing and evaluating information in a digital context (Claro et al., 2012 and European Commision, 2008). With this definition of ICT competences, the question arises as to what factors contribute to explaining differences in these complex abilities.

3. Research aims

As mentioned, most studies on ICT competences focus solely on pupil level factors and do not take into account the multilayered structure in which they are embedded. Zhong's (2011) study is an exception, as the author offers a well-considered overview of factors at the context level (i.e., ICT penetration rate of a country, educational expenditure), the school level (i.e., school type, ICT access at school) and the pupil level (i.e., socioeconomic status, ICT access at home, previous ICT experience, gender) that are understood to affect pupils' self-perceived ICT competence (defined as ICT self-efficacy) in secondary schools. However, in Zhong's (2011) study certain important factors are not taken into account, such as teachers' ICT competences, the schools' ICT policy, or the support that pupils receive at home when they work with a computer. The latter factor can be considered as important, as some single level studies already found a positive relationship between pupils' ICT competences and the support they receive at home (Vekiri, 2010). With respect to teachers' ICT competences and a school's ICT policy, the literature has repeatedly stated these factors promote the integration and effective use of ICT in the classroom (Tondeur, Valcke, & van Braak, 2008; Hew & Brush, 2007). As such, it can also be expected that these factors are related to pupils' ICT competences through the use of ICT in the classroom. Further, Zhong's study (2011) used a self-perceived rather than an actual, performance-based measure of ICT competence. Such measures of pupils' judgment of their competence can have problems related to validity, particularly with respect to self-reported bias (Ballantine, McCourt Larres, & Oyelere, 2007).

The present study attempts to elaborate on Zhong's (2011) research in three ways: 1) ICT competence is conceptualized by means of a self-perceived and an actual measure of the construct; 2) a model is developed within the context of primary education; and 3) more factors are integrated at the pupil, classroom and school level. Consequently, *the first aim of this study is to develop an extensive model that contains factors related to primary school pupils' ICT competences at the school, classroom and pupil level.*

The purpose of developing this model is to guide future empirical research into the differences in primary school pupils' ICT competences. However, for some of the factors integrated in this model, validated instruments are unavailable. More specifically, whereas some scales that have been used in primary education are available (e.g. the school's ICT vision and policy scale of Vanderlinde and van Braak (2010) and the Raven Progressive Matrices scale of Raven, Raven, & Court (2003)), other scales have only been validated for use in secondary and post-secondary education and need to be adapted and validated for their use in primary education (e.g. the PISA learning style scales (OECD, 2004)). Moreover, other factors that we integrate into our model have no existing scales at this time (e.g. primary school pupils' ICT self-efficacy). The second part of this study focuses on instrument development. Thus, *the second aim of this study is to adapt existing and/or design new instruments to measure different factors of the developed model.* In this context we validate scales for measuring the factors in the model designed for primary education.

4. Research aim 1: Development of the EDC-model

Below we outline the development of the Extensive Digital Competence Model (EDC-model). In Section 4.1, we describe the factors that were drawn from the literature for inclusion in the model. Section 4.2, covers a description of development of the EDC-model itself.

The literature reviewed in order to identify factors to integrate into the model includes studies on ICT competences and ICT integration in schools. In terms of the literature on ICT competences, a distinction can be made between studies that use actual measures of ICT competence and those that are based on proxies, such as objective and self-perceived measures. Whereas 'actual' measures of ICT competences tend to be more valid, at this time much research appears to be conducted from the perspective of self-perceived ICT competence (Meelissen, 2008). In order to not overlook any relevant factors, we reviewed studies that are based on actual, objective and self-perceived measures of ICT competence. In this literature review, however, few studies were found on ICT-competence in primary schools. Thus, the literature on kindergarten and post-primary education was also included in our review.

Furthermore, the literature on ICT integration was also considered, as a general aim of integrating ICT in the classroom is to foster pupils' ICT competences. There it is assumed that factors promoting ICT integration could have an effect on pupils' ICT competences. We found that the research on ICT integration typically focuses on the classroom and, more recently, on the school level. For both levels, the literature reports on ICT-related and non-ICT related factors of ICT integration. Because recent quantitative studies indicate that the ICT-related classroom and school conditions are important for the integration of ICT into the classroom and non-ICT-related conditions are not (Vanderlinde, Aesaert, & van Braak, 2014), non-ICT related factors at the classroom and school level, such as teacher efficacy or school leadership (Vanderlinde & van Braak, 2011; Vanderlinde et al., 2014) will not be considered in this study. However, we found that at the pupil level research indicates significant relationships between ICT related pupil factors and ICT competences and also a relation between non-ICT-related pupil factors and ICT competences. As such, ICT-related and non ICT-related pupil factors will be considered in this study. With regard to the 'educational level' of the factors used to build the model, special attention was paid to the school, classroom and pupil level. Factors for the context or macro (i.e. country or state) level were not retained in the model. Research on such macro level factors is extremely scarce and no consistent significant relationships between these factors and pupils' ICT competences have yet been identified (Zhong, 2011). Table 1 provides an overview of the factors that were retrieved from the literature.

Level	Type	Factor
Pupil	ICT related	ICT experience ICT use ICT attitude ICT availability Parental ICT support
	Non ICT-related	Sex Socioeconomic status Age Learning style Learning motivation
Classroom	ICT-related	ICT experience ICT use ICT infrastructure ICT competence ICT attitude ICT professional development
School	ICT-related	ICT infrastructure School's vision and policy on ICT ICT support

Table 1. Overview from the factors retrieved from the literature

4.1. Previous research on factors related to ICT competences

4.1.1. Pupil level

4.1.1.1. ICT related pupil characteristics

ICT experience at home

In the assessment of pupils' ICT competences numerous studies tend to focus on their general ICT experience. General ICT experience is frequently operationalized as the number of years a child has been using a computer/the internet (van Deursen & van Dijk, 2011) or the daily/weekly time spent using a computer/the internet (Tsai & Tsai, 2010). Research indicates that there is either a positive (Fagan, Neill, & Wooldridge, 2003; Liang & Tsai, 2008; van Braak, 2004) or a non-significant relationship (Ballantine et al., 2007; Sam, Othman & Nordin, 2005) between pupils' ICT experience at home and their ICT competences.

Out of school ICT use

ICT use refers to pupils' use of specific types of computer and online applications. Kuhlemeier and Hemker (2007) found that 13 – 15 year-old pupils' level of internet skills is related to the extent to which they use e-mail, online chatting and word-processing software, but not by the extent to which they use home computers for games and music. Livingstone and Helsper (2007) found that 9 - 19 year-olds who use the internet more conservatively and take up less online opportunities have less-developed online skills and lower ICT self-efficacy. Thus, it is possible that the specific nature of ICT use influences ICT competence.

Pupil's ICT attitude

Pamuk and Peker (2009) investigated the relationship between several dimensions of the Computer Attitude Scale and ICT competence. The authors found that pre-service teachers' computer self-efficacy was negatively related to computer anxiety and positively related to computer confidence, liking computers and perceived computer usefulness. Similarly, Wu and Tsai (2006) found that university students a) with higher confidence about their independent control of internet usage, b) who perceive the internet as useful for individuals and society, c) who perceive their actual use of the internet as high, and d) who have positive feelings about the internet (i.e., instead of feeling anxious), show higher general internet self-efficacy and higher communicative internet self-efficacy.

ICT availability

ICT availability (often termed ICT access or ICT infrastructure) is frequently operationalized as computer and internet ownership at home (2004; McCoy, 2010; Sackes, Trundle, & Bell, 2011; van Braak). Several studies (e.g. Pamuk & Peker, 2009; Tsai & Tsai, 2010; Zhong, 2011) indicate that students from secondary and higher education with a computer, educational software and internet availability at home, report higher levels of digital skills.

Parental ICT support

Parental ICT support refers to parents' expressed beliefs about and involvement in their child's ICT use. Parental ICT support can go further than simply providing their children with technological infrastructure. Parents can 1) offer psychological support by expressing the value and usefulness of the child's ICT use; 2) create learning opportunities by providing ICT resources and technological assistance; and 3) regulate the child's ICT activities (Vekiri, 2010). In terms of the relationship between parental ICT support and ICT competences, research reveals mixed findings. Whereas Vekiri (2010) indicates a positive correlation between parental support and primary pupils' ICT competences, Kiesler, Zdaniuk, Lundmark, and Kraut (2000) found no evidence that family support increases internet skills.

4.1.1.2. Non ICT-related pupil characteristics

Sex

ICT competences are often studied with a focus on sex and socioeconomic status (Meelissen, 2008). However, over the years research has produced mixed findings. Whereas some studies indicate that sex is positively related to students' ICT competences in favor of boys (Hakkarainen et al., 2000; Kuhlemeier & Hemker, 2007; Li & Kirkup, 2007), this relationship is not confirmed in other studies (Donker & Reitsma, 2007; Durndell & Haag, 2002; Pamuk & Peker, 2009). Moreover, research indicates that the relationship between ICT competences and sex is determined by the type of skills and ICT use being measured. Whereas the association between sex and online relationship and communication competences is significantly positive in favor of girls, boys appear to rate themselves as more skilled in technical ICT abilities (Bunz et al., 2007; Tsai & Tsai, 2010). Furthermore, Bunz et al. (2007) found a significant relationship between self-perceived computer-email-web fluency in university students and sex in favor of males but not between students' actual fluency and sex.

Socioeconomic status

Similar to sex, consistent findings with regard to how socioeconomic status is related to pupils' ICT competences are lacking. Based on parents' education and occupation, Vekiri (2010) found that low-SES pupils from primary education expressed significantly lower ICT self-efficacy than those from middle- and high-SES groups. Claro et al. (2012) found that the higher the economic goods at secondary students' home, the higher their actual average information and communication competence performance. However, not all studies provide convincing evidence for the existence of such a relationship between SES and ICT competences (Verhoeven et al., 2010). For example, van Braak and Kavadias (2005) and Tondeur, Sinnaeve, Van Houtte, and van Braak (2011) found that SES does not affect ICT competences strongly enough to deduce that low SES contributes to lower and fewer ICT competences.

Age

Appel (2012) found that older secondary-school students possess better theoretical and practical computer knowledge than their younger secondary-school colleagues. Nevertheless, numerous studies have found no relationship between age and ICT competence (in primary, secondary and higher education) (Durndell & Haag, 2002; Hakkarainen et al., 2000). Some studies conducted in higher education and with adults seem to counterbalance these results. For example, older adults seem to have less developed formal and operational internet skills than younger adults (van Deursen & van Dijk, 2011).

Learning style

According to Verhoeven et al. (2010) a pupil's learning style is related to educational outcomes. Vermunt (1996) defines learning styles as “relatively stable, but not unchangeable, ways in which students learn” (p. 25). The author distinguishes between undirected, reproduction directed, meaning directed and application directed learning styles. A similar categorization representing deep and surface learning can be found in the PISA 2009 student survey, in which learning by reading strategies are covered by elaboration, memorization and control (Schleicher, Zimmer, Evans, & Clements, 2009). Verhoeven et al. (2010) found that secondary-school students' learning patterns are related to their self-perception of specific ICT skills. Students who apply meaning-directed learning styles consider themselves better in web editing and using basic ICT skills but not as good on internet use. Students with high scores on application-directed learning are better at basic skills, maintaining a computer and internet use, but do not differ from other students in web editing.

Learning motivation

Research indicates that pupils' learning motivation predicts their learning performance (Miltiadou & Savenye, 2003). Indeed, self-determination theory (SDT), in particular, has established itself as a useful framework in identifying relationships between pupils' motivation to study and learn and eventual outcomes (Vansteenkiste, Sierens, Soenens, Luyckx, & Lens, 2009). Until now, only a small number of studies have addressed this matter in computer and online environments (Miltiadou & Savenye, 2003). For example, Law, Lee, and Yu (2010) indicate that students who value intrinsic learning motivation factors higher (e.g., finding learning challenging), consider themselves better in using programming skills for solving problems.

4.1.2. Classroom level

4.1.2.1. ICT experience in the class

Above we identified ICT experience at home as a pupil level factor. However, the frequency of pupils' computer use in the class can also be considered as the opportunities that they are given by the teacher to learn with computers in the classroom. As such, ICT experience is also considered as a classroom level factor. With regard to computer experience in the classroom, Claro et al. (2012) did not identify frequency of ICT use as a significant predictor of students' digital information processing and communication skills. In contrast, Levine and Donitsa-Schmidt (1998) found that the extent of computer use at school correlates with pupils' self-perceived computer knowledge.

4.1.2.2. Educational ICT use

One major distinction between studies on ICT use concerns those that focus on computers as a subject from a technological perspective, and those that consider the use of computers as an educational tool to teach other subjects (Baylor & Ritchie, 2002). Some studies focusing on the technological perspective concentrate on the degree to which teachers apply specific software and hardware in their classroom (Williams, Coles, Wilson, Richardson, & Tuson, 2000). However, according to Tondeur, van Braak and Valcke (2007) concentrating on the application of software does not clarify the educational use of ICT. The authors' stress that computers can be integrated in different ways and should be approached from a more functional point of view. As such, they distinguish three types of ICT use: 1) use of ICT as an information tool; 2) use of ICT as a learning tool, and 3) use of ICT to learn basic ICT skills. Thus, it is likely that differences in the type of ICT use in the class will lead to differences in pupils' ICT competences.

4.1.2.3. ICT Infrastructure in the class

ICT infrastructure is often operationalized as the number of computers available to students in the classroom. As such, it refers to the physical access that pupils have to computers in the classroom. Whereas numerous studies have focused on ICT infrastructure at home, almost no attention has been paid to the relationship between ICT infrastructure in the classroom and pupils' ICT competences. One exception is the study of Sackes et al. (2011), who found that children who were in kindergarten classrooms with adequate access to computers developed better computer skills from kindergarten to third grade compared to children with low access to computers in the classroom. Moreover, it is not only the quantity, but also the quality of the hardware and software available that matters. In this regard, Vanderlinde and van Braak (2010) comment that teachers must feel satisfied with the available technology sources in order to use them.

4.1.2.4. Teacher's ICT competences

Teachers' ICT competences are considered important for facilitating the use of ICT in classrooms (Hew & Brush, 2007; Hughes, 2005). Evers et al. (2009) state that teachers' ICT competences are mostly operationalized as a combination of technical-instrumental ICT skills and knowledge, pedagogical-didactic competences to use ICT in the classroom, and organizational or management skills to use ICT in education. Research investigating the relationship between teachers' and pupils' ICT competences is very scarce. The results of Ross, Hogaboam-Gray, and Hannay (2001) indicate that teachers' self-perceived competence in teaching pupils how to use ICT is positively related to pupils' ICT self-efficacy. In this context, Berge et al. (2009) remark that the development of teachers' ICT competences can help narrow the divide in ICT literacy among students.

4.1.2.5. Teacher's ICT attitude

A variety of measurement scales are used in research on ICT attitudes (Meelissen, 2008). These scales often focus on one or two overlapping dimensions of ICT attitudes, such as feelings about ICT (e.g., computer anxiety and enjoyment), perceived relevance of computers or self-confidence in computer use (Meelissen, 2008). Research indicates that having a negative attitude towards ICT and not perceiving computer use as beneficial are barriers towards the integration of ICT (Hew & Brush, 2007; Karagiorgi, 2005). It is likely that teachers with a positive attitude towards computers and the internet, use ICT in a more challenging way and expect pupils to develop relevant competences, which in turn should lead to better ICT competences.

4.1.2.6. ICT professional development

Finally, research suggests that teachers' ICT professional development is an important factor for the use of ICT in the classroom (Vanderlinde et al., 2014; Daly, Pachler, & Pelletier, 2009). Hew and Brush (2007) state that ICT professional development that focuses on content provides teachers with opportunities for active learning, addresses their needs and concerns, can lead to positive ICT attitudes, and can improve teachers' ICT knowledge and skills. According to Vanderlinde and van Braak (2010), ICT professional development is not only about following pre-service and in-service teacher training, but also about teachers taking initiative in keeping generally informed about ICT.

4.1.3. School level

4.1.3.1. ICT infrastructure of the school

Hew and Brush (2007) state that the ICT infrastructure of a school can promote or hamper the integration of ICT into the classroom. Zhong (2011) found that schools' ICT infrastructure is positively related to secondary pupils' ICT competences. More specifically, students in schools with a higher number of computers available to teachers, students and administrators, and with a higher number of computers connected with the internet, report higher ICT competence than students in schools with lower ICT access. Berge et al. (2009) elaborate on this matter of computer availability by focusing on ICT infrastructure and access when needed. Their results show that students with access to a computer at school when needed, outperform their student colleagues without such full access. However, Zhao, Lu, Huang, and Wang (2010) found that internet accessibility was not positively related to high-school students' internet self-efficacy.

4.1.3.2. Vision on ICT and learning

Schools with a clear vision on ICT and learning that is shared among its teachers have better chances at successfully integrating ICT (Hughes & Zachariah, 2001). A school's vision and policy on ICT is often operationalized in an ICT policy plan which outlines different elements, such as the school's vision on ICT, professional development, ICT curriculum, software funds etc. (Vanderlinde et al., 2012). The results of Tondeur et al. (2008) indicate that teachers that share the goals and values outlined in an ICT policy plan tend to integrate ICT into their classroom more often. As such, these plans could act as a lever to implement ICT attainment targets developed at the macro level and thus support the development of pupils' ICT competences.

4.1.3.3. ICT support

According to Strudler and Hearrington (2008) ICT support increases the frequency of ICT use in the classroom. Tondeur et al., 2008 and Vanderlinde and van Braak, 2010 describe ICT support as the technological and pedagogical support that teachers receive in order to integrate ICT into their learning environments. Furthermore, Strudler (2004) states that ICT coordinators play an important role in providing teachers with the necessary support. In this regard, the study of Berge et al. (2009) indicates that students'

ICT literacy is significantly correlated with the availability of a full-time ICT coordinator at the school.

Devolder, Vanderlinde, van Braak, and Tondeur (2010) describe four functional roles for the ICT coordinator, i.e., the ICT coordinator as a person that 1) plans the ICT vision and policy of the school; 2) makes decisions about the ICT budget of the school; 3) takes responsibility for the maintenance of the ICT equipment; and 4) supports teachers in implementing and using ICT in the classroom. Lai and Pratt (2004) state that ICT coordinators spend most of their time on technical maintenance of hard- and software. It can be expected that teachers and pupils in schools with an ICT coordinator mainly focusing on pedagogical issues use ICT in a more advanced way in the classroom. In turn, this could result in pupils developing better ICT competences.

4.2. The EDC-model

Fig. 1 presents the EDC-model that was developed in this study. Pupils' ICT competences are considered as the output variable and are the central concept of the model. Within the context of the operational paradigm, ICT competences are defined as an integrated unit of 1) higher-order learning processing skills and knowledge; and 2) technical and application ICT knowledge and skills that pupils use in order to solve problems in a specific digital context. Technical and application ICT skills are considered as prerequisites for performing higher-order learning processing skills (Kuhlemeier & Hemker, 2007). Higher-order learning processing skills and the technical and application skills are deliberately not made concrete in the model. As such, they can be translated to specific subcategories of ICT competences according to the needs and problem statements of future research. It should be stressed that ICT competence is incorporated in the model as an actual, direct measure - preferably assessed with performance based items - as well as a self-perceived, indirect measure, such as ICT self-efficacy.

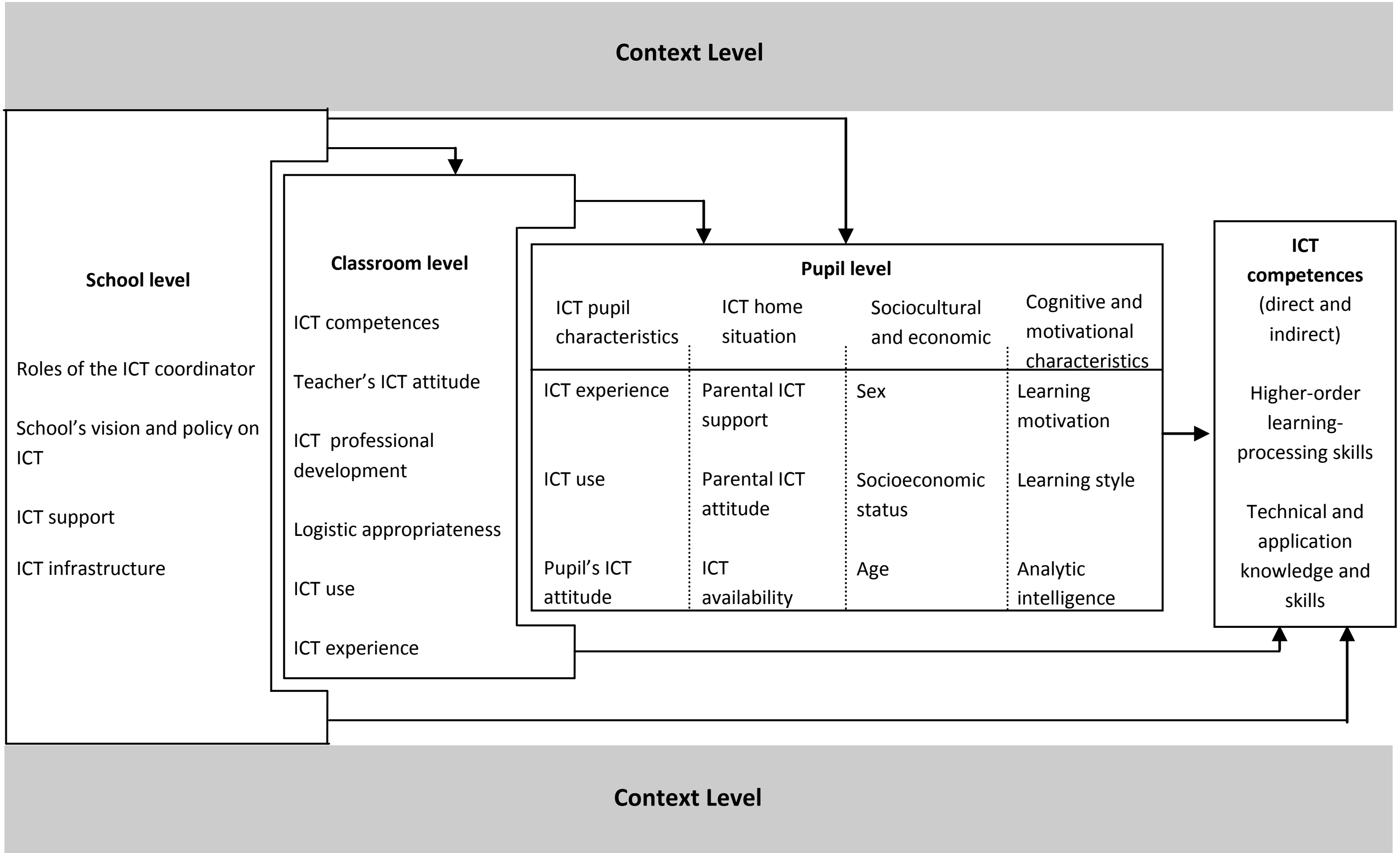

Figure 1. The Extensive Digital Competence (EDC) Model

The extensive nature of the model is expressed by its multilayered structure. Each level represents a set of factors that are likely related to primary school pupils' ICT competences. These factors can be situated at the school, classroom and pupil level. It can be expected that the higher levels provide conditions for the operation of the factors at the lower levels (Creemers & Kyriakides, 2008). This implies that pupils' ICT competences are developed through the combined effects of factors at different levels. Factors at the school and classroom level can have both direct and indirect effects on pupils' achievement. Consequently, the possibility of both direct and indirect effects is taken into account in the EDC-model.

The classification of the factors into school, classroom and pupil levels influences the types of actors that should be questioned in order to validate the model. Whereas teachers are best positioned to gather information on ICT related classroom level factors, ICT coordinators are best for gathering information on ICT related school level factors, such as the ICT infrastructure or a school's vision and policy on ICT (Tondeur, Valcke, & van Braak, 2008). As can be seen in Fig. 1, the ICT oriented home situation is integrated in the model as a subcategory at the pupil level. As the factors in this subcategory particularly refer to the actions that parents take in order to regulate their child's ICT use, it seems advisable to address pupils as well as parents when gathering information on the pupil level factors.

At the pupil level, the ICT related factors drawn from the literature were divided into ICT related factors emerging from the home situation and ICT related pupil characteristics. The non-ICT related pupil factors were categorized as those emerging from a sociocultural and economic perspective and pupil characteristics that have a cognitive and motivational basis. With regard to the latter category, learning styles (Verhoeven et al., 2010) and analytic intelligence were integrated in the model, whereas pupils' learning motivation (Ryan & Deci, 2000) is considered as an important motivational pupil characteristic.

Although not mentioned in previous studies on ICT competences, analytic intelligence was added as a measure of aptitude to the *cognitive and motivational pupil characteristics*. Several studies have indicated that aptitude has a big effect on educational outcomes (Kyriakides, 2005). Creemers and Kyriakides (2008) describe aptitude as general intelligence and prior knowledge. Because our definition of ICT competence focuses on the use of ICT while solving authentic problems, analytic intelligence was integrated as the ability to deal with novelty and to adapt one's thinking to a new cognitive problem (Carpenter, Just, & Shell, 1990). It can be expected that pupils with a higher ability to deal with new cognitive problems, also have a higher ability in dealing with ICT related problems such as synthesizing reliable digital information that was found on different online locations into an understandable and structured new digital product.

With regard to *sociocultural and economic background characteristics*, previous studies have indicated that sex, socioeconomic status and age can explain a part of the variance in pupils' ICT competences (Appel, 2012; Kuhlemeier & Hemker, 2007; Zhong, 2011). The third category of factors at the pupil level refers to the importance of an *ICT oriented home climate*. More specifically, we assume that parents' ICT attitude, the degree to which they support and regulate their child's ICT use (Vekiri, 2010), as well as the degree to which they make proper ICT infrastructure available at home, can have an impact on the child's ICT competences. Because previous research strongly indicates that ICT experience (Fagan et al., 2003), ICT use (Kuhlemeier & Hemker, 2007) and ICT attitude (Pamuk & Peker, 2009) are positively related to pupils' ICT competences, these factors were integrated into the model as *ICT related student background characteristics.*

At the classroom level only ICT related factors were integrated into the model. In the EDC model, the ICT related classroom factors represent the frequency with which ICT is used in the classroom (ICT experience), the specific ways in which ICT is used in the classroom (ICT use), the teacher's ICT competences, the teacher's ICT attitudes, the degree to which the teacher feels satisfied with the available ICT sources (logistic appropriateness), and the efforts that a teacher takes in order to update his own ICT knowledge, skills and attitudes (ICT professional development).

Similar to the classroom level, only ICT related school level factors were integrated into the model. At this level, the ICT related variables of the EDC-model deal with organizational factors that could affect the teaching and learning of ICT competences in the classroom, such as ICT support. This factor was divided into the technical and pedagogical support that teachers receive and the supportive roles that ICT coordinators take on board. Other factors at the school level include the school's vision and policy on ICT and the ICT infrastructure that is available to pupils in the school.

Finally, it is important to stress that the factors at the school, classroom and pupil level are embedded within a broader context of national and international ICT policies and ICT competence frameworks. National ICT policies can regulate school and classroom practices by integrating ICT competences in the curriculum and teacher education, or by providing schools and teachers with ICT resources such as network infrastructure or ICT related professional development (Fraillon & Ainley, 2010; Owston, 2007; Vanderlinde & van Braak, 2010). In this context, it is important to mention that countries with a strict centralized educational ICT policy and ICT curriculum set clear guidelines on what to teach and how to teach it and therefore, leaving schools and teachers not much freedom to decide. For example, in some countries the ICT curriculum strictly regulates whether educational ICT should be taught as a separate subject focusing on ICT competences or as a teaching and learning tool. As such, these factors create a context that can affect the teaching and learning of ICT competences (Aesaert et al., 2013). Besides the national context, international educational ICT policies are also becoming more important. For example, the UNESCO (2008) ‘ICT competency standards for teachers’ provides guidelines for preparing teachers to produce ICT competent pupils.

5. Research aim 2: scale development

The second part of this study focuses on the development, validation and administration of a set of reliable measurement scales for factors in the EDC-model that have not yet been designed for use in primary education.

5.1. Methods

5.1.1. Instruments

Instruments were developed to reliably measure only the factors in the model for which there are currently no validated scales available to use in primary education. For example, the factor ICT infrastructure (school level) does not require a scale to be developed because it can be operationalized as a measure of frequency (number of computers available to pupils in the school) (Zhong, 2011). Similarly, ICT experience is often operationalized as the amount of weekly or daily time during which a pupil makes use of a computer at school or at home (Tsai & Tsai, 2010). With regard to socioeconomic status, different measures exist, such as the educational level of the parents (Vekiri, 2010). ICT availability is mostly measured by asking pupils if they have a computer/internet at home (McCoy, 2010; van Braak, 2004). Pupils' ICT use is often measured at the item level, such as the degree to which pupils use e-mail, chatting, social media etc. (Kuhlemeier & Hemker, 2007). Therefore, scales do not need to be developed for these factors.

Furthermore, research refers to a number of validated measurement instruments for use in primary education at the school level. These include, roles of the ICT coordinator (Devolder et al., 2010), vision and policy on ICT, and ICT support (Vanderlinde & van Braak, 2010). In terms of the classroom level, we have validated measurement instruments for ICT competences, ICT professional development, logistic appropriateness, and ICT use (Tondeur et al., 2008; Vanderlinde & van Braak, 2010). At the pupil level, we have measures for analytic intelligence (Carpenter et al., 1990 and Raven et al., 2003). For our dependent variable ICT competence as an actual measure, a scale has recently been developed and validated for use in primary education by Aesaert, van Nijlen, Vanderlinde, and van Braak (2014).

In this study, instruments were developed for seven other factors of the EDC-model. For the factors learning motivation, learning style and parental ICT support, existing item scales were translated and adapted. With regard to parental ICT attitude and the teacher's ICT attitude, both factors were translated to the same new pair of items. A new set of items was also developed for pupils' ICT attitude and ICT-self-efficacy, of which the latter can be perceived as an indirect measure of ICT competence (dependent part of the EDC-model). Summarized information on the items can be found in Table 2. An overview of all the items can be found in Appendix A.

Factor (N/A)*	Level	Sample	Nr. Items	Item format
Learning motivation (A)	pupil	pupil	19	5 likert (totally disagree – totally agree)
Learning style (A)	pupil	pupil	13	4 likert (almost never – almost always)
Parental ICT support (A)	pupil	parents	21	5 likert (never – always)
Parental ICT attitude (N)	pupil	parents	6	5 likert (totally disagree – totally agree)
Teacher’s ICT attitude (N)	classroom	teacher	6	5 likert (totally disagree – totally agree)
Pupil’s ICT attitude (N)	pupil	pupil	5	6 likert (totally disagree – totally agree)
ICT self-efficacy (N)	pupil	pupil	24	4 likert (not good at all - very good)

Table 2. Item information

*N= new items; A= items adapted or translated for use in primary education

5.1.1.1. Learning motivation

In order to measure learning motivation in primary education, Vandevelde, Van Keer, and Rosseel (2013) adapted the academic self-regulation scale (Ryan & Connell, 1989; Vansteenkiste et al., 2009). The items represent the four SDT constructs of external regulation, introjected regulation, identified regulation and intrinsic motivation. Although these scales were validated for use in primary education, they do not take into consideration that some pupils are perhaps not motivated to learn. Consequently, the items of the Academic Motivation Scale (Vallerand et al., 1992) that represent pupils' amotivation to learn were adapted and translated for use in primary education. These four items measure the degree to which pupils have no sense of purpose or no expectation of a reward for going to school. The adapted items were added to the four scales of Vandevelde et al. (2013). The total of 19 items are rated on a 5-point Likert scale, where 1 = totally disagree and 5 = totally agree.

5.1.1.2. Learning style

Information on how pupils learn is gathered through items on learning style, which are adapted from the learning by reading strategies of the PISA 2009 student background questionnaire (Schleicher et al., 2009). The instrument makes a distinction between three types of learning styles. Pupils that use ‘control’ strategies try to plan, monitor and regulate their learning process, whereas ‘memorization’ strategies involve learning key terms and the repeated learning of material. Pupils that use ‘elaboration strategies’ try to connect the learning content to related material or come up with alternative solutions (OECD, 2004). The 13 items were rated on a 4-point Likert scale, ranging from 1 = almost never to 4 = almost always.

5.1.1.3. Parental ICT support

The parental ICT support items are based on the work of Valcke, Bonte, De Wever, and Rots (2010) on internet parenting styles. They measure the degree to which parents try to control and socialize their child's ICT use. More specifically, the items gather information on 1) the ICT usage rules that are maintained in the child's environment, 2) communication between the parents and the child concerning his/her ICT use, and 3) ICT-activities that parents do together with their child on the computer. Respondents were asked to rate the 21 items on a 5-point Likert scale, ranging from 1 = never to 5 = always.

5.1.1.4. Parents' and teachers' ICT attitude

The newly developed parental ICT attitude items are operationalized as the parents' beliefs about the general importance and usefulness of ICT use for their child. These six items assess the degree to which parents believe that the development of ICT competences will result in educational, social and economic benefit. The same items were used for the factor teacher's ICT attitude, i.e. the items measure the degree to which teachers believe that their pupils will benefit from being able to use ICT. The items are scored on a 5-point Likert scale, ranging from 1 = totally disagree to 5 = totally agree.

5.1.1.5. Pupil's ICT attitude

Five ICT-attitude items were developed that focus on pupils' liking of computers, personal interest in computer use, perceived usefulness of computer use and self-confidence in computer use (Evers et al., 2009). Pupils' answers were scored on a 6-point Likert scale, ranging from 1 = totally disagree to 6 = totally agree.

5.1.1.6. ICT self-efficacy

In order to measure primary school pupils' self-perceived ICT competences, 24 ICT-self-efficacy items were developed. Favoring a functional over a technical perspective, the items describe activities for which pupils must use specific software (e.g., search engine, e-mail program). Some items were accompanied by a screenshot of the software that pupils need to use. These steps were taken to make the items as understandable as possible for pupils in primary education.

The content of the items refers to higher order learning-process skills as well as to technical and procedural knowledge and skills. Because the amount and variety in ICT competences is very large, the items specifically focus on digital information processing and digital communication competences. Both subcategories of ICT competence were chosen because these are identified as two essential and recurring themes in national and international ICT frameworks (Voogt & Roblin, 2012). The ICT-self-efficacy items were rated on a 4-point Likert scale, ranging from 1 = not good at all to 4 = very good.

5.1.2. Participants

To gather information on the pupil level factors learning motivation, learning style, pupils' ICT attitude and ICT self-efficacy, a questionnaire was developed and administered to all the pupils from 6th grade (age 11–12) from 96 primary schools in Flanders, the Dutch speaking region of Belgium. 98.49% of the pupils (n = 2413) completed the pencil and paper questionnaire, with 47.68% being male and 52.32% being female. To collect data on the factors parental ICT support and parental ICT attitude, a questionnaire was administered to the pupils' parents. Parents had the choice between an online or a pencil and paper questionnaire. Of the parent sample, 92.30% (n = 2267) completed the questionnaire. Because the parent that completed the questionnaire spoke on behalf of both parents, the sex of the parents is not mentioned. In order to gather information on the factor teacher's ICT attitude, an online questionnaire was administered to the pupils' teachers. The response rate of the teachers was 94.4% (n = 134) with 32.1% being male and 67.9% being female). The average teaching experience of the teacher sample was 17.7 years (range 1–38 years; SD = 10.6). In order to guarantee school representativeness, there was explicit stratification for school size (small school < 180 pupils; big school ≥ 180 pupils) and educational network, i.e., official public education, subsidized public-authority education and subsidized private-authority education, and implicit stratification for province.

5.1.3. Data analysis

In order to check the quality of our instruments, exploratory (EFA) and confirmatory factor analysis (CFA) is used. Although EFA is a widely used technique for investigating the underlying structure of an instrument, the stability of EFA solutions is mostly not checked with different samples. In this context, simulation studies indicate that EFA often poorly replicate, even with large samples and clear factor structures (Costello & Osborne, 2005; Osborne & Fitzpatrick, 2012). As such, it is not always clear whether the results of EFA are stable over different samples and should be used in CFA or not.

In order to investigate the stability of our EFA solutions, an internal replication study is conducted on the pupil and parent sample. For the teachers, the analyses were conducted on the total sample, as the total sample size was only 134. For this purpose, the pupil and parent sample were proportionally divided into five corresponding subsamples i.e. the first parent subsample contained the data of the parents of the children of the first pupil subsample. The pupils of the five subsamples were evenly distributed over the 96 schools and were all matched for sex ($\chi^2(4, N = 2413) = 0.57, p = .97$). Dividing the original sample allowed us to conduct an EFA replication analysis on subsample 1 and 2, and different CFAs on subsamples 3, 4 and 5. Two thresholds for replicability of EFA are used in this study. The first basic threshold – known as structural replicability – should replicate the same basic factor structure for subsample 2 as subsample 1. This is done by specifying the same number of factors to be extracted from subsample 2 as subsample 1 using the same extraction and rotation procedures. Following this, we check whether the strongest loading for each item on a specific factor is congruent for both subsamples (Osborne & Fitzpatrick, 2012). The second, more rigorous threshold for replicability is the identification of factor loadings that are roughly equivalent in magnitude for each specific item across subsamples. Osborne and Fitzpatrick (2012) suggest a difference of |.20| as a starting value for considering factor loadings as volatile. With regard to the replication analyses in the CFAs, the magnitude of the factor loadings and differences in model-fit measures were checked for subsamples 3, 4 and 5.

All the adapted and new item sets ran through three stages of scale development. First, using SPSS Statistics 21, a Maximum Likelihood EFA was conducted to discover the number of latent variables that underlie the items belonging to each construct. We checked whether any of the items violated the assumption of normal distribution i.e. if the kurtosis and skewness values were not too high. Because we consider it unreasonable that the subconstructs of the variables of the EDC-model are unrelated, factors were allowed to correlate using Oblimin oblique rotation (Reise, Waller, & Comrey, 2000). Because the K1 rule (eigenvalue > 1) tends to overfactor (Hayton, Allen, & Scarpello, 2004), factor extraction was based on the scree test and parallel analysis criterion (Floyd & Widaman, 1995). Further, it should be mentioned that listwise deletion was used in the EFA's, which caused variation in the sample sizes between different constructs. For example, the sample size of subsample 1 is 483 for the EFA on 'learning styles', whereas the size of the same sample is 504 for the EFA on 'pupils' ICT attitude'. As can be seen in Table 3, the generally used minimum requirement of 5–10 participants per item in EFA and CFA, is met for all factors in all five subsamples (Floyd & Widaman, 1995). Next, it was checked whether the EFA solution passed the basic and more rigorous threshold of replicability.

Factor	**Sample**	**Nr. Items**	**subsample 1** ***n*** **(ratio)**	**subsample 2** ***n*** **(ratio)**	**subsample 3** ***n*** **(ratio)**	**subsample 4** ***n*** **(ratio)**	**subsample 5** ***n*** **(ratio)**
Learning motivation	pupil	19	*501* (26)	*443* (23)	*419* (22)	*436* (23)	*404* (21)
Learning style	pupil	13	*483* (37)	*424* (32)	*445* (34)	*443* (34)	*408* (31)
Parental ICT support	parents	21	*366 (17)*	*337* (16)	*343* (16)	*327* (16)	*321* (15)
Parental ICT attitude	parents	6	*476* (79)	*476* (79)	*454* (76)	*430* (72)	*406* (68)
Teacher's ICT attitude	teacher	6	/	/	/	/	/
Pupil's ICT attitude	pupil	5	*504* (101)	*453* (91)	*482* (96)	*466* (93)	*434* (87)
ICT self-efficacy	pupil	24	*361* (15)	*328* (14)	*348* (15)	*335* (14)	*325* (14)

Table 3. Ratio subsample size to number of items

In the second stage, CFA (Amos 21) was used to assess whether the proposed factor structure of the EFAs fits the data well. For this, several fit indices were calculated. Because the commonly used chi-square goodness-of-fit-test depends heavily on the sample size, it is not reported. The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) did not do well in Monte Carlo evaluations (Floyd & Widaman, 1995). Consequently, they are accompanied by alternative measures of fit such as the Tucker–Lewis index (TLI), comparative fit index (CFI) and the RMSEA (Bentler, 1990; Floyd and Widaman, 1995). Values of the RMSEA between .05 and .08 indicate an adequate fit, whereas values less than .05 indicate a close fit (Finch & West, 1997). GFI, AGFI, TLI and CFI are expected to have values above .90. The CFAs were conducted on subsamples 3, 4 and 5.

In the third stage, the reliability of the developed scales was checked. Cronbach's alpha was calculated as a measure of internal consistency in order to determine the psychometric quality of the scales. For the pupil and parent data, Cronbach's alpha was calculated for subsample 1.

5.2. Results

5.2.1. Learning motivation

Because the four amotivation items were adapted for use in primary education, first, an EFA was conducted on these four items. No items violated the assumption of normal distribution. The results of the scree test and the parallel analysis during the first analysis on subsample 1 (n = 501) indicated a one-factor solution. This one-factor model accounts for 47.0% of the common variance. The factor was labeled amotivation and provides information on the degree to which pupils have no sense of purpose or no expectation of reward for going to school. The results of the replication analysis on subsample 2 (n = 443) indicate that this scale meets the threshold of structural and rigorous replication. More specifically, all items in both subsamples (see Table 4) have a strong loading on factor 1 and the largest difference between the factor loadings of subsample 1 and 2 is |.06|.

Following this, a CFA was conducted on subsample 3 (n = 419) in order to check the hypothesized five factor structure stability of amotivation, extrinsic regulation, introjected regulation, identified regulation and intrinsic regulation. The results indicate a good fit between the theoretical model and the data (GFI = .92; AGFI = .90; TLI = .93; CFI = .94; and RMSEA = .06). All factor loadings were significant at the .001-level and varied between .44 and .94. A replication of the CFA on subsample 4 (n = 436) and 5 (n = 404) yielded approximately the same results. All model-fit indices between subsample 3, 4 and 5 were roughly the same. With regard to the differences in factor loading magnitudes, only item 10 and 11 seem to have rather large differences. As such, this was not considered problematic and all items were retained.

Finally, a reliability analysis was conducted on subsample 1. The Cronbach's alphas varied between .68 and .88, indicating relatively good to good internal consistency of the five factors. Five scales were constructed with a range between 1 and 5. Descriptive statistics and Pearson's product–moment correlation coefficients between the scales are shown in Table 5. As expected, the more autonomous forms of motivation (intrinsic and identified regulation) are significantly positive related with each other, but negatively with amotivation and controlled motivation (extrinsic and introjected regulation).

	EFA		CFA														
Subsample	SS1	SS2	SS3					SS4					SS5				
Factor	1	1	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Factor label	Amotivation	Amotivation	Amotivation	Extrinsic regulation	Introjected regulation	Identified regulation	Intrinsic regulation	Amotivation	Extrinsic regulation	Introjected regulation	Identified regulation	Intrinsic regulation	Amotivation	Extrinsic regulation	Introjected regulation	Identified regulation	Intrinsic regulation
Item:																	
Item 1	.65	.70	.63					.57					.62				
Item 2	.59	.65	.71					.60					.66				
Item 3	.71	.68	.63					.72					.62				
Item 4	.77	.75	.71					.82					.70				
Item 5				.82					.80					.87			
Item 6				.94					.92					.90			
Item 7				.80					.76					.76			
Item 8					.44					.31					.43		
Item 9					.45					.57					.56		
Item 10					.81					.60					.54		
Item 11					.58					.35					.38		
Item 12						.69					.63					.70	
Item 13						.66					.67					.73	
Item 14						.63					.68					.81	
Item 15						.83					.84					.85	
Item 16							.79					.83					.83
Item 17							.69					.68					.74
Item 18							.74					.69					.78
Item 19							.74					.73					.76
Model fit:					*GFI:.92*					*GFI:.93*					*GFI: .93*		
					AGFI:.90					*AGFI:.91*					*AGFI:.91*		
					TLI:.93					*TLI:.94*					*TLI:.96*		
					CFI:.94					*CFI:.95*					*CFI:.96*		
					RMSEA:.06					*RMSEA:.05*					*RMSEA:.05*		

Table 4. Factor loadings and model-fit indices for the learning motivation items

		α	**M**	**SD**	**(1)**	**(2)**	**(3)**	**(4)**
(1)	Amotivation	.77	1.91	0.75	1.00			
(2)	Extrinsic regulation	.88	2.77	1.21	.34**	1.00		
(3)	Introjected regulation	.68	2.74	0.87	.24**	.32**	1.00	
(4)	Identified regulation	.86	4.31	0.70	-.56**	-.31**	-.03	1.00
(5)	Intrinsic regulation	.88	3.50	0.92	-40	-.32**	-.04	.63** ;

Table 5. Reliability coefficients, descriptive statistics and correlation coefficients for the learning motivation scales; **p<.01

5.2.2. Learning style

To identify the underlying structure of the 13 learning style items, an EFA was conducted on subsample 1 (n = 483). No items were deleted due to a high kurtosis or skewness. The calculations of the parallel analysis suggested a three-factor solution, which resulted in a model that accounts for 33.8% of the common variance. Four items were deleted due to low loadings. The extracted three factors confirmed the theoretical constructs of the original instruments used in the PISA-study i.e. learning by memorizing, controlling, elaborating (Schleicher et al., 2009). The replication analysis indicates that the instrument meets the threshold of structural replicability. As can be seen in Table 6, all items have their strongest loadings (bold) on congruent factors for subsample 1 and 2. Furthermore, the maximum difference in factor loading magnitude between subsample 1 and 2 is |.11|, indicating that the threshold of rigorous replicability is met.

In order to confirm the stability of this hypothesized structure in primary education, a CFA of the nine remaining items was conducted on subsample 3 (n = 445). The results indicate that the hypothesized three-factor model fits the data relatively well (GFI = .97; AGFI = .94; TLI = .89; CFI = .93; RMSEA = .07). Table 6 shows that the nine remaining items load significantly on the three latent factors with factor loadings between .37 and .84 for subsample 3. These results are reinforced as the CFA on subsample 4 (n = 443) and 5 (n = 408) yielded similar factor loadings and model-fit indices.

The scores of Cronbach's alphas indicate that the internal consistency of the items of memorization (α = .57), control (α = .62) and elaboration (α = .70) is questionable rather than good. Table 7 presents information on the constructed mean scales and the Pearson product–moment correlation between the mean scales. The results indicate a positive significant correlation between the three subscales of pupils' learning styles.

	EFA						CFA									
Subsample	SS1			SS2			SS3			SS4			SS5			
Factor	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Factor label	Memorisation	Control	Elaboration	Memorisation	Control	Elaboration	Memorisation	Control	Elaboration	Memorisation	Control	Elaboration	Memorisation	Control	Elaboration	
Item:																
Item 1	**.43**	.07	-.04	**.32**	.18	.12	.37			.43			.41			
*Item 2**	.17	.25	-.14	.08	.31	-.11										
*Item 3**	.20	.23	-.11	.32	.12	-.04										
*Item 4**	.09	.25	-.34	.25	.12	-.33										
Item 5	**.74**	-.13	-.02	**.70**	-.14	-.09	.56			.67			.52			
Item 6	.09	**.49**	-.04	.15	**.50**	-.01		.64			.65			.70		
Item 7	**.47**	.19	.03	**.53**	.12	-.06	.71			.66			.66			
Item 8	-.00	-.00	**-.60**	-.07	.09	**-.66**			.51			.58			.59	
Item 9	-.17	**.76**	-.08	-.09	**.76**	-.06		.59			.58			.46		
Item 10	.05	-.02	**-.63**	.16	-.09	**-.57**			.59			.60			.57	
Item 11	.07	**.60**	.09	-.02	**.57**	-.01		.57			.38			.57		
Item 12	-.05	-.04	**-.79**	-.08	.09	**-.72**			.84			.75			.68	
*Item 13**	.06	.31	-.16	.17	.33	-.11										
Model fit:							*GFI:.97* *AGFI:.94* *TLI:.89* *CFI:.93* *RMSEA:.07*			*GFI:.98* *AGFI:.97* *TLI:.96* *CFI:.98* *RMSEA:.04*			*GFI: .98* *AGFI:.96* *TLI:.96* *CFI:.98* *RMSEA:.04*			

Table 6. Factor loadings and model-fit indices for the learning style items

* Item was removed due to low loading or cross-loading; items in bold refer to highest loading on a factor for a specific subsample

		A	M	SD	(1)	(2)
(1)	Memorization	.57	2.62	0.65	1.00	
(2)	Control	.62	3.16	0.58	.33**	1.00
(3)	Elaboration	.70	2.08	0.70	.26**	.25**

Table 7. Reliability coefficients, descriptive statistics and correlation coefficients for the learning style scales; **p<.01

5.2.3. Parental support

In order to explore which latent variables underlie the adapted 21 parental ICT support items, an EFA was conducted on the parent subsample 1 (n = 366). Item 20 was deleted due to high kurtosis. The scree plot and the results of the parallel analysis suggested retaining two factors. Consequently, the items were forced onto two factors. Item 6 and 19 were removed due to low factor loadings. The two-factor solution accounts for 47.6% of the common variance. Our solution did not replicate the three-factor structure from the literature. The two factors were labeled 'active ICT support' and 'ICT rules'. The items on active ICT support measure the degree to which parents communicate to the usefulness of ICT to their child and engage in ICT-activities with their child. The ICT rules-items assess the degree to which parents try to control their child's ICT use by imposing rules on them and talking about it. Table 8 shows that this retrieved solution was replicated for subsample 2 (n = 337). All items with the strongest loading on factor 1 in subsample 1, also load on the first factor in subsample 2. This means that the items are assigned to the same factors in both analyses and that structural replicability is met. Furthermore, the factor loadings between subsample 1 and 2 are roughly equivalent in magnitude, with a maximum difference of |.13|. In order to validate the hypothesized two-factor structure, a CFA of the 18 remaining items was conducted on subsample 3 (n = 343). The results show a relatively good fit between the two-factor model and the data (GFI = .88; AGFI = .84; TLI = .90; CFI = .92; RMSEA = .08). The factor loadings varied between .50 and .84 and were all significant at the .001-level. As can be seen in Table 8, the results of the replication CFA on subsample 4 (n = 327) and 5 (n = 321), yield almost identical results, reinforcing the validation of the hypothesized structure.

The reliability analysis indicated that both factors 'active ICT support' (α = .92) and 'ICT rules' (α = .86) have a good internal consistency. Consequently, two scales were created which vary between 1 and 5. The Pearson's product–moment correlation in Table 9 shows that both scales are significantly positive related.

	EFA				CFA					
Subsample	SS1		SS2		SS3		SS4		SS5	
Factor	1	2	1	2	1	2	1	2	1	2
Factor label	Active support	ICT rules	Active support	ICT rules	Active support	ICT rules	Active support	ICT rules	Active support	ICT rules
Item:										
Item 1	.76	.08	.73	.05	.72		.70		.73	
Item 2	.63	-.05	.62	-.01	.67		.61		.68	
Item 3	.61	-.02	.74	.07	.62		.63		.68	
Item 4	.64	.04	.75	.07	.57		.62		.62	
Item 5	.69	.05	.74	.06	.65		.67		.66	
*Item 6**	.28	-.07	.36	-.00						
Item 7	.57	-.04	.62	.03	.64		.64		.64	
Item 8	.82	.07	.70	-.06	.73		.68		.73	
Item 9	.78	-.04	.73	-.10	.75		.75		.76	
Item 10	.72	-.05	.65	-.07	.68		.69		.70	
Item 11	.56	-.01	.46	-.04	.50		.55		.55	
Item 12	.81	-.02	.75	.00	.82		.76		.82	
Item 13	.75	.00	.74	-.07	.81		.84		.76	
Item 14	.63	-.04	.66	-.10	.74		.71		.73	

Item 15	.35	-.51	.22	-.55		.63		.74		.69
Item 16	-.14	-.91	-.12	-.95		.76		.67		.69
Item 17	-.09	-.90	-.19	-.96		.75		.75		.74
Item 18	.10	-.68	.06	-.68		.84		.77		.88
*Item 19**	.06	-.31	.13	-.34						
Item 21	.23	-.48	.13	-.44		.67		.58		.65
Model fit:					*GFI:.88*		*GFI:.87*		*GFI:.87*	
					AGFI:.84		*AGFI:.83*		*AGFI:.83*	
					TLI:.90		*TLI:.90*		*TLI:.90*	
					CFI:.92		*CFI:.92*		*CFI:.92*	
					RMSEA:.08		*RMSEA:.08*		*RMSEA:.08*	

Table 8. Factor loadings and model-fit indices for the parental support items

* Item was removed due to low or cross-loading; items in bold refer to highest loading on a factor for a specific subsample

	α	**M**	**SD**	**(1)**	**(2)**
(1) Active ICT support	.92	3.14	.76	1.00	
(2) ICT rules	.86	3.93	.92	.57**	1.00

Table 9. Reliability coefficients, descriptive statistics and correlation coefficients for the ICT support and ICT rules scales; **p<.01

5.2.4. Parental ICT attitude

In order to investigate the underlying structure of the six ICT attitude items, an EFA was conducted on the parental subsample 1 (n = 476). Item 1 was removed due to violation of the assumption of normal distribution. Following the results of the scree test and the parallel analysis, a one-factor solution was retained which accounts for 53.9% of the common variance. This factor was labeled parental ICT attitude and refers to parents' beliefs about the educational, social and economic usefulness of being able to work with a computer. With regard to the replication EFA on subsample 2 (n = 476), Table 10 shows that all items in subsamples 1 and 2 have a strong loading on factor 1. Moreover, the items' factor loadings between the subsamples are very similar in magnitude. As such, both thresholds of replication are met and the identified one-factor structure will be used in the CFA.

The CFA on the parent subsample 3 (n = 454) confirmed the hypothesized one-factor structure (GFI = 1.00; AGFI = .98; TLI = 1.00; CFI = 1.00; RMSEA = .03). All five items loaded significantly (p < .001) on the one factor with values between .52 and .84. As can be seen in Table 10, similar factor loadings and model-fit indices were also found during the CFAs on subsample 4 (n = 430) and 5 (n = 406).

The reliability analysis showed a good internal consistency (α = .85) for the five items. A mean scale was created with values within a range of 1–5 (M = 3.86, SD = .71).

	EFA		CFA		
Subsample	SS1	SS2	SS3	SS4	SS5
Factor	1	1	1	1	1
Factor label			Parental ICT attitude	Parental ICT attitude	Parental ICT attitude
Item:					
Item 2	.71	.69	.63	.61	.60
Item 3	.85	.78	.84	.83	.81
Item 4	.82	.86	.78	.83	.76
Item 5	.58	.62	.52	.65	.56
Item 6	.68	.74	.60	.71	.71
Model fit:			*GFI:.1.00*	*GFI:.99*	*GFI:.99*
			AGFI:.98	*AGFI:.97*	*AGFI:.96*
			TLI:.1.00	*TLI:.99*	*TLI:.98*
			CFI:.1.00	*CFI:.99*	*CFI:.99*
			RMSEA:.03	*RMSEA:.05*	*RMSEA:.06*

Table 10. Factor loadings and model-fit indices for the parental ICT attitude items

5.2.5. Pupil's ICT attitude

In order to investigate the underlying structure of the five ICT attitude items, an EFA was conducted on subsample 1 (n = 504). No items were deleted due to a high kurtosis or skewness. The results of the scree test and parallel analysis showed a one-factor solution, which accounted for 45.9% of the common variance. This factor was labeled pupil's ICT attitude and measures the degree to which pupils 1) perceive themselves as interested and confident computer users; and 2) see the use of computers as beneficial. The results of the replication EFA on subsample 2 (n = 453) indicate the stability of the solution in different samples. With regard to subsample 1 and 2, all items have high factor loadings on factor 1, with a maximum difference in magnitude of |.05|.

The CFA conducted on subsample 3 (n = 482) confirmed the hypothesized one-factor solution. The fit estimates indicate that the data fit the model well (GFI = 1.00; AGFI = 0.99; TLI = 1.00; CFI = 1.00; and RMSEA = .02). All items load well on the latent factor with factor loadings between .55 and .88. All factor loadings were significant at the .001

level. As can be seen in Table 11, the replication CFAs on subsample 4 (n = 466) and 5 (n = 434) yielded similar results.

Finally, the internal consistency of the 'pupil's ICT attitude' items was checked on subsample 1. The good internal consistency (α=.80) allowed us to summarize the items of pupils' general ICT attitude into a mean scale with a range 1-6 (M=4.36, SD=0.99).

	EFA		CFA		
Subsample	SS1	SS2	SS3	SS4	SS5
Factor	1	1	1	1	1
Factor label			Pupils' ICT attitude	Pupils' ICT attitude	Pupils' ICT attitude
Item:					
Item 1	.65	.66	.71	.75	.79
Item 2	.80	.77	.69	.75	.78
Item 3	.81	.76	.88	86	.90
Item 4	.62	.61	.55	.54	.62
Item 5	.45	.49	.56	.45	.54
Model fit:			*GFI:.1.00*	*GFI:.1.00*	*GFI:.1.00*
			AGFI:.99	*AGFI:.99*	*AGFI:.1.00*
			TLI:.1.00	*TLI:.1.00*	*TLI:.1.00*
			CFI:.1.00	*CFI:.1.00*	*CFI:.1.00*
			RMSEA:.02	*RMSEA:.00*	*RMSEA:.00*

Table 11. Factor loadings and model-fit indices for the pupils' ICT attitude items

5.2.6. ICT self-efficacy

In order to explore the structures underlying the 24 ICT self-efficacy items, an EFA was conducted on subsample 1 (n = 361). Five items were removed from the analysis due to high values of kurtosis and/or skewness. The results of the scree test and the parallel analysis indicate a one-factor solution. Item 21 was deleted due to a low factor loading. The one factor model accounts for 32.8% of the common variance. The factor was labeled 'ICT self-efficacy' and measures pupils' perceptions about their own competence in higher-order information and communication processing knowledge and skills with ICT as well as their technical ICT skills. The results of the replication analysis on subsample 2 (n = 328) indicate that this ICT self-efficacy scale meets the threshold of structural and rigorous replication. All items in subsamples 1 and 2 (see Table 12) have a strong loading on factor 1 and the largest difference between the loadings of subsample 1 and 2 is |.14|. Although item 4 has a factor loading of .33 in subsample 2, the item was retained due to its importance for construct validity and the good factor loading in subsample 1.

Following this, a CFA was conducted on subsample 3 (n = 348). The fit indices illustrate that the one-factor model fits the data relatively well (GFI = .90; AGFI = .87; TLI = .89; CFI = .90; RMSEA = .06). All items load significantly ($p < .001$) on the one factor with factor loadings varying between .42 and .67. As can be seen in Table 12, the CFA on subsample 3 was well replicated on subsample 4 (n = 335) and 5 (n = 325).

In the last step of the analysis, a reliability analysis was conducted. Based on the good internal consistency of the items (α = .89), a mean scale was constructed with a range between 1 and 4 (M = 3.38, SD = .42).

	EFA		**CFA**		
Subsample	SS1	SS2	SS3	SS4	SS5
Factor	1	1	1	1	1
Factor label			ICT self-efficacy	ICT self-efficacy	ICT self-efficacy
Item:					
Item 1	.64	.52	.62	.64	.62
Item 2	.54	.40	.44	.48	.53
Item 3	.62	.56	.53	.56	.55
Item 4	.48	.33	.42	.46	.41
Item 5	.49	.50	.53	.52	.62
Item 6	.48	.43	.44	.36	.38
Item 7	.57	.45	.55	.58	.42
Item 8	.57	.58	.66	.59	.60
Item 9	.60	.50	.55	.51	.59
Item 11	.57	.53	.53	.56	.58
Item 12	.62	.48	.53	.60	.56
Item 13	.69	.68	.51	.63	.69
Item 14	.66	.71	.61	.69	.65
Item 17	.47	.54	.51	.60	.55
Item 20	.67	.62	.67	.69	.61
*Item 21**	.39	.39			
Item 22	.60	.61	.59	.64	.63
Item 23	.57	.57	.57	.62	.58
Item 24	.54	.58	.50	.57	.51
Model fit:			*GFI: .90*	*GFI: .91*	*GFI: .91*
			AGFI: .87	*AGFI: .88*	*AGFI: .88*
			TLI: .89	*TLI: .92*	*TLI: .91*
			CFI: .90	*CFI: .93*	*CFI: .92*
			RMSEA: .06	*RMSEA:.06*	*RMSEA: .06*

Table 12. Factor loadings and model-fit indices for the ICT self-efficacy items

5.2.7. Teacher's ICT attitude

To investigate the underlying structure of the teachers' ICT attitude items only a CFA was conducted for two reasons. First, the teacher sample only consisted of 134 subjects. An EFA on such a small sample would lead to instable results. Second, the items presented to the teachers were the same as those presented to the parents, which revealed a one-factor solution.

Similar to the analysis of the parents' ICT attitude items, the first item was deleted due to violation of the assumption of normal distribution. As the fit indices show, the data of the teacher sample fits the one-factor model well (GFI = .99; AGFI = .96; TLI = .99; CFI = 1.00; RMSEA = .015). The five remaining items load relatively well on the one factor, with values between .54 and .81 ($p < .001$). The factor was labeled teacher's ICT attitude and measures the degree to which teachers believe that the use of computers has educational, social and economic benefits for their pupils.

The results of the reliability analysis indicated a relatively good internal consistency of the one factor ($\alpha = .79$). Based on these results the mean scale teachers' ICT attitude was created with a range between 1 and 5 ($M = 3.60$; $SD = 0.60$).

6. Discussion and conclusion

The first aim of this study was to develop a model that gathers factors that are likely related to primary school pupils' ICT competences. This resulted in the EDC-model. The development of the EDC-model adds to the research literature on ICT competences by providing a multilayered extensive model that can act as a blueprint when studying pupils' learning and achievement of ICT competences. The model contains factors that are expected to affect the development of pupils' ICT competences. The factors are presented in different categories representing ICT related school characteristics, ICT related classroom characteristics, pupils' socio-economic background variables, pupils' cognitive and motivational characteristics, pupils' ICT related factors and pupils' ICT supportive climate at home.

In the model, the dependent variable 'ICT competence' is conceptually perceived as a direct measure as well as a self-perceived measure of ICT self-efficacy, of which the latter can be considered as a proxy of pupils' actual ICT competences. The model can be used to guide future research that focuses on the assessment of pupils' actual competences, their self-perceived ICT ability, and the differences and interactions between these. Thus, researchers can investigate the factors that affect the degree to which pupils can accurately judge their ICT competences. More particularly, they can investigate whether the difference between pupils' actual and self-perceived ICT competences (i.e., the accuracy of their judgment of their ICT competences) is related to their actual ICT proficiency, and which factors contribute to this relationship. This is particularly relevant in a primary-school educational context as it can be expected that young children experience more difficulties in judging their own abilities than their adolescent and adult colleagues in secondary and higher education.

An advantage of the model is its ability to be adapted to suit various research needs. The content of the factors included was intentionally not made mutually exclusive or specifically predefined. For example, depending on researchers' interest in specific ICT skills, the model can be used to measure the application of specific software skills and influencing factors. At present, the conceptual nature of the model and the importance of testing its validity must be emphasized. Results of future studies should help generate empirical support for the EDC-model. These studies can shed light on the stability and/or actual existence of the proposed effects of the factors and lead to possible expansions, restrictions or adaptations to the model.

The second aim of this study was to develop and validate reliable measurement scales that represent the factors of the EDC-model for use in primary education. The results of the EFA and CFA in this study indicate that the new and adapted scales have a relatively good to adequate level of factorial validity that is stable across different samples. With the exception of parents' active ICT support and rules, all of the scales confirm the factor structures as hypothesized in previous literature. Parents' active ICT support is considered as one factor, whereas previous research makes a distinction between parents communicating with their children about ICT and parents engaging in ICT-activities with their children (Valcke et al., 2010). With regard to the reliability of the scales, all scales show an adequate level of internal consistency, except for the learning styles subscales with alphas between .57 and .70. A possible explanation for this is that primary-school pupils are not yet fully aware of their own learning style and cannot yet make a clear distinction between different learning styles. Consequently they can experience difficulty expressing themselves in terms of how they learn. Future research could focus on learning styles from a more performance-based perspective e.g. observations of pupils when they are actually learning.

Although the results of our study only indicate preliminary support for the factorial validity and reliability of the developed scales, they provide psychometric evidence for using the scales in future research into the assessment of pupils' ICT competence and factors related to it. However, future research should focus on a complete assessment of the psychometric properties of the scales. For example, in order to fully understand whether the developed instruments have the same factor structure across different groups, measurement invariance (in CFA) could be checked for some specific grouping criteria such as sex or socioeconomic status. Furthermore, the scales should be cross-culturally validated considering the national and international context level in which the model is embedded.

Within the context of instrument development and validation, we consider it as a limitation of this study that the validity problem of self-reported ICT competences was only addressed in a conceptual way. More specifically, ICT competences were integrated in the EDC-model as a direct and indirect measure, but only an indirect measure of ICT competence, i.e., ICT self-efficacy was developed and empirically validated. As such, the difficulties in measuring pupils' actual ICT competences were not resolved in this study. Recently however, some performance based standardized scales have been developed to measure pupils' actual ICT competences, such as the Basic Computer Skills scale (Goldhammer, Naumann, & Keßel, 2013) or the digital information and communication scale (Aesaert et al., 2014), of which the latter is based on the concept of ICT competence as perceived in the EDC-model.

To conclude, this study provides a set of reliable instruments that can be used in future quantitative research to investigate factors that may determine primary-school pupils' ICT competences. More specifically, the developed scales can be used in order to control the degree to which the characteristics of the EDC-model are related to primary pupils' actual and self-perceived ICT competences. In this context, special attention should be paid to interaction effects between the factors as well as to differential effectiveness.

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Appendix A

Learning motivation
I do my best for school…

Item 1	but actually I do not know why.
Item 2	but I think it is a waste of time.
Item 3	but I do not understand why I should do my best.
Item 4	but I do not see the advantage of doing it.
Item 5	because I am supposed to do so by others (my parents, the teacher, …).
Item 6	because others (my parents, the teacher, …) oblige me to do so.
Item 7	because others (my parents, the teacher, …) force me to do so.
Item 8	because I would feel guilty if I didn't do my best.
Item 9	because I would feel ashamed if I didn't to my best.
Item 10	because I want others (my parents, the teacher, …) to think I'm smart.
Item 11	because I want to show others (my parents, the teacher, …) that I am a good student.
Item 12	because I want to learn new things.
Item 13	because I think it is important for the future.
Item 14	because I find it useful for myself.
Item 15	because I find it important for me as a person.
Item 16	because I find it very interesting.
Item 17	because I enjoy doing it.
Item 18	because it intrigues me.
Item 19	because I like doing it.

Learning style
When I learn…

Item 1	I try to learn everything by heart.
Item 2	I try to find out what I must learn exactly.
Item 3	I try to learn as much possible details by heart.
Item 4	I search connections between new things and things I've learned in other lessons.
Item 5	I read the learning material until I can say it by heart.
Item 6	I check if I understand what I have read.
Item 7	I read the learning material over and over again.
Item 8	I try to find out how I could use that what I'm learning outside the school.
Item 9	I try to find out which things I do not understand completely.
Item 10	I try to understand the lessons better by linking them to my personal experiences.
Item 11	I make sure I remember the most important elements of the lesson.
Item 12	I check how the information from the lesson fits in daily life.
Item 13	I try to search for extra information in order to get something I do not fully understand.

Parental ICT support

Item 1	My partner or I show my child how to search for information on the Internet in an efficient way.
Item 2	My partner or I show my child the difference between websites with reliable information and websites with non-reliable information.
Item 3	My partner or I show my child how to write an e-mail that is social acceptable.
Item 4	My partner or I sit together at the computer with my child to write a message to someone of which the content is understandable.
Item 5	My partner or I sit together at the computer with my child to compare the information of different websites.
Item 6	My partner or I sit together at the computer with my child to play games.
Item 7	My partner or I sit together at the computer with my child when he/she must create something (e.g. a presentation, poster, text, …).
Item 8	My partner or I talk with my child about the information he/she finds on the Internet.
Item 9	My partner or I talk with my child about the information he/she wants to search on the Internet.
Item 10	My partner or I talk with my child about the things he/she creates on the computer.
Item 11	My child asks my partner or me for advice when he/she encounters technical problems with the computer.
Item 12	My partner or I talk with my child about different ways to search for information.
Item 13	My partner or I talk with my child about how he/she can communicate with others using a computer.
Item 14	My partner or I talk with my child about the content of the messages that he/she receives from and sends to others.

Item 15	My partner or I discuss the house rules about computer and Internet use with my child.
Item 16	My partner or I decide on which moments our child can use the computer and the Internet.
Item 17	My partner or I limit the time in which our child can use the computer.
Item 18	My partner or I decide on the activities that our child can and cannot do on the computer.
Item 19	My partner or I prohibit our child to put personal information on the Internet (e.g. for an online competition or survey).
Item 20	My child may use the Internet to communicate only with persons he/she knows.
Item 21	My partner or I decide which websites our child can visit on the Internet.

Parental ICT attitude

Item 1	My partner or I think it is important that my child can work with a computer.
Item 2	If my child learns to work with a computer, he/she will get better grades at school.
Item 3	If my child learns to work with a computer, he/she will be more successful in the future.
Item 4	If my child learns to work with a computer, he/she will get a better job.
Item 5	If my child learns to work with a computer, he/she will get in contact with information that otherwise remains unknown to him/her.
Item 6	If my child learns to work with a computer, he/she will be able to participate better in society.

Teacher's ICT attitude

Item 1	I think it is important that my pupils can work with a computer.
Item 2	If my pupils learn to work with a computer, they will get better grades at school.
Item 3	If my pupils learn to work with a computer, they will be more successful in the future.
Item 4	If my pupils learn to work with a computer, they will get a better job.
Item 5	If my pupils learn to work with a computer, they will get in contact with information that otherwise remains unknown to him/her.
Item 6	If my pupils learn to work with a computer, they will be able to participate better in society.

ICT self-efficacy

Item 1	How good can you search for information on the internet?
Item 2	How good can you configure a search engine to search for images?
Item 3	How good can you improve a false search query in order to find the right information?
Item 4	How good can you judge if the information on a website is true or false?
Item 5	How good can you use the information of different websites to make a new product with the computer?
Item 6	How good can you send a polite e-mail?
Item 7	How good can you use e-mail to ask a clear question that is completely understandable for the receiver?
Item 8	How good can you use e-mail to inform a friend about something you have found on the internet?
Item 9	You are sitting at a computer, together with a pupil who has difficulties with reading. How good can you add matching images to a text, in order for the pupil to be able to follow the text?
Item 10	Here you see an image of a search engine. How good can u use a search engine to find the information that you need?*
Item 11	Here you see an image of a website's menu. How good can u use the menu of a website to find something on that website?*
Item 12	Here you see an image of a digital form. How good can you fill in such a digital form?*
Item 13	How good can you save a text on a computer?
Item 14	How good can you find a saved text on a computer?
Item 15	How good can you open an image on a computer?
Item 16	How good can you copy an image on a computer?
Item 17	How good can you play a movie on a computer?
Item 18	How good can you send an e-mail?
Item 19	How good can you delete an e-mail?
Item 20	How good can you open an attachment of an e-mail?
Item 21	How good can you type with a computer?
Item 22	How good can you use an USB-stick?
Item 23	How good can you use a cd-rom?
Item 24	How good can you change the background of your desktop?

* items supported by an image in order to make the content more concrete and understandable for pupils.

4

Gender and socioeconomic differences in pupils' ICT competences: The development of a performance-based ICT competence test

This chapter is based on:

Aesaert, K., & van Braak, J. (2015). Gender and socioeconomic related differences in performance based ICT competences. *Computers & Education, 84*, 8-25.

Chapter 4

Gender and socioeconomic differences in pupils' ICT competences: The development of a performance-based ICT competence test

Abstract

In the past, several studies have investigated the relationship between gender and socioeconomic status on the one hand, and students' ICT competences on the other. In this research field, two problems seem to occur. First, research findings are inconclusive. Second, most studies are conducted from the perspective of self-perceived ICT competence. Such measures suffer from self-reported bias, as they depend on students' own judgment of their ICT competences. This study aims to tackle both these problems. First, the outline of the design of a computer and performance-based assessment test that measures primary school pupils' ICT competences in a direct and valid way is presented. Second, the relationship between gender and socioeconomic status, and the pupils' results on the test i.e. their actual ICT competences was investigated. The performance-based test was administered to a representative sample of 378 sixth-grade pupils of 58 primary schools. The results of this study indicate that primary school pupils in general have particular difficulties in higher-order ICT competences that focus on communicating in a socially acceptable and clearly understandable way. Moreover, results show that girls have better technical ICT skills and higher-order ICT competences than boys. With regard to socioeconomic status, results show that the educational level of the mother is positively related to both pupils' technical ICT skills and higher-order ICT competences.

1. Introduction

The acronym ICT stands for information and communication technology and refers in principle to all possible technologies that are used for locating and processing information, communicating and producing digital media such as computer technology, smartphones, the Internet, multimedia, etcetera (Anderson, 2008; Ito, 2008). In this study, ICT is limited to the use of computers and the Internet. Mastery of ICT competences is considered as an essential key competence to function in our present economy and society (Bunz, Curry, & Voon, 2007; European Commission, 2007). Computers and the Internet – and especially the ability to operate them – are considered as important in order to develop skills for social interaction, civic participation, information retrieval and processing, and professional success and advancement (Sieverding & Koch, 2009; Zhong, 2011). For these purposes, some national governments have recently designed and administered formal expectations to schools in terms of ICT competence frameworks or standards (Vanderlinde, van Braak, & Hermans, 2009). Consequently, ICT competences can be considered as educational outcomes that pupils need to acquire. As schools are expected to take the initiative to develop pupils' ICT competences, a valid assessment of pupils' ICT competences is necessary.

With regard to the assessment of ICT competences, a distinction can be made between research using self-reported measures (indirect measurement) and research using observation and performance based measures (direct measurement) (Litt, 2013). The literature indicates that the main research interest is directed towards self-reported measures of ICT competences and ICT self-efficacy (Hargittai, 2005; Meelissen, 2008; van Deursen & van Dijk, 2011) as such measures easily permit the collection and analysis of data from big samples. In this context, several self-report instruments have been developed and used to measure certain aspects of pupils' ICT competences or pupils' ICT competences in general, such as the general internet self-efficacy scale (GISE) and the communicative internet self-efficacy scale (CISE) of Liang and Tsai (2008), or the online exploration and online communication scale of Tsai and Tsai (2010). Torkzadeh and Van Dyke (2002) have operationalized Internet self-efficacy as students' confidence in browsing, system manipulation and encryption/decryption. Bunz' (2004) Computer-Email-Web fluency scale measures students' self-perceived ability in general computer use, e-mail use, Web navigation and Web editing. Although these measures are useful for investigating students' self-perceived abilities within large samples, they are less appropriate for measuring students' actual ICT competences. It is well-known that ability measures that are based on students' own judgment cope with validity-problems of self-reported bias (Ballantine et al. 2007; Bunz et al., 2007; Hakkarainen et al., 2000; van Deursen & van Dijk, 2011). Students can over and underestimate their own ICT competences (Merritt, Smith, & Di Renzo, 2005). As such, self-perceived or self-reported measures are not always a valid representation of their actual ability to use ICT.

Some researchers have tried to tackle these shortcomings of self-reported measurements by assessing students' ICT competences in a more direct way, i.e., through observation and performance based ICT competence studies. In general, such studies involve students performing actions on a computer while being observed and evaluated by the researcher (Litt, 2013). Performance-based assessment tasks are valuable because they guarantee direct and authentic appraisals of complex competences (Messick, 1994). As such, it can be expected that performance-based tests using authentic tasks are more valid for measuring the complexity of students' ICT competences. Although these observations and performance-based measures have higher validity, they are also time consuming, expensive, more difficult to replicate and more difficult to conduct on large samples. In order to cope with some of these limitations, international large-scale assessment initiatives have recently been set up to measure students' ICT competences in a direct and standardized way using computer based software, such as ICILS or iSkills (Fraillon & Ainley, 2010; Katz, 2007). Although these studies have great scientific value, they do not address the ICT competences of primary school pupils.

The general purpose of this study is twofold: 1) First, we wish to tackle the problem of indirect assessment by outlining the design of a computer-based assessment test that can be used to measure primary school pupils' ICT competences in a direct and valid way; 2) Second, we wish to investigate primary school pupils' ICT competences by describing their performance on the developed test. For this, special attention will be paid to the relationship between gender and socioeconomic status on the one hand, and pupils' ICT competences on the other. We consider this essential, as previous research states that both of these variables are important correlates (Bunz et al., 2007; Claro et al., 2012; Volman, van Eck, Heemskerk, & Kuiper, 2005), but offers inconclusive results on the matter. Moreover, most studies that investigate the relationship with gender and SES are conducted from the perspective of self-assessment rather than focusing on actual, valid measures of ICT competence.

2. Background

2.1. ICT competences

In general, ICT competences refer to a student's ability to use information and communication technology. In the last 35 years, the interpretation of the concept of ICT competence has gone through three stages (Martin, 2006). During a first stage, ICT competences referred to basic skills incorporating specialist knowledge, basic programming and computer mastery (up until the mid-1980s). In the second stage, ICT competences were characterized as practical application skills for using common software at home and at work (up until the late 1990s). In a third and present stage, these basic skill and application oriented approaches to ICT competences are considered as important, but insufficient to cope with the challenges of our present information society (Voogt, 2008). In the context of the third stage, the need for a more critical, evaluative and reflective approach to ICT competences that supersede technical and application skills is stressed. As such, ICT competences are perceived as complex and multilayered constructs, in which the skills of the earlier stages remain as subordinate layers (Martin, 2006). Several authors follow this reflective and hierarchical conceptualization of ICT competences. For example, Markauskaite (2007) describes an ICT competence as the interactive use of general cognitive and technical capabilities in order to solve computer based problems and tasks. Within the context of the 21st century skills movement, the European Commission (2007) defines ICT competences as the "the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet" (p. 7). Similarly, van Deursen and van Dijk (2011) stress the hierarchical structure and complexity of ICT competences in the specific context of internet skills. The authors make a distinction between two types of content related skills, i.e., information internet skills and strategic internet skills, and two types of medium related skills, i.e., operational internet skills and formal internet skills (navigation and orientation skills). The authors emphasize the conditional nature of these four types of internet skills. More specifically, they state that the content related skills depend on the medium related skills. This means that a person without mastery of the basic skills will not even come to perform the content related skills (van Deursen & van Dijk, 2011). In this study, the same reflective and hierarchical approach to ICT competences is followed. As such, an ICT competence refers to a multilayered unit of a higher-order learning-process oriented competences used and developed in complex situations, and in which technical ICT knowledge and skills are integrated. We elaborate on this definition in section 4.1 below.

2.2. Gender, socioeconomic status and ICT competences

A vast amount of research in the field of educational ICT use has focused on gender differences in ICT skills (Volman et al., 2005). However, consistent results with regard to the relationship between gender and ICT competences are still lacking. Nevertheless, what has become clear in recent years is that more nuanced measures that focus on specific types of ICT competences and ICT related activities provide more detailed results than general measures. For example, Li and Kirkup (2007) found that males consider themselves better than females at using search engines to find digital information. Similarly, the results of Hargittai and Hinnant (2008) indicate that females report lower ability in understanding Internet-related terms. Bunz et al. (2007) found a significant positive association between sex and online relationship and communication competences in favor of girls, whereas boys rate themselves as more skilled in technical ICT abilities. Similarly, a study of Jones, Ramanau, Cross and Healing (2010) indicates that male students perceive themselves better at certain ICT activities, such as using spreadsheets, graphics, audio/video, computer maintenance and security. However, no relationship was found for other ICT activities such as using presentation software, using online library resources, and writing and commenting on blogs and wikis. Whereas the studies mentioned did find a relationship in favor of males or females, some studies could not replicate these results and did not find a significant association between gender and ICT competences (Pamuk & Peker, 2009).

Similar to gender, research reports mixed findings with regard to the relationship between socioeconomic status and ICT competences. Claro et al. (2012) found that the higher the students' socioeconomic goods at home, the better they score on ICT competence tests measuring their competence in digital information sourcing and processing, effective communication, and interacting and collaborating in virtual environments. Volman et al. (2005) found that students from an ethnic-minority background consider themselves less equipped with ICT skills related to the use of word-processing, Internet, illustrations, e-mail, presentation software, Windows and bookmarking favorites. On the contrary, other studies provide evidence that the relationship between SES and ICT competences is too weak to determine whether lower SES contributes to less developed ICT competences (Tondeur, Sinnaeve, Van Houtte, & van Braak, 2011).

Besides being inconsistent, these results are often acquired through studies that focus on students' self-reported ICT competences rather than on their actual ICT competences. As such, more nuanced and valid measures that assess students' actual ICT competences might provide further insight into the relationship between gender, SES and ICT competences.

3. Research aims

The general purpose of this study is twofold. First, this study aims to tackle the shortcoming that research focusing on ICT competences is mostly conducted through indirect measurement. As mentioned above, these indirect measurements suffer from self-reported bias, as students can over-and underestimate their own ICT competences.

Although some direct assessment initiatives with good scientific value have been set up, these are often based on observation, making them expensive, difficult to replicate, and hard to conduct on large samples. This study tries to elaborate on these direct assessment initiatives by presenting a large scale assessment initiative that can be used to measure primary school pupils' ICT competences in a valid and standardized way with large samples. As such, the first aim of this study is to *outline the design of a computer-based test that can be used to measure primary school pupils' ICT competences in a direct and valid way*.

The second purpose of this study is to use the results of the computer-based test to gain clearer insight into primary school pupils' ICT competences, and how differences in ICT competences are related to gender and SES. This study elaborates on previous research on the relationship between gender, SES and ICT competences, as the results will be based on a direct performance-based measurement rather than on self-reported measures. As such, the second aim of this study is to *identify differences in pupils' ICT competences and how these relate to gender and socioeconomic status.*

4. First purpose: General outline of a performance based ICT competence test

4.1. Developing a test framework

A first step into the process of test development is the delineation of the construct of ICT competence into a test framework. The test framework delineates and operationalizes the concept of ICT competence to be measured, i.e., it describes the scope of the construct to be measured (APA-AERA-NCME, 1999). More specifically, it contains all the competences and skills that will be measured with the test. The delineation of the test framework is guided by a content analysis of the construct. Based on this content analysis, all competences are divided into subcompetences and categorized into the test framework (Van Nijlen et al., 2013). The test framework can be considered as the heart of the test-development process as it guides subsequent item development and evaluation. As the performance-based test is to be administered to the primary school pupils of Flanders, it is important that the developed test framework matches the Flemish ICT curriculum. The attainment targets of the Flemish ICT curriculum (see Chapter 1) are perceived as learning process oriented ICT competences such as searching and processing information, communicating using ICT, and being creative with ICT, underpinned by technical and application oriented ICT skills (De Craemer, 2008). This means that the Flemish ICT curriculum follows the same hierarchical approach to ICT competences as used in this study (Aesaert, Vanderlinde, Tondeur, & van Braak, 2013).

4.1.1. Selection of ICT competences

A first step into the delineation of the test framework was the selection of the ICT competences to be measured with our test. As stated above, an ICT competence is perceived as a multilayered unit of higher-order learning-process oriented competences used in complex situations and in which technical ICT knowledge and skills are integrated. In order to measure the complexity of an ICT competence in a valid way, the use of a performance-based test with authentic tasks is preferred over conventional item designs such as multiple choice (Aesaert, Van Nijlen, Vanderlinde, & van Braak, 2014). However, the administration of a performance-based test with authentic tasks takes time. As a result of this, it was impossible to develop a test that covers the total scope of the construct of ICT competence or all eight attainment targets of the Flemish ICT curriculum. The scope of the construct of ICT competence itself is very broad, containing a wide range of different competences, such as locating digital information, being creative with computers, actively producing digital media, etc. (Ito et al., 2008). Because of the time restrictions associated with performance-based testing and the broad scope of the construct of ICT competence, it was decided only to select two competences for measurement.

The results of Voogt and Pareja Roblin's (2012) international comparative study of 21st century skill frameworks indicate that locating and processing digital information as well as communicating with a computer and the internet are two essential competences that students should master in the present knowledge society. Similarly, Aesaert et al. (2013) found that retrieving, processing and saving appropriate digital information and communicating in a safe, sensible and appropriate way using ICT, emerged as two central attainment targets in national ICT curricula such as the Flemish ICT curriculum. Moreover, students still seem to encounter difficulties with both themes. In this regard, Calvani, Fini, Ranieri, and Pici (2012) state that students experience problems with higher-order cognitive competences such as locating and using the right information on the internet. Additionally, Kuiper, Volman and Terwel (2005) state that students have difficulties evaluating the reliability and relevance of online information. Van Deursen and van Diepen (2013) elaborate on these results, suggesting that students still have difficulties defining proper search queries and evaluating the reliability of the information in the results of these search queries. Moreover, students that search online information seem to have trouble selecting relevant categories from web-like menus (Puustinen & Rouet, 2009). With regard to digital communication, it seems that students still have less developed abilities in communicating in non-structured digital environments such as an e-mail program (Kuiper et al., 2005). As such, the two following ICT competences were selected for measurement and guided the design of the test framework:

1) Pupils can use ICT to search for, process and store digital information

2) Pupils can use ICT to communicate in a safe, responsible and effective way

Both ICT competences were extracted from the eight attainment targets of the Flemish ICT curriculum. As such, the performance-based test can be used to measure a part of the Flemish ICT curriculum.

4.1.2. The test framework

During the next phase, the selected ICT competences are made concrete. More specifically, a literature study on digital information processing and communicating was conducted to identify the different higher-order learning-process oriented competences that make up the two ICT competences. Because ICT competences are perceived as integrated, multilayered units, a list of technical skills that underlie the higher-order learning-process oriented ICT competences was also integrated into the test framework. During the development of the test framework, an expert panel provided feedback on the results of the literature study. This expert panel consisted of test developers, teachers, ICT researchers and computer scientists. The expert panel used the results of the literature study as input for constructing the test framework.

4.1.2.1. Concretization 'pupils can use ICT to search for, process and store digital information'

The ICT competence under consideration covers three general components, i.e. searching, processing and storing digital information. With regard to the latter component, 'storing digital information' was perceived as a technical skill rather than a higher-order learning-process competence. As such, it was decided to delete this component from the literature review and integrate it into the technical skills section.

Based on a literature review of digital information searching and processing, the actions and behavior children are expected to perform when they locate and use information with a computer and the internet were inventoried (AASL, 1998; ACRL, 2000; Ananiadou & Claro,2009; Brand-Gruwel, Wopereis, & Vermetten, 2005; Eisenberg & Johnson, 2002; Eisenberg, 2005; ETS, 2002; Fraillon & Ainley, 2010; ISTE, 2007; Kuiper, 2007; Madden, Ford, Miller, & Levy, 2006; NCREL, 2003; Puustinen & Rouet, 2009; Savolainen, 2002; Somerville, Smith, & Macklin, 2008; Tsai & Tsai, 2003; Tsai, 2009). Afterwards, these actions were categorized into three clusters concerning getting access to digital information, transforming digital information and creating digital information. As can be seen in Table 1, each of these clusters contains a number of higher-order competences that pupils are expected to master when they search for or process digital information.

Use ICT to search for, process and store digital information
1. Getting access to digital information
1.1. Search for digital information in different efficient and effective ways
1.1.1. Pupils can use a search engine by entering one correct search term derived from a task or question*
1.1.2. Pupils can use a search engine by entering more correct search terms derived from a task or question*
1.1.3. Pupils use a search index in an efficient way to find information*
1.1.4. Pupils can efficiently use an URL*
1.1.5. Pupils can efficiently use the menu of a website*
1.1.6. Pupils can use useful links*
1.1.7. Pupils use the title and textual information found in the results of a conducted search*
1.2. Adapt software application characteristics in order to improve the search process
1.2.1. Pupils can configure a search engine to improve an intended search for figures or other media files*
1.2.2. Pupils can adapt the features of a digital application such as a digital library (e.g. title. author. etc.) in order to narrow and improve their searching process*
1.3. Select digital information based on its relevance and reliability
1.3.1. Pupils can assess and judge the relevance of the information that was found for answering a question*
1.3.2. Pupils can judge the reliability of digital information*
2. Transforming digital information
2.1. Pupils can replace information in a text by another representation to make it more understandable for specific purposes*
3. Creating digital information
3.1. Pupils can generate a new information product by comparing and synthesizing information that was found elsewhere*
3.2. Pupils can integrate new information into existing information products*

Table 1. Sub competences for the ICT competence ‘pupils can use ICT to search for, process and store digital information’

* Higher-order competences that were measured in the test

Cluster 1: Getting access to digital information

Getting access to digital information refers to the actions that pupils must make in an online environment in order to find and retrieve the information they require in the unstructured and non-linear information resource that the Internet is. Pupils can search for digital information in various ways (Kuiper, 2007) such as using keywords with different levels of complexity (using one or more keywords), using a search index or using the menu of a website. It is important that pupils demonstrate efficiency and effectiveness in these searching abilities. This means that they must find the information that was specifically requested (effective) within a certain number of attempts or following the shortest route (efficient). Moreover, selecting what types of online resources might yield the best information is an important aspect of efficient and effective online information searching behavior (Somerville, Smith, & Macklin, 2007). However, the expert panel did not include this competence into the test framework as national ICT curricula indicate that this competence should only be acquired in secondary education (FME, 2007). As the amount of information available on the internet is so huge, it is also important that students can limit their search when accessing information (Eisenberg & Johnson, 2002). By adapting certain software application characteristics, such as search engine commands, they can specify their search process by date, format, location or other criteria, which in turn leads to a more efficient and effective search process. Another way to filter digital information before using it is to evaluate the relevance and reliability or quality of the results found (Savolainen, 2002). As the quantity and range of online information keeps increasing, and as this information can be adapted by online users, the amount of unfiltered digital information is vast. Thus, it is important that children can make judgments about the usefulness, integrity and relevance of the information that has been found on the Internet (Ananiadou & Claro, 2009; Fraillon & Ainley, 2010).

Pupils can demonstrate their proficiency in accessing digital information by performing actions, such as using a search engine by entering one correct search term derived from a task or question; using the title and textual information found in the results of a conducted search; configuring a search engine to improve an intended search for figures or other media files; assess and judge the relevance of the information that was found for answering a question.

Cluster 2: Transforming digital information

Whereas ‘getting access to digital information’ (cluster 1) refers to locating and searching for information, ‘transforming digital information’ (cluster 2) and ‘creating digital information’ (cluster 3) refer to the activities pupils can perform with digital information once it has been collected or is already available to them, i.e. information processing. With regard to cluster 2, pupils can transform digital information in various ways to understand it better and communicate it more effectively to others (Ananiadou & Claro, 2009). As such, ‘transforming digital information’ refers to the actions that pupils take to edit and change the representation format of digital information in order to tailor it to a particular audience and purpose (Fraillon & Ainley, 2010). This ICT competence is closely related to the communicative function of ICT. Transforming information to meet a particular audience’s needs will make the information more understandable and easier to disseminate, which in turn will increase the communicative effect (Somerville et al., 2007; Fraillon & Ainley, 2010).

Pupils can demonstrate their proficiency in this matter by replacing a text with pictures so that younger children can understand the meaning of the text.

Cluster 3: Creating digital information

Besides transforming information, pupils can also process digital information to create new ideas, knowledge and information (Ananiadou & Claro, 2009). According to Fraillon and Ainley (2010) these new information products may be entirely new or build upon given information. Processes that pupils encounter while creating new digital information products include synthesizing, summarizing, and comparing relevant information as well as integrating new information into existing information products (Brand-Gruwel et al., 2005; ETS, 2002; Katz, 2007).

4.1.2.2. Concretization ‘pupils can use ICT to communicate in a safe, responsible and effective way’.

The second ICT competence that was selected for measurement is pupils’ ability to communicate in a safe, responsible and effective way while using a computer and the Internet. Within the context of communicating with ICT, the following main themes reoccur in the research literature and existing ICT competence frameworks: share information and ideas effectively to multiple audiences, respect social-ethical conventions and netiquette when communicating with ICT, communicate with others by choosing the medium most appropriate for the communication purpose, communicate with others using a variety of media and formats, and communicate with each other using ICT to collaboratively solve problems (AASL, 1998; ACRL, 2000; Fraillon & Ainley, 2010; ISTE, 2007; NCREL, 2003). As ICT curricula indicate that choosing an appropriate ICT application for a specific purpose should be acquired in secondary rather than primary education (FME, 2007), the theme of choosing the medium most appropriate for the communication purpose was not retained for integration in the test framework. From a more practical point of view, communicating with each other using ICT to collaboratively solve problems was also not retained. Although the expert panel claimed that a performance-based test is highly appropriate to measure the interaction and collaboration patterns of pupils when solving a problem with ICT, all panel members agreed it would take too much administrative time to measure this aspect, leaving no room for the other competences of the test framework.

The other three themes were integrated in the test framework as they correspond to the different components that the ICT competence under consideration covers. ‘Communicate in a safe and responsible way’ refers to pupils’ ability to use elementary rules and conventions when communicating with ICT (FME, 2007), whereas ‘communicating effectively’ focuses on the ability to deliver information that is actually understood by the receiver (Claro et al., 2012). Similarly, Fraillon and Ainley (2010) state that the focus of sharing information is on understanding the information and social conventions. Moreover, sharing information must be done using a variety of computer-based communication media such as e-mail, wikis, blogs, etc. As such, three clusters were created in the test framework with respect to using ICT to communicate in a safe, responsible and effective way, i.e., communicating in a socially acceptable way, communicating in an understandable way, and disseminating information by using a variety of media (Table 2).

Use ICT to communicate in a safe, responsible and effective way
1. Communicating in a socially acceptable way
1.1. Pupils use ICT applications to ask a question or deliver a message in a socially acceptable way*
2. Communicating in an understandable way
2.1. Pupils use ICT applications to ask a question or deliver a message, the content of which is understandable for the receiver*
2.2. Pupils formulate a subject (for example of a mail/forum) that refers adequately to its content*
3. Dissemination of information by using a variety of media
3.1. Pupils can deliver information to others by using a structured format such as a digital form*
3.2. Pupils can deliver information to others by using a non-structured format such as an e-mail *

Table 2. Sub competences for 'pupils can use ICT to communicate in a safe, responsible and effective way'
* Higher-order competences that were measured in the test

Cluster 1: Communicating in a socially acceptable way

Communicating in a socially acceptable way refers to the actions pupils take to make the information that they share with others socially acceptable. This means that the delivered message should be contextualized and follow social conventions concerned with politeness and netiquette (Puustinen, Volckaert-Legrier, Coquin, & Bernicot, 2009). For example, pupils can do this by mentioning their identity, starting the digital message with an opening keyword and ending it with a closing keyword, using polite markers such as 'kind regards', etc. It is important that pupils can share information or ask a question in a socially acceptable way, as this contributes to the receiver engaging in the communication (Puustinen et al., 2009).

For example, pupils can demonstrate their ability in this competence by using an e-mail to ask a teacher for help, taking the tips mentioned above into account.

Cluster 2: Communicating in an understandable way

Whereas cluster 1 focuses on the social aspect of digital communication, the ICT competence 'communicating in an understandable way' refers to the core element of sharing information with others. It concerns the pupils' ability to create a message with a clear and complete content, such that the information requested or delivered is cognitively understandable for the receiver (Puustinen et al., 2009). Pupils can integrate different components into their messages such that the information is understandable, for example a clear problem statement, an explicit question, a description of the steps already taken to solve a problem, etc.

Pupils can demonstrate their proficiency in this competence by performing activities such as asking their teacher a question by e-mail, taking into account the above tips, or by formulating a subject on a forum that refers adequately to the content of the message that is posted.

Cluster 3: Dissemination of information by the use of ICT

Finally, the dissemination of information by means of ICT refers to the ability to use a variety of computer-based media tools to communicate and exchange digital information (NETS, 2007). In this regard, Fraillon and Ainley (2010) state that pupils can use different types of software to disseminate information such as e-mail, wikis, blogs, instant messaging, media sharing and social networking sites. The expert panel decided that the competence of sharing information by means of a variety of computer-based media tools depends on the specific tool being used. More specifically, the panel contended that the degree to which the tool has a prestructured format influences the required level of ICT competence. The panel asserted that it is easier to share information using a structured format – such as filling in a digital form – than using a non-structured format – such as writing an e-mail that contains the same information as that requested in the digital form.

4.1.2.3. Concretization of the technical skills

As mentioned above, the technical skills are instrumental to the higher-order learning-process oriented competences. This means that pupils need to master certain technical skills in order to demonstrate their ability in the higher-order learning-processing skills. For example, it is necessary that pupils recognize a link on a website, know the buttons of keyboard, can copy an image or can save a text in order for them to successfully complete ICT related information and communication tasks. Based on the higher-order learning-process oriented ICT competences of the test framework, the expert panel inventoried the technical skills they thought were necessary for demonstrating these higher-order competences. However, through the process of item development, it appeared that the initially formulated technical skills depended on the tasks and ICT applications selected for the test. As such, the technical skills were adapted during the process of test development. A final overview of the technical skills can be found in Table 3.

Technical ICT skills
1. Pupils can save a file with a specific name
2. Pupils can retrieve a file from a specific location
3. Pupils can use basic software commands such as copying and pasting an image
4. Pupils can use basic software commands such as copying and pasting a text
5. Pupils can send an e-mail to one known person
6. Pupils can send an e-mail to more known persons
7. Pupils can answer an e-mail to one known person
8. Pupils can reply to all persons addressed in an e-mail
9. Pupils can delete an e-mail
10. Pupils can add an attachment to an e-mail
11. Pupils can open an attachment
12. Pupils can fill in a subject
13. Pupils can react on a forum
14. Pupils can start a topic on a forum
15. Pupils can fill in an online form.

Table 3. Technical skills that were measured in the test

4.2. Item development

In the second step of the test development process, items were developed for each of the higher-order ICT competences and technical skills included in the test framework. Below we discuss the design principles for developing the test and the items, the test itself, and the scoring procedures of the items.

4.2.1. Design principles

During the development of the test, three underlying principles guided the design process. The first principle taken into account was the complex nature of an ICT competence. As mentioned above, an ICT competence refers to a multilayered and integrated unit of higher-order learning-process oriented competences and technical ICT skills which are used and developed in complex situations. As our instrument intended to measure primary school pupils' ICT competences in a direct way, the test required tasks in which pupils could demonstrate their ICT competence by interacting with computer hardware, software and applications. In this regard, Messick (1994) states that performance or simulation-based tasks are very valuable because they guarantee direct and authentic appraisals of educational competences. According to Wirth (1994) this authenticity embedded in simulation-based tasks leads to a more valid assessment than conventional item designs such as multiple choice. Consequently, the developed test comprises simulation-based assessment tasks, referring to real-life information searching, processing and communication activities.

The second principle that was taken into account was the need for standardized items. For this purpose, a walled (closed) computer-based test environment was developed using PHP, Flex framework and MYSQL. This means that all of the applications and websites were simulation based and explicitly created for administering the test. A counter effect of not allowing pupils to use real software applications and freely roam the Internet is a reduction in the authenticity of the developed items. However, the use of a walled environment allowed us to control the complexity of variables that comes with authentic tasks (Messick, 1994). Furthermore, the use of a walled environment made it possible to anticipate the actions that pupils can perform during the tasks. For example, the information pupils encounter when conducting a specific search was determined in advance. This also made it easier to control the development of the scoring criteria and to decide which data needed to be stored as log files. Finally, the use of a closed environment enabled us to make comparisons between pupils as the administration of the test is standardized.

The third principle that was taken into account is the cultural and social value-laden determination of ICT competences. ICT competences are not neutral, but rather situated capacities that develop and emerge through cultural and social experiences (Gee, 2010). Such experiences are in turn mediated through regular use of familiar applications and tools. As pupils mostly use the same applications when performing certain actions with a computer, such as browsing on the Internet, they can be very familiar with specific ICT applications. In order to reduce possible benefits of using well-known applications, the developed applications were based on the general characteristics of software most commonly used by pupils and relevant for our test. This means that the developed applications were recognizable but unknown. Similarly, actions were taken to minimize the effect of prior content knowledge necessary for completing the items. In order to reduce the influence of prior knowledge, ‘the organization of a school festival’ was chosen as subject overarching general theme of the test. The theme of the school festival was specified as ‘a journey through time’.

4.2.2. The test environment

In total, the test comprises 56 simulation-based items that represent the 19 higher-order ICT competences and 15 technical ICT skills of the test framework. These 56 items were integrated into 19 tasks, which were in turn incorporated into four large assignment modules that make up the test (see Figure 1). This means that each ICT competence or technical skill of the test framework was targeted by at least one item and some by two or more.

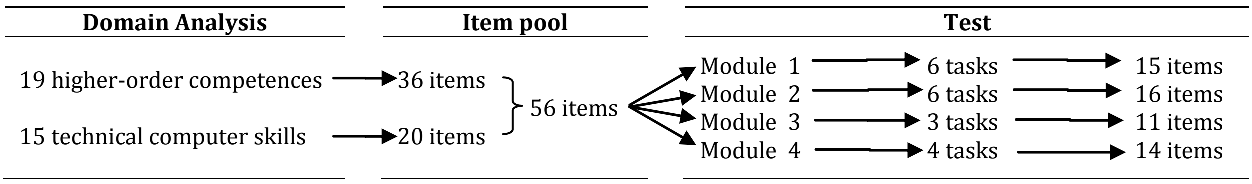

Figure 1. Overview of test development

Six general software applications were designed for this test: a web browser, e-mail software, presentation software, a word processor, a file management system and spreadsheet software. The choice for these six applications was guided by the tasks that were necessary to measure the two ICT competences of the test framework. With regard to the web browser, different types of website applications were built, such as a search engine, a digital library, a blog, informative websites, movie players, etc. For each task, pupils needed to use at least one of the designed applications. During each task, pupils could freely switch between the different applications using the buttons at the bottom of the screen (see Figure 2). As can be seen in Figure 2, the general interface of all tasks is made up of three basic parts. At the bottom of the screen there is a toolbar containing buttons for accessing and switching between the six applications. The center of the screen contains a large window in which the pupils can conduct their hands-on activities with the different applications, such as browsing the Internet. On the left-hand side of the screen, the instructions for the assignments are displayed during the tasks.

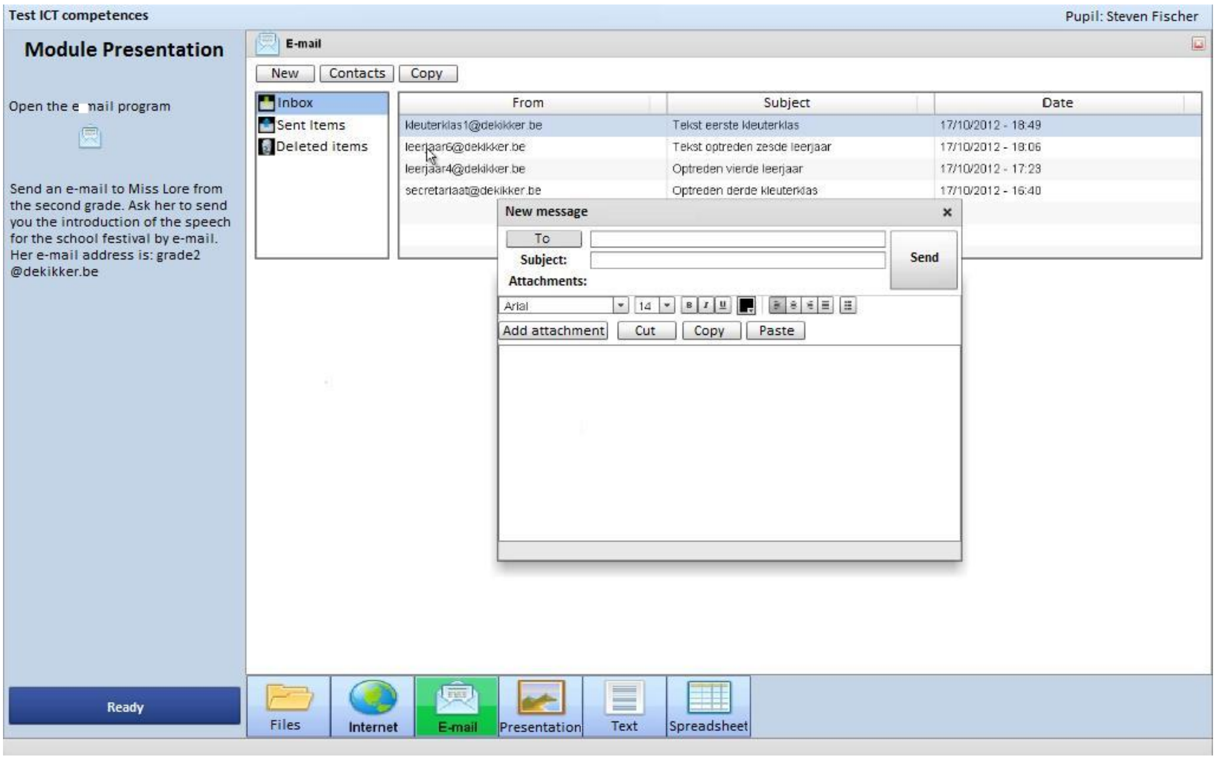

Figure 2. General interface of the performance-based ICT competence test

Each task starts with a pop-up window in the center of the screen, containing the instruction for the task. When the student has confirmed that he/she has read the task, an abridged version of the instruction appears on the left-hand side of the screen. From this moment, the pupils can begin the task using the application at the center of the screen. The abridged instruction remains visible until the task has been completed. Pupils must confirm that they have finished a task in order to start a new one, i.e. a new instruction appears at the center of the screen. All tasks were deliberately presented in a fixed sequence in order to standardize their administration. Furthermore, a time limit was assigned to each task. This was done to gather as much information as possible on all the different ICT competences and skills. Pupils received a warning when the time was almost up for a specific task and were automatically transferred to the next assignment when they exceeded the time limit. Multiple preliminary test administrations (see section 4.3) were conducted to create realistic time limits for each task. This resulted in a maximum total test time of 2 hours.

Each student received a personal code connected to his/her name to log in to the test environment. This code served two purposes. First, this personalizes the test each student receives, i.e. the student’s name is used in the instructions and assignments of the different items. For example, if a student receives an e-mail, the header of the e-mail will contain his/her name. Second, this code is used to link the data gathered to a specific student and to analyze the data in an anonymous way.

4.2.3. Scoring procedures

Parallel to the development of the test, scoring keys were developed for all items. All items were scored dichotomously, with 1 = correct, and 0 = incorrect. A detailed psychometric analysis of how the 1's and 0's of all items were used to create an examinee's overall ICT competence can be found in Aesaert et al. (2014). The items referring to the technical ICT skills were scored automatically, as the logged information provided direct information as to whether the item was scored correctly or incorrectly. The decision whether a higher-order ICT competence was scored correctly or incorrectly depended on the quality of the content included in the answer. As these items required more judgment they were manually rated by a panel of test raters. In order to guarantee the quality of the scoring procedure of the higher-order ICT competences, all test raters were selected from the expert panel and from a psychometric panel. Moreover, the test raters received training in advance. After their initial development, all scoring keys were fine-tuned using the pupils' answers. For example, with regard to item 3 'Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver', the pupils needed to send an e-mail to the second grade teacher in which they ask her/him to deliver the introduction speech of the second grade for the school festival. The scoring key for this item contained a description of all the elements that the student's e-mail needed to contain in order for the teacher to understand the question and deliver the correct part of the speech. For this particular item, the student's e-mail needed to contain at least the following three elements: 1) introduction/text; 2) show/performance/school festival, and 3) 2^{nd} grade.

4.3. Preliminary studies

In order to guarantee the quality of the items under development, the items were preliminarily administered to ten educational experts and to sixth grade primary school pupils. The team of educational experts consisted of teachers, ICT coordinators, educational advisers and test developers. The evaluation of the educational experts focused on the match between the cognitive level of the items and the cognitive level of sixth grade primary school pupils as well as on the manner in which the tasks were formulated and presented to the pupils. All of the educational experts unanimously agreed that the content of the tasks matched the cognitive level of sixth grade primary school pupils. With regard to presentation and formulation, many tasks were reformulated, which led to a more univocal interpretation of the tasks and less dependence on reading ability. A few tasks were replaced as they did not fit the general aim of the test.

With regard to a preliminary check by the pupils, the different tasks were administered to two classes of sixth graders in two different schools. Each task was tested by these pupils as soon as it was programmed. More specifically, the pupils used the developed software applications to solve the items while being observed by test developers. During their observations, the test developers especially focused on 1) the influence of the ICT infrastructure in the schools on the developed software, 2) the difficulty level of the items, 3) the time that pupils required for each item, 4) the usability level of the developed software, 5) the comprehensibility of the item instructions, and 6) the construct validity of the developed items.

Finally, a larger pilot study of the entire test was conducted in March 2012. In total, 86 pupils of three schools participated in the pilot study. The pupils were given 2 hours, which was estimated as the time required to complete the test. In order to match the actual test administration as much as possible, the test was administered by a person that was not involved in the process of test development. Rather than evaluating the difficulty and reliability of the items, the purpose of this pilot study was to investigate 1) the most effective way for logging the results, 2) the possibilities for investigating the log files, 3) the time requirements for the total test, and 4) whether organizational measures were required. A detailed psychometric analysis of the quality, reliability and validity of the items can be found in Aesaert et al. (2014). The results indicated that the logfiles delivered usable information to analyze and make statements about primary school pupils' ICT competences. Moreover, insight into the logfiles provided input for adapting the scoring keys. With regard to the evaluation of the time requirements, the results of the pilot study indicate that pupils can complete the entire test within two hours. With regard to the individual tasks, some tasks were allocated more time to complete whereas others were allocated less time. Finally, two organizational measures were taken. First, it was decided to provide the pupils with an overview of all tasks. As such, they could check their progress during the test. Second, the end of the test was adapted in order for pupils to understand that the test was finished.

5. Second Purpose: Primary school pupils' ICT competences

In the second part of the study we attempt to provide insight into primary school pupils' ICT competences, and how differences in ICT competences are related to gender and SES. For this purpose, the results of a first administration of the developed test are discussed. As the test measures ICT competences in a direct way, the results provide a first insight into primary school pupils' actual ICT competences, and more specifically into pupils' actual ability in digital information processing and communication.

5.1. Method

5.1.1. Participants and test administration

In order to gather information on pupils' ICT competences, the developed test was administered to 378 sixth-grade pupils of 58 primary schools in Flanders (the Dutch speaking region of Belgium). To guarantee that the schools are representative to the total Flemish school population, a stratified sample design was used. More specifically, the total Flemish school population was explicitly stratified for educational network (official public education, subsidized public-authority education and subsidized private-authority education) and school size (small school < 180 pupils; large school ≥180 pupils), and implicitly stratified for province (5 provinces in Flanders). Based on the two explicit stratification factors, a 3 x 2 –matrix of 6 school subpopulations (strata) was created. In each stratum, schools were sorted according to province. Afterwards, schools were randomly selected from the different strata. Within each school, pupils were randomly selected with an average of 6.52 pupils/school. With regard to sociocultural background, the use of the stratified sample design also guaranteed that the selected schools and their pupils were located in both rural and urban areas. Further, the pupils come from families with different economic backgrounds: 19.1% comes from a family with a net salary of 0-2000 euros/month; 57.6% comes from a family with a net salary of 2000-4000 euros/month; and 23.3% comes from a family with a net salary of 4000 euros/month or more. The age of the pupils ranged between 10.79 and 13.85 years old with a mean age of 12.06 years old (SD=0.46). Of the pupils, 50.0% were male and 50.0% were female. Information on the pupils' gender and SES was requested from the pupils and their parents (N=378) respectively.

5.1.2. Instruments

ICT competences were measured using the 56 performance-based items of the developed computer simulation-based test environment. The 56 items refer to higher-order learning-process oriented competences and technical skills that pupils need for searching and processing digital information as well as for communicating in a safe, responsible and effective way using ICT. All items had a dichotomous answer-format

(1=correct, 0=incorrect). Based on the logged information, the items referring to the technical ICT skills were scored automatically by the system. The items referring to the higher-order ICT competences required more human judgment, as the correctness of these items depended on the content quality included in the answer. As such, these items were rated by a team of test raters (see also section 4.2.3. of this paper). The content quality of an item was captured by a scoring key that described all elements an answer to an item needed to contain, in order to be scored correctly.

Socioeconomic status (SES) was operationalized as the highest educational level of the student's mother. A distinction was made between three educational levels or categories, i.e., the mother having a primary education degree (1), having a secondary education degree (2), having a college or university degree (3).

5.1.3. Data analysis

First, a classical item analysis was conducted in order to evaluate the dichotomous items incorporated in the test. In general, an item analysis based on classical test theory focuses on two item statistics, i.e. item difficulty and item discrimination. The difficulty of an item is calculated as the proportion of pupils that has successfully completed the item, known as the p-value. This p-value is an inverse indicator as lower values indicate more difficult items and higher values indicate easier items (Fan, 1998). P-values of 1.00 indicate very easy items that are answered correctly by all pupils, whereas p-values of 0.00 indicate very difficult items that are answered incorrectly by all pupils. As such, items with a p-value of 1.00 or 0.00 cannot discriminate between pupils. Consequently, these items were removed from further analysis. Besides item difficulty, a classical item analysis also investigates an item's ability to discriminate between pupils. Item discrimination refers to the degree to which the performance on an item correlates with the performance on the total test. It is often calculated as the point-biserial correlation, which is calculated as the Pearson correlation between each item and the total test score. The point-biserial correlation should be positive, as a negative value indicates that those answering incorrectly have a higher total test score and those answering correctly have a lower total test score (Osterlind, 2002). Items with a negative or point-biserial correlation value below .15 were removed from the analysis (Pallant, 2007; Varma, 2006).

Second, pupils' ICT competences were analyzed at the item level. For each item, the proportion of pupils that have correctly answered the item provides information on the mastery of that specific higher-order ICT competence or technical skill the item refers to.

As ICT competences were dichotomously scored and gender and SES are both categorical variables, a chi-square test for independence was used to determine whether these factors correlate at the item level.

Third, the effect of gender and SES on the total test scores was investigated using a t-test and a one-way between-groups ANOVA (SPSS 21) respectively. For this purpose, a test score was calculated for the higher-order ICT competences, technical ICT skills and overall test. In order to justify the calculation of the three test scores, an exploratory factor analysis was conducted to check whether the developed items represented the underlying traits of technical ICT skills, higher-order ICT competences and overall ICT competence. More specifically, a nonlinear factor analysis (NLFA) was conducted using the NOHARM-software, as this takes the binary scoring of the items into account (Abswoude, van der Ark, & Sijtsma, 2004; De Ayala, 2009). The RMSR (Root Mean Square Residual) and Tanaka's GFI (Goodness of Fit Index) were used as overall measures of model-data fit. Whereas Tanaka's GFI requires values above .9, the RMSR-values need to be smaller than four times the reciprocal of the square root of the sample size (De Ayala, 2009). As our items had binary scores, Ordinal alphas were used to calculate the internal consistency of the items that were used for calculating the three test scores (Gadermann, Guhn, & Zumbo, 2012).

5.2. Results

5.2.1. Item analysis CTT

Before analyzing pupils' ICT competences, a classic item analysis was conducted to investigate the quality of the developed items. With regard to item difficulty, all p-values lie within the range of .14 and .94 (M= .60, SD= .23), indicating that none of the items was too difficult or too easy to complete. With regard to item discrimination, the corrected item-total correlation values of item 20, 21 and 31 lie below the critical value of .15. As these items cannot sufficiently discriminate between pupils, they were removed for further analysis.

5.2.2. ICT competences, gender and SES

With regard to searching for digital information, the results (p-values in Table 4 or total score column in Table 5) indicate that pupils in general have a lot of problems with assessing and judging the relevance of the information that was found. Furthermore, the results show that most pupils are able to find information by using a search index or by using the menu of a website. Pupils can also configure a search engine to specify an intended search. The majority also finds information by entering one search term into a search engine. However, pupils experience more problems when they need to enter more search terms into a search engine or when they need to choose useful links to find information. With regard to processing information, the results indicate that pupils have less difficulty integrating new information into existing information than with generating new information by comparing and synthesizing information. With regard to digital communication, the results indicate that pupils experience problems using ICT applications to ask a question or deliver a message in a socially acceptable way and using ICT applications to ask a question or deliver a message where the content is understandable for the receiver. Moreover, pupils seem to have less difficulty communicating while using a structured digital format rather than a non-structured format. For example, almost all pupils are equipped with the ability to deliver information to others using a digital form, whereas only half of them are able to deliver information using e-mail. With regard to the technical ICT skills, the results are mixed. Whereas some basic ICT skills are mastered by most pupils, e.g. copying and pasting an image, other skills, such as adding an attachment, remain less developed. Moreover, the results indicate that some technical ICT skills are less mastered than some higher-order learning-process oriented ICT competences. For example, fewer pupils are able to copy and paste a text than able to use the menu of a website. Furthermore, it should be stressed that some of the ICT competences that are represented by more than one item yield different percentages for different items. We elaborate on this in the discussion below.

With regard to gender, the results of this study indicate that certain differences exist between boys' and girls' ICT competences. The results show a general trend in favor of females, i.e. primary school girls outperform primary school boys in 47 of the 53 items (see Table 5), with 16 of these 47 relationships between gender and ICT competence (at the item level) being statistically significant. Girls especially seem better at ICT activities that focus on communicating in a safe, responsible and effective way, such as delivering digital information in a socially acceptable way, delivering digital information with understandable content for the receiver, delivering information using a non-structured format, reacting on a forum. Boys outperformed girls only in 6 of the 53 items. However, none of these differences seem to be significant.

With regard to SES, more significant differences were found at the item level. All significant relationships (34 out of 53 items) indicate that the higher the educational degree of the mother, the better the pupils' ICT competences (see Table 6). Rather than focusing on a particular aspect of digital information searching, processing and communication, the SES related differences apply to almost all clusters of the test framework. The results indicate that higher SES pupils (i.e. pupils that have a mother with a higher educational level) are particularly better at integrating information into existing information products, using the title and textual information found in a conducted search, judging the reliability and relevance of digital information, delivering information using structured and non-structured formats, and at various technical ICT skills, such as adding attachments to e-mails and filling in online forms.

Next to the analysis at the item level, the effect of gender and SES on pupils' overall test performance was also investigated using a t-test and a one-way between-groups ANOVA. For this purpose, three test scores needed to be created i.e., a test score for the higher-order ICT competences, a test score for the technical ICT skills, and an overall test score. In order to justify the calculation of the three test scores, a NLFA was conducted on the 33 higher-order ICT competences, the 20 technical ICT skills, and the technical skills and higher-order competences together. With regard to higher-order ICT competences, Tanaka's GFI had a value of .949 and the RMSR-value was .013, which is below the critical value of .206 ($4^*/(1/\sqrt{378})$. Item 3 (λ=.273), item 9 (λ=.246) and item 48 (λ=.255) were removed due to low factor loadings. Item 27 had a factor loading of 1.00 and was also removed. The 29 remaining items had a factor loading between .346 and .934 and showed high internal consistency (α= .94). As these results support a unidimensional solution, the 29 remaining items representing higher-order ICT competences, could be used to calculate a test score for higher-order ICT competences. With regard to technical ICT skills, a similar result was found. The RMSR-value of .015 and the GFI of .950 supported a unidimensional solution. As item 52 (λ=.214) was removed due to a low factor loading, 19 items were used to create a test score for technical ICT skills. The 19 items had a factor loading between .338 and .937 and showed a high internal consistency (α= .93). To check whether an overall score for the total test could be calculated, a NLFA was conducted on the 48 remaining items i.e the 29 remaining higher-order ICT competences together with the 19 remaining technical ICT skill items. The RMSR and GFI showed acceptable values of .014 and .931 respectively. All factor loadings varied between .348 and .973. The internal consistency of the 48 items was very high (α= .96). As such, the overall test score is based on these 48 items. All three test scores were calculated as sum scores i.e. the number of items correctly answered. To improve interpretability, the test scores are calculated on a scale from 0-100.

Description	p-value	Corrected Item-Total Correlation
Pupils can assess and judge the relevance of the information that was found for answering a question (item 33)	.143	.414
Pupils use the title and textual information found in the results of a conducted search (item 31)	.148	**-.325**
Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver (item 3)	.164	.156
Pupils can assess and judge the relevance of the information that was found for answering a question (item 24)	.185	.318
Pupils use ICT applications to ask a question or deliver a message in a social acceptable way (item 2)	.238	.252
Pupils can reply to all persons addressed in an e-mail (item 52)	.275	.176
Pupils can use useful links (item 30)	.286	.400
Pupils can assess and judge the relevance of the information that was found for answering a question (item 20)	.296	**.011**
Pupils use the title and textual information found in the results of a conducted search (item 19)	.299	.257
Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver (item 6)	.317	.492
Pupils can use a search engine by entering more correct search terms derived from a task or question (item 18)	.325	.360
Pupils can use basic software commands such as copying and pasting a text (item 45)	.381	.259
Pupils can judge the reliability of digital information (item 34)	.415	.561
Pupils can use basic software commands such as copying and pasting a text (item 39)	.426	.389
Pupils can generate a new information product by comparing and synthesizing information that was found elsewhere (item 7)	.450	330
Pupils can answer an e-mail to one known person (item 42)	.463	.260
Pupils can add an attachment to an e-mail (item 43)	.492	.490
Pupils can send an e-mail to more known persons (item 56)	.505	.448
Pupils can deliver information to others by using a non-structured format such as a e-mail (item 35)	.519	.573
Pupils can use basic software commands such as copying and pasting a text (item 40)	.526	.476
Pupils can replace information in a text by another representation to make it more understandable for specific purposes (item 44)	.532	.362
Pupils can assess and judge the relevance of the information that was found for answering a question (item 8)	.548	.503
Pupils can use a search engine by entering more correct search terms derived from a task or question (item 16)	.558	.408
Pupils can adapt the features of a digital application such as a digital library in order to narrow and improve their searching process (item 23)	.561	.344
Pupils can deliver information to others by using a non-structured format such as a e-mail (item 25)	.566	.491
Pupils can use a search engine by entering more correct search terms derived from a task or question (item 17)	.569	.414
Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver (item 29)	.593	.473
Pupils can react on a forum (item 32)	.593	.524
Pupils can integrate new information into existing information products (item 5)	.601	.566
Pupils can generate a new information product by comparing and synthesizing information that was found elsewhere (item 21)	.635	**.126**

Table 4. Item characteristics from the classic test analysis

* Items in bold were removed for further analysis

Description	p-value	Corrected Item-Total Correlation
Pupils can use basic software commands such as copying and pasting an image (item 46)	.653	.507
Pupills can retrieve a file from a specific location (item 14)	.656	.433
Pupils can assess and judge the relevance of the information that was found for answering a question (item 11)	.659	.560
Pupils can configure a search engine to improve an intended search for figures or other media files (item 48)	.690	.158
Pupils formulate a subject of a mail/forum that refers adequately to its content (item 28)	.701	.466
Pupils can send an e-mail to one known person (item 36)	.730	.410
Pupils formulate a subject of a mail/forum that refers adequately to its content (item 1)	.746	.489
Pupils use a search index in a efficient way to find information (item 9)	.749	.184
Pupils can configure a search engine to improve an intended search for figures or other media files (item 50)	.762	.403
Pupils can use a search engine by entering more correct search terms derived from a task or question (item 13)	.772	.469
Pupils can open an attachment (item 41)	.775	.524
Pupils can use a search engine by entering one correct search term derived from a task or question (item 22)	.780	.523
Pupils can fill in a subject (item 37)	.802	.464
Pupils can start a topic on a forum (item 54)	.815	.319
Pupils can fill in a subject (item 55)	.815	.612
Pupils can deliver information to others by using a structured format such as a digital form (item 15)	.828	.527
Pupils can use basic software commands such as copying and pasting an image (item 47)	.828	.552
Pupils can use basic software commands such as copying and pasting an image (item 49)	.844	.603
Pupils can delete an e-mail (item 38)	.857	.298
Pupils can use a search engine by entering one correct search term derived from a task or question (item 12)	.881	.501
Pupils can deliver information to others by using a structured format such as a digital form (item 27)	.892	.626
Pupils can save a file with a specific name (item 51)	.892	.437
Pupils can fill in an online form (item 53)	.892	.626
Pupils can integrate new information into existing information products (item 4)	.902	.243
Pupils can efficiently use the menu of a website (item 26)	.931	.505
Pupils can efficiently use an URL (item 10)	.942	.343

Table 4 (continued)

Item	Description	Total	Male	Female	Chi-square
1	Pupils formulate a subject of a mail/forum that refers adequately to its content	74.6%	68.8%	81.2%	6.94*
2	Pupils use ICT applications to ask a question or deliver a message in a social acceptable way	23.8%	11.8%	36.0%	28.59*
3	Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver	16.4%	10.2%	23.1%	10.24*
4	Pupils can integrate new information into existing information products	90.2%	90.3%	90.9%	0.00
5	Pupils can integrate new information into existing information products	60.1%	55.9%	64.5%	2.53
6	Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver	31.7%	28.0%	35.5%	2.10
7	Pupils can generate a new information product by comparing and synthesizing information that was found elsewhere	45.0%	37.6%	52.7%	7.91*
8	Pupils can assess and judge the relevance of the information that was found for answering a question	54.8%	45.7%	65.1%	13.33*
9	Pupils use a search index in a efficient way to find information	74.9%	73.7%	76.3%	0.23
10	Pupils can efficiently use an URL	94.2%	94.1%	94.6%	0.00
11	Pupils can assess and judge the relevance of the information that was found for answering a question	65.9%	62.9%	69.9%	1.74
12	Pupils can use a search engine by entering one correct search term derived from a task or question	88.1%	85.5%	91.4%	2.63
13	Pupils can use a search engine by entering more correct search terms derived from a task or question	77.2%	73.7%	81.7%	3.04
14	Pupills can retrieve a file from a specific location	65.6%	64.0%	67.7%	0.43
15	Pupils can deliver information to others by using a structured format such as a digital form	82.8%	81.2%	84.9%	0.69
16	Pupils can use a search engine by entering more correct search terms derived from a task or question	55.8%	54.8%	57.5%	0.18
17	Pupils can use a search engine by entering more correct search terms derived from a task or question	56.9%	51.5%	63.4%	5.32*
18	Pupils can use a search engine by entering more correct search terms derived from a task or question	32.5%	26.3%	39.8%	7.00*
19	Pupils use the title and textual information found in the results of a conducted search	29.9%	27.4%	32.8%	1.04
22	Pupils can use a search engine by entering one correct search term derived from a task or question	78.0%	74.2%	82.3%	3.09
23	Pupils can adapt the features of a digital application such as a digital library to narrow and improve their searching process	56.1%	53.8%	58.6%	0.70
24	Pupils can assess and judge the relevance of the information that was found for answering a question	18.5%	17.7%	19.9%	0.16
25	Pupils can deliver information to others by using a non-structured format such as a e-mail	56.6%	42.5%	72.0%	32.03*
26	Pupils can efficiently use the menu of a website	93.1%	91.9%	95.2%	1.11
27	Pupils can deliver information to others by using a structured format such as a digital form	89.2%	87.6%	91.4%	1.03
28	Pupils formulate a subject of a mail/forum that refers adequately to its content	70.1%	65.6%	74.7%	3.29
29	Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver	59.3%	58.1%	61.8%	0.40
30	Pupils can use useful links	28.6%	23.1%	34.9%	5.75*
32	Pupils can react on a forum	59.3%	49.5%	69.4%	14.45*
33	Pupils can assess and judge the relevance of the information that was found for answering a question	14.3%	11.8%	17.2%	1.76
34	Pupils can judge the reliability of digital information	41.5%	34.4%	50.0%	8.64*

Table 5. Pupils' ICT competences and gender differences

*significant at the .05-level

Item	Description	Total	Male	Female	Chi-square
35	Pupils can deliver information to others by using a non-structured format such as a e-mail	51.9%	45.7%	59.1%	6.21*
36	Pupils can send an e-mail to one known person	73.0%	70.4%	76.3%	1.38
37	Pupils can fill in a subject	80.2%	76.9%	84.4%	2.91
38	Pupils can delete an e-mail	85.7%	86.6%	84.9%	0.09
39	Pupils can use basic software commands such as copying and pasting a text	42.6%	41.9%	42.5%	0.00
40	Pupils can use basic software commands such as copying and pasting a text	52.6%	54.8%	50.0%	0.69
41	Pupils can open an attachment	77.5%	72.6%	82.8%	5.03*
42	Pupils can answer an e-mail to one known person	46.3%	45.2%	48.9%	0.39
43	Pupils can add an attachment to an e-mail	49.2%	47.3%	51.1%	0.39
44	Pupils can replace information in a text by another representation to make it more understandable for specific purposes	53.2%	47.3%	60.2%	5.72*
45	Pupils can use basic software commands such as copying and pasting a text	38.1%	39.2%	36.6%	0.18
46	Pupils can use basic software commands such as copying and pasting an image	65.3%	61.3%	69.9%	2.68
47	Pupils can use basic software commands such as copying and pasting an image	82.8%	80.1%	86.0%	1.91
48	Pupils can configure a search engine to improve an intended search for figures or other media files	69.0%	72.0%	67.2%	0.81
49	Pupils can use basic software commands such as copying and pasting an image	84.4%	80.1%	89.2%	5.30*
50	Pupils can configure a search engine to improve an intended search for figures or other media files	76.2%	76.3%	76.9%	0.00
51	Pupils can save a file with a specific name	89.2%	88.7%	90.9%	0.26
52	Pupils can reply to all persons addressed in an e-mail	27.5%	29.0%	26.9%	0.12
53	Pupils can fill in an online form	89.2%	87.6%	91.4%	1.03
54	Pupils can start a topic on a forum	81.5%	81.7%	81.2%	0.00
55	Pupils can fill in a subject	81.5%	79.6%	83.9%	0.88
56	Pupils can send an e-mail to more known persons	50.5%	41.9%	59.1%	10.34*

Table 5 (continued)

Item	Description	SES: highest educational degree			Chi-square
		Primary education	Secondary education	Higher education	
1	Pupils formulate a subject of a mail/forum that refers adequately to its content	50.0%	72.9%	77.2%	4.98
2	Pupils use ICT applications to ask a question or deliver a message in a social acceptable way	7.1%	23.1%	27.9%	3.37
3	Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver	0.0%	13.1%	23.5%	9.29*
4	Pupils can integrate new information into existing information products	85.7%	87.9%	93.4%	2.95
5	Pupils can integrate new information into existing information products	21.4%	51.8%	75.0%	26.95*
6	Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver	21.4%	24.6%	42.6%	12.85*
7	Pupils can generate a new information product by comparing and synthesizing information that was found elsewhere	35.7%	41.2%	50.7%	3.44
8	Pupils can assess and judge the relevance of the information that was found for answering a question	35.7%	51.3%	62.5%	6.32*
9	Pupils use a search index in a efficient way to find information	71.4%	73.9%	76.5%	0.38
10	Pupils can efficiently use an URL	92.9%	93.0%	96.3%	1.74
11	Pupils can assess and judge the relevance of the information that was found for answering a question	50.0%	62.8%	73.5%	5.94
12	Pupils can use a search engine by entering one correct search term derived from a task or question	71.4%	86.9%	90.4%	4.49
13	Pupils can use a search engine by entering more correct search terms derived from a task or question	57.1%	76.9%	80.1%	3.90
14	Pupills can retrieve a file from a specific location	42.9%	63.8%	65.6%	4.99
15	Pupils can deliver information to others by using a structured format such as a digital form	64.3%	79.4%	88.2%	7.54*
16	Pupils can use a search engine by entering more correct search terms derived from a task or question	42.9%	51.3%	63.2%	5.65
17	Pupils can use a search engine by entering more correct search terms derived from a task or question	42.9%	50.8%	66.2%	8.91*
18	Pupils can use a search engine by entering more correct search terms derived from a task or question	14.3%	27.6%	33.0%	10.54*
19	Pupils use the title and textual information found in the results of a conducted search	21.4%	23.1%	41.2%	13.05*
22	Pupils can use a search engine by entering one correct search term derived from a task or question	71.4%	72.9%	84.6%	6.60*
23	Pupils can adapt the features of a digital application such as a digital library to narrow and improve their searching process	35.7%	52.8%	59.6%	3.63
24	Pupils can assess and judge the relevance of the information that was found for answering a question	0.0%	15.6%	23.5%	6.67*
25	Pupils can deliver information to others by using a non-structured format such as a e-mail	35.7%	52.3%	65.4%	8.34*
26	Pupils can efficiently use the menu of a website	78.6%	91.0%	97.1%	8.99*
27	Pupils can deliver information to others by using a structured format such as a digital form	57.1%	86.4%	94.9%	19.81*
28	Pupils formulate a subject of a mail/forum that refers adequately to its content	50.0%	65.3%	75.7%	6.47*
29	Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver	42.9%	53.8%	65.4%	5.86
30	Pupils can use useful links	14.3%	24.6%	36.0%	6.61*
32	Pupils can react on a forum	50.0%	52.3%	70.6%	11.77*

Table 6. Pupils' ICT competences and SES differences

*significant at the .05-level

Item	Description	SES: highest educational degree			Chi-square
		Primary education	Secondary education	Higher education	
33	Pupils can assess and judge the relevance of the information that was found for answering a question	0.0%	9.0%	22.8%	15.04*
34	Pupils can judge the reliability of digital information	35.7%	33.7%	53.7%	13.52*
35	Pupils can deliver information to others by using a non-structured format such as a e-mail	35.7%	43.7%	64.7%	15.71*
36	Pupils can send an e-mail to one known person	35.7%	71.4%	77.2%	11.06*
37	Pupils can fill in a subject	64.3%	77.4%	83.1%	3.52
38	Pupils can delete an e-mail	57.1%	84.4%	89.0%	10.31*
39	Pupils can use basic software commands such as copying and pasting a text	35.7%	35.7%	57.7%	10.13*
40	Pupils can use basic software commands such as copying and pasting a text	42.9%	45.7%	64.7%	12.28*
41	Pupils can open an attachment	71.4%	70.9%	84.6%	8.56*
42	Pupils can answer an e-mail to one known person	21.4%	44.7%	50.7%	4.76
43	Pupils can add an attachment to an e-mail	28.6%	41.2%	61.8%	16.04*
44	Pupils can replace information in a text by another representation to make it more understandable for specific purposes	64.3%	47.2%	60.3%	6.28*
45	Pupils can use basic software commands such as copying and pasting a text	42.9%	35.2%	42.6%	2.03
46	Pupils can use basic software commands such as copying and pasting an image	57.1%	59.3%	73.5%	7.54*
47	Pupils can use basic software commands such as copying and pasting an image	71.4%	77.4%	89.7%	9.38*
48	Pupils can configure a search engine to improve an intended search for figures or other media files	64.3%	65.8%	75.0%	3.37
49	Pupils can use basic software commands such as copying and pasting an image	64.3%	81.4%	90.4%	9.34*
50	Pupils can configure a search engine to improve an intended search for figures or other media files	50.0%	75.9%	79.4%	6.09*
51	Pupils can save a file with a specific name	64.3%	88.4%	92.6%	10.74*
52	Pupils can reply to all persons addressed in an e-mail	28.6%	26.1%	30.9%	0.91
53	Pupils can fill in an online form	57.1%	86.4%	94.9%	19.81*
54	Pupils can start a topic on a forum	78.6%	79.9%	84.6%	1.26
55	Pupils can fill in a subject	57.1%	77.9%	86.8%	9.14*
56	Pupils can send an e-mail to more known persons	42.9%	43.7%	59.6%	8.39*

Table 6 (continued)

As can be seen in Table 7, all pupils on average score higher on technical ICT skills (M=68.13, SD= 22.24) than on higher-order ICT competences (M=57.27, SD= 21.07). Moreover, this result remains the same when SES and gender are taken into account. For example, male pupils score lower on higher-order ICT competences (M=53.02, SD=21.07) than on technical ICT skills (M=65.67, SD=23.63). With regard to SES, similar results are found. For all three SES-groups, pupils score higher on technical skills than on higher-order ICT competences. For example, pupils that have a mother with a secondary degree as highest educational level on average score 64.06 (SD=22.22) in technical ICT skills and 53.18 (SD=20.16) in higher-order ICT competences. This indicates that the higher-order ICT competences are more difficult for pupils to master compared to the more technical ICT skills, i.e. pupils have a higher ability in technical ICT skills than in higher-order ICT competences with regard to digital information searching, processing and communication.

	Overall test score ***M (SD)***	**Higher-order ICT competence *M (SD)***	**Technical ICT skill *M(SD)***
All pupils	61.57 (20.66)	57.27 (21.07)	68.13 (22.24)
Male pupils	58.06 (21.22)	53.02 (21.07)	65.76 (23.63)
Female pupils	65.65 (18.94)	62.24 (19.60)	70.85 (20.00)
Primary degree	46.13 (29.13)	42.36 (26.21)	51.88 (34.84)
Secondary degree	57.49 (20.16)	53.18 (20.16)	64.06 (22.22)
Higher degree	68.32 (18.65)	64.12 (19.91)	74.73 (19.50)

Table 7. Descriptives for the overall, higher order ICT-competence and technical ICT skill test scores

A t-test was conducted to compare differences between male and female pupils for the three test scores. As unequal variances were assumed, Welch's t-test was conducted (Field, 2009; Kohr & Games, 1974). The results in Table 8 show a significant difference for the technical ICT skill score, the higher-order ICT competence score and the total test score in favor of females. However, the effect of gender was small with η^2 varying between .01 and .05.

	t	***df***	***P***	***Mean difference***	***η²***
Overall score	-3.63	365.31	.000	-7.58	.03
Higher-order ICT competence score	-4.367	368.06	.000	-9.21	.05
Technical ICT skill score	-2.243	360.16	.025	-5.09	.01

Table 8. Between-groups effects for gender on overall, higher-order ICT competence and technical ICT skill test scores

Finally, a one-way ANOVA was conducted to check whether there are differences in the three test scores across the three SES-groups. As unequal variance was assumed, the Welch test was used. As can be seen in Table 9, there is a significant effect of SES for pupils' overall ICT competence [$F(2,34.39)= 14.57$,p=.000], for pupils' higher-order ICT competences, [$F(2,34.70)= 14.14$, p=.000], and for pupils' technical ICT skills [$F(2,34.22)= 12.23$, p=.000], with regard to digital information processing and communication. The effect of SES on the three test scores is moderate, with estimated ω^2 varying between .06 and .07. In order to identify between which SES-groups these differences specifically occur, a post-hoc comparison was conducted using the Games-Howell test (see Table 10). The results show that the mean test score for the 'higher education degree' group is significantly different from the 'secondary education degree' group in the three cases of overall test score, higher-order ICT competence test score and the technical ICT skill test score, and significantly different from the 'primary education degree group' in the case of the overall test score and the higher-order ICT competence test score. Furthermore, the 'primary education degree' group did not significantly differ from the 'secondary education degree' group. These results indicate that primary school pupils from families of which the mother has a higher education degree have more ability in searching and processing digital information and in communicating with a computer.

	F	*df 1*	*df 2*	*P*	estimated ω^2
Overall score	14.57	2	34.39	.000	.07
Higher-order ICT competences score	14.14	2	34.70	.000	.07
Technical ICT skills score	12.23	2	34.22	.000	.06

Table 9. Between-groups effects for SES on overall, higher-order ICT competence and technical ICT skills test scores

	Overall test score		Higher-order ICT competence		Technical ICT skill	
	Mean difference	***p***	**Mean difference**	***p***	**Mean difference**	***p***
Primary degree –secondary degree	-11.35	.35	-10.82	.32	-12.18	.42
Primary degree – higher degree	-22.19	.04	-21.76	.02	-22.85	.07
Secondary degree – higher degree	-10.84	.00	-10.94	.00	-10.67	.00

Table 10. Mean differences between the three SES groups

6. Discussion and conclusion

Several studies that have assessed students' ICT competences and skills can be found in the research literature. However, these studies are mostly conducted from the perspective of indirect or self-reported measurement. Consequently, these studies must cope with the problem of self-reported bias, as students can over and underestimate their own ICT competences. Moreover, most studies are conducted within the context of secondary and higher education.

The first aim of this study was to outline the development of a computer-based test that measures primary school pupils' ICT competences in a direct and valid way. The development of the computer-based test adds to the research on ICT competences in several ways. First, the test framework that was developed as a theoretical foundation of the test can act as a blueprint for other test developers who wish to assess primary school pupils' ICT competences. Moreover, teachers can use the framework from a curricular point of view, to test and evaluate their students' ICT competences. The test framework contains ICT competences related to using ICT for searching and processing digital information, as well as using ICT to communicate in a safe, responsible and effective way. An advantage of the test framework is the operationalization of digital information searching, processing and communication into specific technical ICT skills and higher-order learning-oriented ICT competences. As the framework brings together technical ICT skills as well as higher-order learning-process oriented ICT competences, it operationalizes the wider reflective perspective on ICT literacy that considers multilayered ICT competences relevant for successful participation in all areas of life (Claro et al., 2012; Voogt, 2008). The specific higher-order learning-oriented ICT competences are categorized into clusters referring to gaining access to digital information, transforming digital information, creating digital information, communicating in a socially acceptable way, communicating in an understandable way and disseminating digital information by using a variety of media.

The second advantage of developing the test is the provision of a computer and performance-based instrument that can be used in future research to measure primary school pupils' ICT competences in a valid and standardized way with large-scale samples. The results of the classic item analysis indicate that the items incorporated in the test are not too easy or too difficult and are can discriminate between pupils. As such, they are a first indicator for the psychometric quality of the test. However, it should be stressed that this basic item analysis is only a first step into the validation of the instrument and further research into the internal and external validity, as well as the reliability of the instrument is needed. Besides educational research, the test can also be deployed at different levels in educational practice, i.e., the results of the test can serve purposes at the micro, meso and macro level. For example, at the micro level teachers can use students' individual test results to identify specific shortcomings in students' ICT competences. It is well-known that differences exist in students' ICT competences, as the opportunities that students have at home to develop these ICT competences also differ (Vekiri, 2010). In turn, students enter the classroom with a different set and ability of ICT competences. Teachers can use the results of the developed test to identify these differences and shortcomings, and adapt their instruction to address the specific ICT competences individual students need to develop. Furthermore, the students' test results can also be used at the meso or school level. Teachers and school leaders can gather the test results of all students of a school in order to create an ICT competence profile of the school. Such an ICT profile can map the degree to which certain ICT competences are mastered by the students of a school in different grades. As such, schools can decide which ICT competences need to be addressed in a specific grade. In this context, schools could also integrate these results as part of an ICT policy plan. Tondeur, Van Keer, van Braak, & Valcke (2008) state that schools with an ICT policy plan of which the goals are shared by its teachers use ICT more regularly in the classroom. Moreover, it is believed that an ICT policy plan facilitates the realization of an ICT curriculum, i.e. ICT competences (Vanderlinde, van Braak, & Hermans, 2009). As such, we believe that the integration of the test results into an ICT policy plan could lead to more regular and systematic teaching and acquiring of ICT competences at school. At the macro or national level, the test can be used to measure the degree to which students master the parts of the national curriculum that refer to digital information searching and processing as well as to communicating with a computer and the Internet.

The second aim of this study was to gain insight into primary school pupils' actual ICT competences and to identify the gender and socioeconomic differences that exist in students' ICT competences. The results of this study indicate that primary school pupils have particular difficulties in higher-order ICT competences that focus on communicating in a socially acceptable and clearly understandable way. These results confirm earlier research of Claro et al. (2012) who found that ICT activities, such as publishing a post or writing an e-mail that is adequate in content requires a high level of ICT competence compared to other activities, such as searching for information. In this context, this study confirms that students can easily find information using a search index, the menu of a website or a search engine. However, the ability to use a search engine seems to be related to the number of keywords required to obtain a correct search result. More specifically, children experience fewer problems conducting a search with one keyword than with more than one. Kuiper, Volman and Terwel (2005) state that students experience more problems using keywords to find digital Information than browsing the Internet. More specifically, students find it difficult to choose the right keyword in a structured and systematic way. In our opinion, this is also related to the freedom that comes with a search engine in terms of being a less structured application compared to a search index or the menu of a website. Students should first learn to use applications with a specifically designed interface that guides and structures their searching behavior and use of keywords. Afterwards, they can use the acquired searching strategies in other applications where they are free to roam. Furthermore, this study indicates that students also experience difficulties in assessing and judging the relevance of the information that they found. With regard to technical ICT skills, it appears that some basic ICT skills are more difficult to master than some higher-order learning-process oriented ICT competences. However, on the overall test, students seem to score higher on the technical ICT skills than on the higher-order learning-oriented ICT competences. As such, our data illustrate that technical skills on average are easier to master than the higher-order learning-process oriented ICT competences (with regard to digital information searching and processing, and digital communication). It is important to mention that some items that were intended to measure the same higher-order ICT competence yielded different results. A possible explanation is that students' experience and familiarity with specific applications and software makes it easier for them to show their ability in a certain ICT activity compared to showing the same ability using less-known applications. Although we took this into account during the test development, future research should investigate the effect of application familiarity and experience on ICT competences, and take these results into account when new assessment tasks are being developed. Another explanation is that the developed items did not entirely measure the essence of the ICT competence they were intended to measure. For example, if two items were expected to measure the same higher-order ICT competence, it is possible that one item focused on the essence of the higher-order ICT competence whereas the other referred more to a similar competence or an underlying technical skill. As such, future research should further investigate the construct validity of the developed items.

With regard to the relationship between gender and ICT competences, a significant overall difference was found in favor of girls for both the technical ICT skills and higher-order ICT competences. The item analysis showed that girls are particularly better at delivering digital information in a socially acceptable way, delivering digital information where the content is understandable for the receiver, delivering information using a non-structured format, reacting on a forum, assessing and judging the relevance of information, and sending e-mails to more known persons. It is remarkable that the majority of these items is related to communication oriented activities. This was to be expected as previous research has indicated that girls consider themselves better at online relationship and communication competences than boys (Bunz, 2007). Similarly, Tsai and Tsai (2010) found that boys and girls consider themselves equally competent in online exploration, whereas girls have much more confidence in their online communication competences than boys. These findings reinforce the statement that future research should use nuanced and specific measures when investigating ICT competences and related factors, rather than focusing on general measures of Internet and computer ability. A possible explanation that girls outperform boys on online communication activities and less on online information processing activities can be found in their specific ICT use and experience. Earlier research has indicated that social online activities such as e-mailing and using social network sites are more popular computer activities for girls than for boys (Jones et al., 2010; Volman, Van Eck, Heemskerk, & Kuiper, 2005). According to social cognitive theory (Bandura, 1986; Pajares, 1997), these social online activities are previous experiences that can raise students' ICT self-efficacy if the results of the conducted social online activities are interpreted as successful. In turn, this increased ICT self-efficacy for social online activities raises a student's motivation to engage in similar – and often more difficult - tasks, as he/she feels competent in completing them successfully. Again, these tasks can be considered as previous experiences and the process starts over again. As girls have more experience in online communication activities this could lead to higher online communication self-efficacy (Tsai & Tsai, 2010). This in turn may activate girls to engage in more challenging and more difficult online communication activities, and as such, develop better online communication related ICT competences. Studies that focus on the relationship between ICT self-efficacy and ICT use/experience mostly do not take students' actual ICT competences into account (Durndell & Haag, 2006; Tømte & Hatlevik, 2011). Further, we have no knowledge of any studies that consider the interpretation of previous ICT experiences as a conditional characteristic in the relationship between previous ICT experiences, ICT self-efficacy and ICT competences. However, research into other academic domains has shown that students' interpretation of successfully completing previous experiences is not always accurate, mostly in the direction of positive bias (Kruger & Dunning, 1999), i.e., students tend to overestimate the degree to which they successfully completed a task. This in turn might lead to less valid measures of ICT self-efficacy. As such, future research should explore whether sex related differences in ICT competences are related to students ICT self-efficacy and prior ICT experience, taking into account the accuracy of students' interpretation of their prior ICT experience.

Furthermore, a moderate effect of SES on primary school pupils' ICT competences exists. More specifically, it seems that pupils that have a mother with a degree of higher education have better developed technical ICT skills and higher-order ICT competences with regard to digital communication and digital information searching and processing. In contrast to the gender related differences, the effect of SES applies to almost all clusters of the developed framework. As such, this study provides evidence that SES is an important factor for software developers and teachers to consider during the selection and development of digital tasks in which students can develop their ICT competences. A possible reason for these SES related differences in ICT competences, can be found in specific types of out of school ICT use of different socioeconomic groups. Volman et al. (2005) studied computer and Internet use from the perspective of ethnic differences. These authors found that students from an ethnic-minority background use the computer at home more to practice what they have learned at school (such as word processing and doing math), whereas students from a majority background use the computer more to communicate and surf on the Internet. This effect is possibly even reinforced by the fact that the use of computers as a learning tool and to learn basic ICT skills, receives higher priority in primary education as compared to using ICT as an information tool (Tondeur, van Braak, & Valcke, 2007). Similarly, it can be expected that students from higher SES groups have more experience with the ICT competences incorporated in this study's performance-based test i.e. digital communication and information processing. In this context, Vekiri (2010) found that the percentage of high SES students that searches the Internet for information is higher than the percentage of low SES students conducting this specific type of ICT activities. Future research could focus on this phenomenon by investigating interaction effects between SES and specific types of ICT use on ICT competences. This research is of major importance, as students' ICT use and ICT competences can make a difference in their academic related performances (Claro et al., 2012; OECD, 2010). This means that SES related differences in ICT competences could also enlarge differences in academic related performance, and eventually maintain socioeconomic differences.

A limitation of this study is the absence of testing measurement invariance before making the comparisons between gender and SES groups. Although we found differences in ICT competences between SES groups, it is difficult to say whether these differences can be attributed to characteristics of the SES group or characteristics of the test. As such, future research should investigate whether our test is interpreted in a similar way in different groups before making comparisons between groups. For this purpose, the latent variables underlying the items of our test should first be identified. Afterwards it should be checked whether the mathematical function that relates these latent variables to the data is the same in each SES and gender group (Teo, 2014).

Although we consider it a strength of this study that a performance based measure of ICT competences was used, it is regrettable that the investigation of the gender and SES differences was not expanded to self-report measures of ICT competence or measures of ICT self-efficacy. Future research should investigate whether the relationships identified in this study could be replicated using self-report measures. With regard to the relationship between gender and ICT competences, the study of Tsai and Tsai (2010) provided results similar to those of this study. More specifically, their study indicated a positive relationship between gender and students' self-reported online communication competences in favor of girls, whereas our results indicate the same relationship using a performance-based rather than a self-report measure of ICT competence. These similar results indicate that the relationships found between gender and actual ICT competences, perhaps also will be found between gender and self-reported measures of ICT competence. However, the items in the study of Tsai and Tsai (2010) are not based on the exact same construct that provided input for the development of the items in this study. As such, future research should first develop self-reported and performance-based items that highly match, in order to investigate whether relationships identified in the case of performance-based items, could also be replicated using self-report measures.

Another limitation of this study was the restriction of the number of ICT competences that were measured. As the performance-based test only measured locating and processing digital information and digital communication, it did not address the measurement of other ICT competences. In this context, several authors refer to the importance of ICT competences that focus on creative expression and active media producing abilities such as web design or digital video production (Barron, Kennedy Martin, & Roberts, 2007). Further, Litt (2013) advocates the incorporation of socio-emotional skills that students need to use social media into measurement instruments, such as understanding one's online audience or judging the credibility of other users. Besides these alternative ICT competences, it can be expected that the swift evolutions in technology – such as the increased use of mobile devices and their specific apps - influence the possible ways of searching and processing digital information and communication. As such, future research should also address the assessment of the ICT competences that students need according to these new ways of digital communicating and information processing.

These changes and evolutions in technology also have implications for the use and development of performance-based tests such as the one described in this study. As the ICT competences that students need depend on these fast changes in technology, the usability of a performance-based test that measures these ICT competences is limited for an extended time. Consequently, performance-based tests need to be adapted on a regular basis, taking into account future technology changes. More specifically, the ICT competences as well as the simulated applications used to measure them, need to be adapted according to technology changes. This also implies that studies that make comparisons between similar ICT competences, need to control for competence differences due to changes in the technology applications that were used.

The research literature indicates that nuanced and validated measures of ICT competences are needed. Moreover, it is important that these measures can be used for assessing nationally representative samples, as this allows for demographic comparisons and delivers information for educational policy and training resource decisions (Litt, 2013). By developing a performance and computer based test that can be deployed in large scale settings, we hope to contribute to unraveling students' ICT competences and factors related to them.

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5

Direct measures of ICT competences in primary education: Using Item Response Theory for the development and validation of an ICT competence scale

This chapter is based on:

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Chapter 5

Direct measures of ICT competences in primary education: Using Item Response Theory for the development and validation of an ICT competence scale

Abstract

In the past decade, several studies have measured ICT competences from the perspective of ICT self-efficacy. Such indirect measurements tend to have validity problems, as they depend on the pupils' ability to judge their own ICT competences. This study outlines the development of a performance-based digital test and the validation of a direct measure of ICT competence through the use of item response theory (IRT). More specifically, the test and the developed measure focus on primary-school pupils' proficiency in digital information processing and communication. 56 Items were administered to 560 pupils at the end of their primary-school education (age between 10.79 and 13.85 years old). The items were controlled for dimensionality, model-data fit, local item dependence and monotonicity. The final measure contains 27 items that refer to retrieving and processing digital information, and communication with a computer. The results indicate that the instrument is particularly reliable for low and median ability levels. Further refinement and possible future use of the instrument is discussed.

1. Introduction

In the context of the 21st century skills movement, it is widely accepted that people, and particularly children, must have a range of ICT competences in order to cope with the economic, social and educational changes and challenges of our current knowledge society (European Commission, 2007). This significance of being ICT competent is reflected in international and national policies for educational ICT use (European Commission, 2007; ISTE, 2007; Kozma, 2008). Some European countries have issued clear formal expectations to schools in terms of ICT competence frameworks, standards or attainment targets (Vanderlinde, van Braak, & Hermans, 2009). Although much time and money is being invested in the development of such educational policies and frameworks, little is known about the degree to which pupils benefit from these initiatives in terms of ICT competence development.

Meelissen (2008) states that there is rather limited research interest in the measurement of ICT competences. Because research that has been carried out produces such a wide range of different measures, making comparisons between the results is hindered. Moreover, most of the measures that have been developed are directed toward students' ICT self-efficacy, which is mostly measured using a Likert-scale. A big disadvantage of a Likert-scale is that we cannot exactly say how competent a pupil is, because there is no assumption that the different positions on the scale are equally spaced. Another limitation using such indirect measures is that students' self-reported results are not always an accurate representation of their actual performance level (Hakkarainen et al., 2000). Conclusions drawn from these studies can have severe consequences. For example, some research indicates that sex is not related to people's actual computer and internet fluency. However, with regard to self-perceived abilities, a significant effect of sex often seems to appear in favor of men (Bunz, Curry, & Voon, 2007; Hargittai & Shafer, 2006). Such results reinforce the already existing gender stereotype of computing being a male domain, with women considering themselves as less competent in technology use. In turn, this feeling of being less ICT competent could result in taking less advantages of available ICT services, using less computers and the internet, and pursuing less technology related careers (Bunz et al., 2007; Hargittai & Shafer, 2006). Furthermore, according to Meelissen (2008), in most cases ICT competence measurements target students from post-secondary education.

This study outlines the development of a direct measure of ICT competence for pupils in primary-school education. Direct measurement means that the assessment is based on the analysis of pupils' directly demonstrated performance (Allen, Noel, Rienzi, & McMillin, 2002). It refers to pupils' actual skills and knowledge, and does not rely on their own judgment. In the specific case of ICT competences, pupils have to perform hands-on tasks with a computer, the results of which are then analyzed based on the logged data files. Using this task-based approach rather than a questionnaire approach, allowed the measure to reflect the actual behavioral ICT competence of the pupils and overcome issues of self-reported bias. To our knowledge, no instruments that assess primary-school pupils' ICT competence in a direct and valid way have yet been described in the research literature. However, the need for developing such direct assessment instruments for primary-school age pupils is necessary, as ICT skills and competences more and more are being integrated as attainment targets in compulsory primary-school curricula (Aesaert, Vanderlinde, Tondeur, & van Braak, 2013). Moreover, it can be expected that the younger pupils are, the more difficulties they experience in judging their own competences (Bouffard, Markovits, Vezeau, Boisvert, & Dumas, 1998), and thus the higher the need for performance-based actual measures.

2. Background

2.1. ICT competence

Various terms are used to define the range of human attributes associated with ICT use. The terms most commonly used in recent international reports and reviews include ICT competences, skills, and literacy. Although these terms have specific and distinct meanings, they are often used interchangeably in similar contexts (Markauskaite, 2006), and are also used rather unsystematically within national educational technology curricula (Aesaert et al., 2013). In this study, pupils' proficiency in ICT use is considered from the perspective of ICT competences.

Since the 1960s the concept of ICT literacy passed through a three-phase development, parallel to the evolution of other literacies: the mastery stage (up to the mid-1980s), the application stage (to late 1990s), and the reflective stage (since the late 1990s) (Martin, 2006). Corresponding to these concepts, in schools, the focus on specific types of ICT skills and competences has also evolved. In the mastery stage, schools focused on the acquisition of simple computer science (e.g. how the computer works), and the rudiments of computer programming. During the application phase, emphasis was placed on the application of the computer as an everyday tool in education, work, leisure, and home. That is, rather than developing specialist knowledge, the focus was on developing practical basic competences in using and applying common software. During the reflective stage, the mastery of technical ICT skills has been considered insufficient with respect to developing proficient ICT literacy skills (ETS, 2002). In other words, simply acquiring technical ICT knowledge and skills is now considered insufficient for adequately coping with the changes in our contemporary society (Voogt, 2008). A major characteristic of the reflective stage is that technical ICT skills are superseded by generic skills or meta-skills (Martin, 2006).

At the international level, the importance of ICT competences has been acknowledged and several definitions have been developed. For example, the European Commission (2007) posits digital competence as one of eight key competences for lifelong learning, also known as 21st century skills. In this context, digital competence is concerned with critical thinking, problem solving, and the creative and innovative use of a computer, over and beyond simply mastering technical ICT skills. Digital competence is defined as "the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet" (European Commission, 2007, p. 7). Similarly in the United States, ISTE's National Educational Technology Standards for Students are organized into the following six categories: 1) Creativity and Innovation; 2) Communication and Collaboration; 3) Research and Information Fluency; 4) Critical Thinking, Problem Solving, and Decision Making; 5) Digital Citizenship; and 6) Technology Operations and Concepts (ISTE, 2007). As these definitions indicate, recent developments in the concept of ICT competences lean toward the use of ICT for creative purposes, problem solving and information literacy, placing less emphasis on technical computer skills. In this regard, Ito et al. (2008) contend that children's participation in society does not only require the ability to access "serious" online information and culture, but also the ability to creatively participate in recreational and social activities online. The authors stress the importance of imaginative and expressive forms of production, based on children's individual choices and available media. As such, ICT competences do not only encompass media consuming abilities, but also those necessary to act as active media producers through videos, photos, profiles, etc. (Ito et al., 2009). Similarly, Barron, Kennedy Martin, and Roberts (2007) describe technological fluency as the ability to reformulate knowledge, to express oneself creatively and appropriately, and to generate information (rather than solely comprehend it) such as digital video production, web design, database authoring.

Within the context of 21st century skills and the continual emphasis on the challenges of our contemporary society (i.e., the reflective phase), this study perceives ICT competences as multilayered constructs. As such, Markauskaite's (2007) view on ICT literacy was followed, which is described as the interactive use of general cognitive and technical capabilities in order to complete cognitive and computer based tasks. This means that an ICT competence in this study refers to a higher-order learning-process oriented competence used in complex situations, and in which technical ICT knowledge and skills are integrated (Aesaert et al., 2013).

As the definitions above indicate, ICT competences have a very broad scope, ranging from information retrieving abilities to active media producing abilities. Both retrieving and processing digital information, and communicating with a computer can be considered as two essential components of ICT competence. In their international comparison of frameworks of 21st century skills, Voogt and Pareja Roblin (2012) refer to digital communication and information processing as two essential competences that pupils should possess. Similarly, Aesaert et al. (2013) identified retrieving and processing appropriate digital information; and communicating in a safe, sensible and appropriate way as two regular reoccurring themes in national ICT curricula. Moreover, research indicates that pupils' still experience problems related to information retrieving and processing skills, such as defining proper search queries, evaluating the information found, etc. (van Deursen & van Diepen, 2013). Although they are often labeled as digital natives (Prensky, 2001), pupils still encounter problems with higher-order cognitive skills such as finding and using the right information on the internet (Calvani, Fini, Ranieri, & Picci, 2012; Kuiper, Volman, & Terwel, 2005). Moreover, this study uses performance-based tasks to develop a direct measure of ICT competence. Because the administration of authentic performance-based tasks takes time, the number of ICT competences selected for measurement was limited. As research indicates that retrieving and processing digital information, and communicating with a computer are two general ICT competences, these were selected as competences to be measured in this study.

2.2. Direct measurement of ICT competences

As noted above, research interest in the measurement of students' ICT competences is rather limited (Meelissen, 2008). The few studies that have been conducted have mainly been concerned with indirect assessment of ICT competences, i.e. computer self-efficacy. Compeau and Higgins (1995) have focused on the concept of computer self-efficacy, which they define as the judgment of one's own ability to use a computer for broad tasks, rather than simple component subskills. However, there are a number of limitations with regard to computer self-efficacy. The first limitation concerns the fact that the concept has been operationalized in different ways by different authors, and has evolved over time. For example, Marakas, Yi, and Johnson (1998) divide the concept of computer self-efficacy into general computer self-efficacy and application-specific self-efficacy, in which the latter is defined as an individual's belief in his or her ability to perform specific computer tasks. Papastergiou, Gerodimos, and Antoniou (2012) conceptualize ICT self-efficacy as students' individual beliefs regarding their ability to use the internet and multimedia blogging. Similarly, Tsai and Tsai (2010) operationalize Internet self-efficacy as the perceived ability to navigate and search information on the internet (online exploration) and to communicate via the internet (online communication).

The second limitation of assessing pupils' ICT self-efficacy is the indirect nature of the measurement itself, i.e. pupils' self-reported results are not always a good representation of their actual performance level (Hakkarainen et al., 2000). More recently, certain international assessment initiatives have been set up to measure pupils' level of technological competences in more direct ways, by using performance-based software such as ICILS and iSkills (Fraillon & Ainley, 2010; Katz, 2007). However, these initiatives do not address the ICT competences of pupils in primary-school education. Direct assessment methods collect data of students' actual performance or attainment by analyzing observable data, such as portfolios, standardized tests, performances, etc. Performance or simulation-based assessment tasks are very valuable because they guarantee authentic and direct appraisals of educational competences (Messick, 1994).‘Real tasks’ are considered to be more authentic and therefore more valid than the conventional item designs such as multiple choice (Wirth, 2008). Consequently, performance-based tests using authentic tasks seem to be a more valid way of measuring the complexity of ICT competences.

2.3. Item response theory

Next to the problem of indirect measurement, the assessment of ICT competences is also faced with another problem of measurement. More specifically, most of the instruments developed to assess pupils' ICT competences are based on the principles of classical test theory (CTT). The major focus of classical test models is at the level of test scores. This means that CTT models do not consider how an individual or group of examinees will respond to a specific item (Hambleton, Swaminathan, & Rogers, 1991). The major shortcoming of CTT is its circular dependency i.e. test taker and test/item characteristics are dependent and can only be interpreted in the context of each other (Hambleton et al., 1991). More specifically, the test taker statistic (i.e., observed score) depends on the sample of items included in the test and the item statistics (i.e. item difficulty and item discrimination) depend on the sample of respondents that the test is administered to. This circular dependency can complicate test development and analysis situations such as test equating. Modern test theories such as item response theory (IRT) can overcome the limitations of CTT. IRT explicitly models examinee responses at the item level. Moreover, IRT models produce test statistics that are not examinee dependent and examinee scores that are not test/item dependent (Hambleton et al., 1991). In order to create valid measures of ICT competence, both the problem of indirect measurement and the measurement problems associated with CTT should be tackled.

The general purpose of this study was to develop a direct measure of ICT competence for pupils at the end of primary education. More concretely, this study has two specific aims:

1) to outline the procedure followed in the development of the item pool and the assessment instrument; and

2) to use IRT to examine the item and test characteristics and to construct and validate a direct measure of ICT competence for pupils in primary education.

3. Methods

3.1. Item development

Prior to the development of the items, a domain analysis was conducted in order to clearly define and operationalize the concept of the two competences to be measured. Based on a literature review on digital information processing and digital communication, the higher-order skills that make up both of these competences were summed up (AASL, 1998; ACRL, 2000; Ananiadou & Claro, 2009; Brand-Gruwel, Wopereis, & Vermetten, 2005; Eisenberg, 2005; Eisenberg & Johnson, 2002; ETS, 2002; Fraillon & Ainley, 2010; ISTE, 2007; Kuiper, 2007; Madden, Ford, Miller, & Levy, 2006; NCREL, 2003; Puustinen & Rouet, 2009; Savolainen, 2002; Somerville, Smith, & Macklin, 2008; Tsai, 2009; Tsai & Tsai, 2003). With regard to information processing, higher-order skills concern getting access to digital information, transforming digital information, and creating digital information. The higher-order skills for digital communication concern communicating in a socially acceptable way, communicating in an understandable way and the dissemination of information by the use of computers. Furthermore, basic technical computer skills that are instrumental to the selected higher-order skills were also included. This resulted in 19 higher-order competences and 15 technical skills, which were registered in a test matrix (see Appendix A). An expert panel of ICT researchers, test developers, and teachers reviewed this matrix of competences, and the matrix was adapted according to their feedback and comments.

This study aims to develop an instrument that can be used to measure primary-school pupils' ICT competences in a direct way. This means that pupils must demonstrate their ICT competence by actually interacting with computer applications and software. Consequently, the test comprises simulation-based assessment tasks. Each of the simulation tasks developed comprises real-life information searching, processing and communication activities. In order to minimalize pupils' prior knowledge, ‘the organization of a school festival’ was chosen as the subject-overarching general theme of the test. ‘A journey through time’ was chosen as the theme of the school festival. For this test, 56 items were developed that represent the 19 higher-order competences and the 15 technical skills identified in the domain analysis. All 56 items were included across the 19 tasks, and incorporated in four major assignments or modules that made up the test (see Figure 1). At least one item targeted each ICT competence or technical skill. Some competences were represented by two or more items.

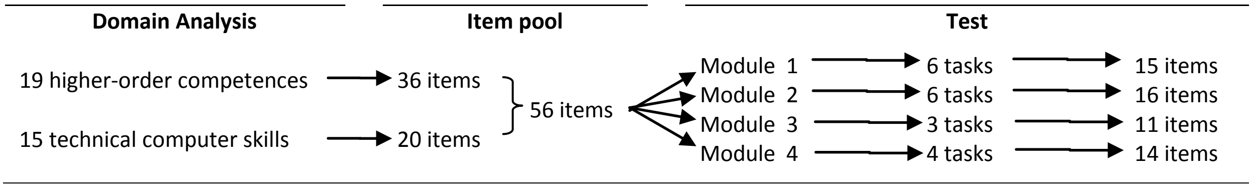

Figure 1. Overview of test development

Using Flex framework, PHP and MYSQL, a closed (walled) test environment was created, i.e., an environment in which all applications and websites were explicitly created for administering this test. Not allowing pupils to freely roam the internet reduced the authenticity of the developed items. In this context, along with realism a number of variables that cannot be controlled come into play, which puts a burden on the development of scoring criteria for the relevant aspects of this complexity (Messick, 1994). The use of a closed assessment environment, however, allowed us to control and standardize the items of the test. Further, during the development of the test it was taken into account that ICT competences are socially and culturally value-laden. Within the context of Gee's (2010) situated socio-cultural approach to literacy and technology, ICT competences are not considered as neutral but rather as social and cultural achievements. They are situated capacities that emerge and develop through social and cultural experiences. Experiences that are in turn mediated through the use of familiar tools and technologies. In order to take this socio-cultural value of ICT competences into account, the general characteristics of the ICT applications most commonly used by pupils and relevant for our test, were integrated into the developed software. This means that the new applications were recognizable, but unknown to all the pupils. As such, the possible benefits of using well-known, existing applications were reduced.

Figure 2 shows the general interface of all tasks that were developed for the assessment tool. More specifically, the task shown in the figure simulates an average web search engine for kids. For this specific task, pupils were asked to search for an image of two dinosaurs that could be integrated in a publicity poster for a school festival. Each task began with an instruction, given to pupils in the form of a pop-up window on the screen.

When the pupils confirmed that they had read the instruction, a brief version of the instruction was shown on the left-hand side of the screen. This instruction remains on the screen until the pupil confirms that the task has been completed. For each task, the pupils must use one of the six designed software applications, which can be accessed with the buttons at the bottom of the screen: a file management system, a web browser, e-mail software, presentation software, a word processor, and spreadsheet software. During each task, pupils can switch freely between the different applications. The hands-on activities of the pupils with respect to the different applications take place in a large window in the center of the screen.

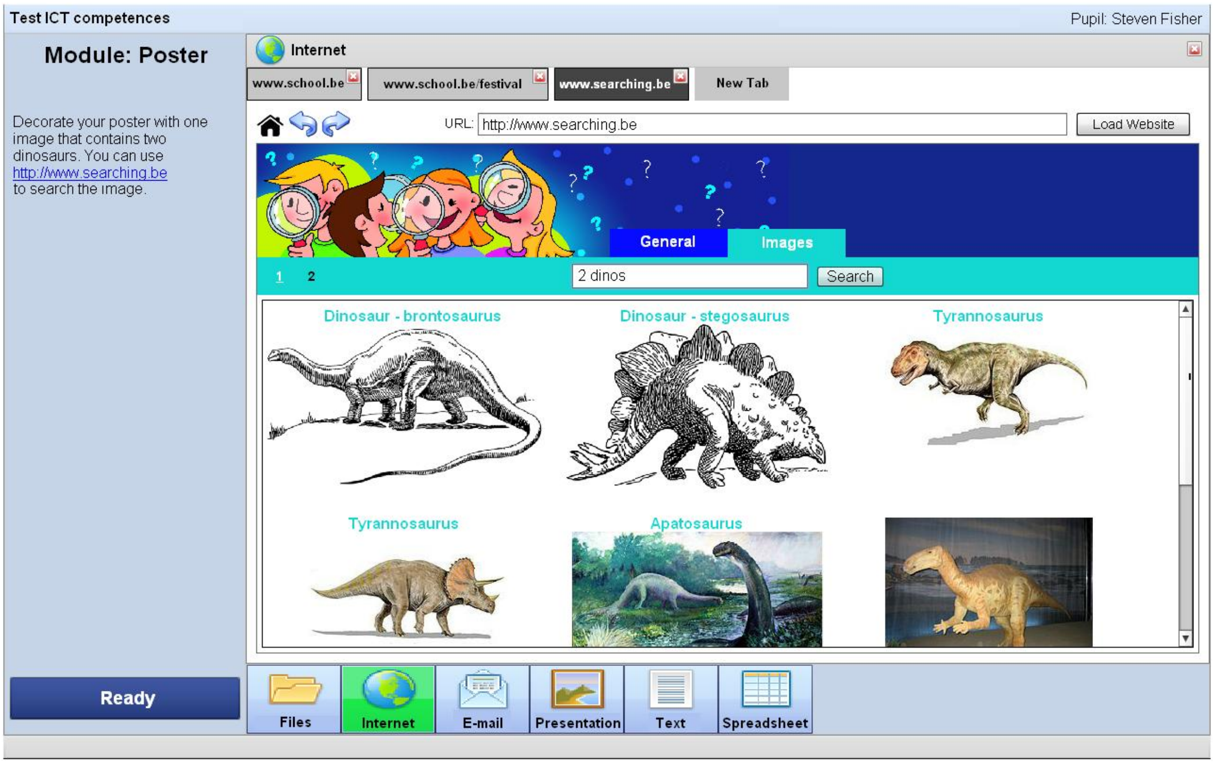

Figure 2. General task interface

During the entire item development process, the items were continuously administered to pupils in order to make necessary adaptations. More specifically, the sixth graders of two classes used the software under development to answer the items while being observed by the test developers. This was done to check 1) the influence of the ICT infrastructure in the schools on the developed software, 2) the difficulty level of the items, 3) the time that pupils required for each item, 4) the level of usability of the developed software, 5) the comprehensibility of the item instructions, and 6) the construct validity of the developed items. The developed items were also evaluated by an expert team consisting of educational advisers, test developers, teachers, and ICT-coordinators.

Together with the development of the item pool, scoring keys were developed. All items were scored dichotomously (1 = correct; 0 = incorrect). As such, the test does not provide a degree of mastery at the item level, but rather a decision whether a specific skill occurs or not for an examinee. The 1's and 0's of all the items create an examinee's item-response vector which is then used with the item parameters to estimate the examinee's overall ability/competence parameter, using maximum likelihood procedures (Baker, 2001). The items referring to technical computer skills were automatically scored as they could be directly logged as true of false. Items that were related to the higher information processing and communication competences often had a content related component that required a more intelligible judgment. These items were manually scored by a team of test raters. In order to guarantee scoring expertise, all test raters were selected from the psychometric and test development team, and all test raters received training in advance. For each item a scoring key was developed in advance, which was eventually fine-tuned using the answers of the pupils. For example, with regard to item 13 “pupils can generate a new information product by comparing and synthesizing information that was found elsewhere”, the pupils needed to gather the correct information from different parts of the school website and integrate it into a publicity poster for the school festival. The scoring key of this item contained a description of all the information elements the poster needed to contain in order to fully inform the guests about the school festival.

3.2. Participants and administration

In order to validate the instrument, the 56 items were administered to a representative sample of 560 sixth-grade primary-school pupils in Flanders in May and June 2012. The mean age of the pupils was 12.06 years, with a minimum of 10.79 and a maximum of 13.85. The administration of the test was limited to 100 min. Data were collected in 67 schools, with a mean of 8.36 pupils/school (minimum = 1; maximum = 43). Schools were stratified for school size (small school < 180 pupils; big school ≥ 180 pupils), province and educational network, i.e. official public education, subsidized public-authority education and subsidized private-authority education. Of the pupils, 49.8% were male and 50.2% were female.

3.3. IRT calibration

IRT models are generally used to measure an individual's latent traits (Baker & Kim, 2004). These are features that cannot be measured directly, such as pupils' ICT competences. In essence, IRT models use a set of items to construct an ability scale that enables the comparison between a person's latent trait and the characteristics of an item. Difficult and easy items are located on the higher and lower end of the ability scale respectively (Hambleton et al., 1991). A basic assumption in the application of IRT models is that the model fits the data. This implies choosing the correct model and evaluating the model fit. Choosing the correct IRT model firstly depends on the number of item-response categories being used (Edelen & Reeve, 2007; Tezza, Bornia, & de Andrade, 2011). For dichotomous items – as used in this study – the one, two and three parameter logistic models (1PLM, 2PLM, 3PLM) are most commonly used. All three models have a difficulty parameter, which is reflected in the localization of the item on the ability scale where the probability of a correct response is .5. This means that the greater the value of the difficulty parameter, the greater the required ability to get a 50% chance of answering the item right, and thus the more difficult the item (Hambleton et al., 1991). The 2PLM and 3PLM have a second parameter i.e. a discrimination parameter. This parameter allows the 2PLM and 3PLM for differently discriminating items. Items with a higher discrimination parameter value are more useful for separating examinees into different ability levels than items with a low value (Hambleton et al., 1991). Finally, the 3PLM has a third parameter, known as the pseudo-chance parameter. This parameter allows the 3PLM to take guessing into account. It represents a low-ability examinee's probability of answering the item correctly (Hambleton et al., 1991). Below we outline the steps taken to examine the item and test characteristics in the construction and validation of a direct measure of ICT competence.

3.3.1. Classical item analysis

First, a classical item analysis was conducted. Items with a difficulty parameter (*p*-value) of .00 or 1.00 cannot discriminate between respondents and were not retained for further analysis. A *p*-value of .00 refers to a very difficult item that is answered incorrectly by all respondents, whereas *p*-values of 1.00 indicate very easy items that are answered correctly by all respondents. Besides item difficulty, it is also important to check whether the items have equal discrimination indices (Hambleton et al., 1991). The investigation of the equality of the discrimination indices can be used as a first indication to justify model choice. More concretely, the 1PLM assumes that the discrimination indices of all items are equal i.e. the 1PLM has only one free parameter which is the difficulty parameter. If a substantial variation is found between the discrimination indices of the different items, the use of the 1PLM is not recommended. The item discrimination indices were studied by examining the distribution of the point-biserial correlations or biserial correlations. The number of biserial correlations that fall outside the range of [M_{biserial} correlation − .15;M_{biserial} correlation + .15] can be used to verify the assumption of equal discrimination (Reid, Kolakowsky-Hayner, Lewis, & Armstrong, 2007). As a point-biserial correlation is nothing more than the Pearson correlation between each item (0 or 1) and the total test score for each examinee, a negative value indicates that the lower-ability pupils would have a bigger chance than the higher-ability pupils in answering the item correctly (Osterlind, 2002). As such, items with a negative point-biserial value were removed for further analysis. Moreover, items should have a point-biserial value of at least .15 (Varma, 2006).

3.3.2. Dimensionality

Using the 1PLM, 2PLM and 3PLM to calibrate a test requires that the test is sufficiently unidimensional. Linear factor analysis is traditionally used to determine the dimensionality of dichotomous scores. However, violation of the assumptions that linear factor analysis requires continuous ratings and normality, often leads to underestimation of factor loadings and/or overestimation of the number of underlying dimensions (Embretson & Reise, 2000). Nonlinear factor analysis (NLFA) takes these shortcomings into account (Abswoude, van der Ark, & Sijtsma, 2004). The NOHARM (Normal Ogive Harmonic Analysis Robust Method) software (De Ayala, 2009) was used to conduct an NLFA to check whether the developed items were actually measuring one underlying trait. NOHARM produces a matrix of residuals, which indicate the discrepancy between the observed and predicted covariances. The residual matrix is summarized by the RMSR (root mean square residual), which is an overall measure of model-data misfit. RMSR-values smaller than four times the reciprocal of the square root of the sample size indicate a good fit (De Ayala, 2009). Besides the RMSR, Tanaka's Goodness of Fit Index (GFI) was used to check the fit of a unidimensional model, with values over .90 indicating an acceptable level of fit (De Ayala, 2009).

3.3.3. Local independence

A second important assumption to check is that of local independence. Items are locally independent when the ability specified in the model is the only factor influencing the item responses (Hambleton et al., 1991). Several studies indicate that violation of the local independence assumption can have a substantial impact on the estimation of item difficulty and discrimination parameters (Chen & Wang, 2007; Monseur, Baye, Lafontaine, & Quittre, 2011). Since the expected level of local item dependence (LID) is much higher with performance-based items (Yen, 1993) – as in the developed test – local independence was checked. Because Yen's Q_3 has been shown to be a powerful statistic (Chen & Thissen, 1998), this was used for the identification of local dependent items. The Q_3 statistic is a Pearson product moment correlation between the residuals of two items across items (Chen & Thissen, 1998; Monseur et al., 2011). Yen's (1993) commonly used .2 cut point was used to identify local independent items. Although violation of the assumption of local independence can sometimes be identified before the actual LID analysis, it is recommended to only remove the local dependent items after calibrating the test with all items. This way, maximum information is gained about the performance of all items in the context of the total scale (Edelen & Reeve, 2007).

3.3.4. Model-data fit

Checking the degree to which the model fits the data is done at the item level. Item parameters were estimated for the 1PLM, 2PLM and 3PLM using the Bayes expected a posteriori (EAP) method in BILOG. A chi-square fit statistic was calculated for each item (Stone & Zhang, 2003). The differences between the actual and predicted performances were also studied by comparing the item characteristic curves (ICC) with the plots of the observed values of each item for each model (Hambleton et al., 1991; Yen & Fitzpatrick, 2006). The closer and the more randomly the observed scores are distributed around the ICC, the better the model fits the data.

3.3.5. Test information function

Within the context of IRT, item and test information functions (IIF and TIF) are often used as evidence for reliability. It should be noted that IIF and TIF are more reliability-like statistics instead of evidence of actual reliability, since they do not relate to measurement replication. However, this does not mean that information functions aren't important for selecting and describing items (Doran, 2005). Here, information refers to the reciprocal of the precision with which an ability level can be estimated. Since the variance is a measure of precision for estimating an ability level, the amount of information is given by $I = 1/SE^2$. Consequently, a large amount of information results in a precise estimation of the ability level whereas a small amount of information means that the ability cannot be estimated with precision (Baker, 2001). Test information was plotted against ability, resulting in the test information function. The information provided by the ICT test as a whole is calculated by summing up the item information functions at a given ability level θ (Hambleton et al., 1991). Finally, the empirical reliability index is calculated, with a value that approaches 1 indicating a reliable instrument.

4. Results

4.1. Classical item analysis

First, a classical item analysis was conducted in order to investigate the difficulty and discrimination parameters. All p-values lie within the range of .134 and .945 with a mean of .610 and SD of .225 (see Table 1). The item discrimination indices are presented by the point-biserial correlations and the biserial correlations. The biserial correlations have a range of −.513 to 1.00 (M = .545; SD = .250). Out of the 56 items, 27 are located outside the critical range of .395 (M − .150) and .695 (M + .150). This is a first indication that the use of the 1PLM, which requires equal discrimination indices, is not viable. Item 20 and item 31 were removed because they cannot sufficiently discriminate between pupils (point-biserial < .15).

Item	p-value	Corrected Item-Total Correlation	Point-biserial correlations	Item	p-value	Corrected Item-Total Correlation	Point-biserial correlations
Item 1	.746	.489	.480	Item 29	.593	.473	.469
Item 2	.238	.252	.265	Item 30	.286	.400	.390
Item 3	.164	.156	.185	**Item 31**	.148	**-.325**	-.325
Item 4	.902	.243	.194	Item 32	.593	.524	.545
Item 5	.601	.566	.554	Item 33	.143	.414	.410
Item 6	.317	.492	.465	Item 34	.415	.561	.570
Item 7	.450	330	.356	Item 35	.519	.573	.584
Item 8	.548	.503	.473	Item 36	.730	.410	.375
Item 9	.749	.184	.150	Item 37	.802	.464	.453
Item 10	.942	.343	.318	Item 38	.857	.298	.311
Item 11	.659	.560	.565	Item 39	.426	.389	.383
Item 12	.881	.501	.442	Item 40	.526	.476	.495
Item 13	.772	.469	.389	Item 41	.775	.524	.515
Item 14	.656	.433	.418	Item 42	.463	.260	.229
Item 15	.828	.527	.488	Item 43	.492	.490	.479
Item 16	.558	.408	.350	Item 44	.532	.362	.327
Item 17	.569	.414	.410	Item 45	.381	.259	.302
Item 18	.325	.360	.361	Item 46	.653	.507	.495
Item 19	.299	.257	.244	Item 47	.828	.552	.530
Item 20	.296	**.011**	.029	Item 48	.690	.158	.245
Item 21	.635	**.126**	.190	Item 49	.844	.603	.573
Item 22	.780	.523	.517	Item 50	.762	.403	.396
Item 23	.561	.344	.269	Item 51	.892	.437	.390

Table 1. Item characteristics from the classic item analysis

Item	p-value	Corrected Item-Total Correlation	Point-biserial correlations	Item	p-value	Corrected Item-Total Correlation	Point-biserial correlations
Item 24	.185	.318	.297	Item 52	.275	.176	.158
Item 25	.566	.491	.477	Item 53	.892	.626	.602
Item 26	.931	.505	.497	Item 54	.815	.319	.398
Item 27	.892	.626	.602	Item 55	.815	.612	.599
Item 28	.701	.466	.501	Item 56	.505	.448	.444

Table 1 (continued)

4.2. Dimensionality

As mentioned above, a classical PCA can be inappropriate for the analysis of dichotomous data. Consequently, an NLFA was conducted on the 54 items. NOHARM was used to force a unidimensional solution to the data. The value of the root mean squared residual (RMSR = .013) was smaller than the critical value of .169 (4*/(1/$\sqrt{560}$). Tanaka's GFI had a value of .928. Consequently, both fit indices offer support for the unidimensional solution. Further study of the factor loadings and unique variances in the output did not reveal any items with a factor loading of 1.00 or a negative residual variance, which can be considered as a problematic Heywood case. Item 9 (λ = .203), item 21 (λ = .264) and item 52 (λ = .225) were deleted due to a factor loading below .300. A second unidimensional factor analysis with the 51 remaining items resulted in a GFI of .929 and RMSR of .013.

Item	One factor solution (N=54)	One factor solution (N=51)	Two factor solution (N=51)		Item	One factor solution (N=54)	One factor solution (N=51)	Two factor solution (N=51)	
			Factor 1	Factor 2				Factor 1	Factor 2
Item 1	.648	.651	.619	.274	Item 29	.615	.615	.186	.745
Item 2	.367	.367	.298	.215	Item 30	.585	.586	.305	.552
Item 3	.309	.308	.277	.147	Item 32	.731	.734	.379	.695
Item 4	.325	.329	.353	.089	Item 33	.755	.755	.345	.783
Item 5	.710	.710	.684	.291	Item 34	.795	.794	.461	.690
Item 6	.665	.663	.605	.311	Item 35	.790	.789	.475	.665
Item 7	.461	.463	.457	.175	Item 36	.520	.525	.506	.212
Item 8	.606	.603	.609	.213	Item 37	.651	.653	.624	.271
Item 9	**.203**				Item 38	.473	.474	.405	.254
Item 10	.608	.598	.582	.234	Item 39	.525	.527	.516	.205
Item 11	.732	.730	.644	.367	Item 40	.649	.646	.672	.208
Item 12	.706	.703	.671	.295	Item 41	.720	.721	.724	.259
Item 13	.544	.542	.524	.218	Item 42	.308	.312	.238	.201
Item 14	.546	.546	.449	.313	Item 43	.628	.629	.587	.279
Item 15	.717	.717	.603	.395	Item 44	.437	.439	.371	.240
Item 16	.444	.446	.417	.196	Item 45	.422	.425	.451	.124

Table 2. Factor loadings of the NLFA

Item	One factor solution (N=54)	One factor solution (N=51)	Two factor solution (N=51)		Item	One factor solution (N=54)	One factor solution (N=51)	Two factor solution (N=51)	
			Factor 1	Factor 2				Factor 1	Factor 2
Item 17	.526	.529	.485	.244	Item 46	.643	.640	.674	.195
Item 18	.477	.478	.412	.250	Item 47	.788	.787	.836	.232
Item 19	.336	.334	.303	.158	Item 48	.330	.327	.287	.165
Item 21	**.264**				Item 49	.851	.850	.821	.348
Item 22	.723	.722	.590	.417	Item 50	.550	.549	.495	.263
Item 23	.355	.357	.314	.179	Item 51	.643	.639	.580	.301
Item 24	.470	.470	.361	.299	**Item 52**	**.225**			
Item 25	.621	.620	.434	.446	Item 53	.964	.963	.560	.829
Item 26	.930	.928	.482	.876	Item 54	.590	.590	.100	.807
Item 27	.964	.963	.560	.829	Item 55	.851	.852	.311	.951
Item 28	.674	.675	.185	.843	Item 56	.609	.609	.333	.553

Table 2 (continued)

In order to verify the one-dimensional structure, a two-factor solution was conducted using NOHARM. The two-factor analysis revealed an increase of Tanaka's GFI to .942 indicating a slight model improvement. The RMSR decreased to .012. According to Tate (2003), test dimensionality is defined as the model with the highest number of dimensions that still produces a 10% or greater decrease in the RMSR over the preceding model. In this case, the GFI and the RMSR do not provide decisive evidence for a two-factor solution. The factor loadings indicated that most items had problematic low loadings on the second factor ($\lambda < .300$) or cross-loadings (see Table 2). Based on these data and following the economical principle, it was decided that the unidimensional model is appropriate to conduct further IRT analyses with the remaining 51 items.

4.3. Fitting the model

In order to check which model fits the data best, the fit of the individual items was checked using the computed likelihood ratio χ^2. BILOG provides these values at the end of the final estimation cycle. The analysis of the χ^2 values supports the suitability of the 2PLM as best fitting model (see Table 3). For the 1PLM, 21 items did not fit the data well with $p < .05$. For the 3PLM 19 items had a poor fit to the data, whereas for the 2PLM only six items could be identified as misfitting. These findings are supported by the χ^2/df ratio with a ratio lower than 3.0 indicating good fit. For the 1PLM, 11 items have a χ^2/df ratio above 3.0 whereas for the 2PLM, only four items exceed the critical value. Six items of the 3PLM indicate a bad model-data fit.

Item	1PLM χ^2	*(p)*	X^2/df	2PLM χ^2	*(p)*	X^2/df	3PLM χ^2	*(p)*	X^2/df
Item 1	8.5	.485	.94	6.7	.461	.96	7.0	.536	.88
Item 2	11.3	.124	1.61	5.2	.818	.58	11.4	.246	1.27
Item 3	1.6	.103	1.77	9.6	.295	1.20	16.2	**.024**	2.31
Item 4	26.5	**.001***	**3.31**	11.3	.185	1.41	16.8	**.032**	2.10
Item 5	22.0	**.005**	2.75	13.5	.094	1.69	13.7	.135	1.52
Item 6	19.0	**.008**	2.71	12.0	.101	1.71	14.5	**.043**	2.07
Item 7	1.0	.264	1.25	4.8	.855	.53	6.4	.701	.71
Item 8	1.4	.240	1.30	8.3	.408	1.04	18.6	**.017**	2.33
Item 10	1.7	.883	.34	2.0	.922	.33	1.7	.887	.34
Item 11	22.5	**.007**	2.50	7.3	.507	.91	17.2	**.028**	2.15
Item 12	4.3	.834	.54	7.6	.365	1.09	9.2	.163	1.53
Item 13	16.6	.056	1.84	25.6	**.001**	**3.20**	3.8	**.000**	**3.85**
Item 14	6.5	.687	.72	8.9	.442	.99	14.1	.079	1.76
Item 15	14.4	.108	1.60	9.9	.194	1.41	26.2	**.001**	**3.28**
Item 16	8.2	.510	.91	5.3	.810	.59	11.5	.245	1.28
Item 17	4.1	.847	.51	5.8	.757	.64	16.3	.062	1.81
Item 18	3.1	.876	.44	4.3	.827	.54	11.9	.158	1.49
Item 19	13.6	.059	1.94	7.0	.633	.78	18.1	**.021**	2.26
Item 22	9.2	.420	1.02	4.9	.771	.61	8.4	.395	1.05
Item 23	39.5	**.000**	**4.39**	21.9	**.009**	2.43	27.4	**.001**	**3.04**
Item 24	2.6	.857	.43	3.2	.787	.53	15.3	**.018**	2.55
Item 25	16.2	**.040**	2.03	11.3	.126	1.61	11.6	.168	1.45
Item 26	18.2	**.001**	**4.55**	13	**.005**	**4.33**	6.3	.096	2.10
Item 27	22.2	**.001**	**3.70**	3.4	.636	.68	7.2	.208	1.44
Item 28	6.3	.611	.79	12.6	.127	1.58	12.1	.097	1.73
Item 29	5.8	.568	.83	7.2	.406	1.03	21.9	**.003**	**3.13**
Item 30	18.6	**.010**	2.66	21.1	**.004**	**3.01**	13.3	.102	1.66
Item 32	26.0	**.001**	**3.25**	11.1	.086	1.85	18.3	.011	2.61
Item 33	43.4	**.000**	**14.47**	15.5	**.004**	**3.88**	23.7	**.000**	**5.93**
Item 34	56.2	**.000**	**9.37**	5.6	.342	1.12	19.4	**.002**	**3.88**
Item 35	49.4	**.000**	**7.06**	9.9	.129	1.65	17.9	**.006**	2.98
Item 36	8.2	.511	.91	3.3	.949	.37	4.9	.844	.54
Item 37	14.1	.079	1.76	5.3	.626	.76	5.9	.661	.74
Item 38	17.9	**.037**	1.99	8	.432	1.00	5.8	.669	.73
Item 39	7.2	.519	.90	11.1	.266	1.23	11.4	.250	1.27
Item 40	11.7	.232	1.30	8.5	.385	1.06	1.3	.324	1.14
Item 41	12.6	.182	1.40	12.5	.129	1.56	7.7	.461	.96
Item 42	34.9	**.000**	**4.36**	3.7	.927	.41	5.8	.757	.64
Item 43	14.3	.075	1.79	13.7	.090	1.71	19.4	**.022**	2.16
Item 44	13.9	.084	1.74	7.3	.604	.81	7.2	.619	.80
Item 45	9.6	.214	1.37	12.1	.147	1.51	14.7	.064	1.84
Item 46	8.1	.421	1.01	9.8	.277	1.23	21.7	**.006**	2.71
Item 47	1.2	.250	1.28	13.9	.054	1.99	19.6	**.012**	2.45
Item 48	48.1	**.000**	**5.34**	9.1	.431	1.01	1.1	.343	1.12
Item 49	15.9	**.026**	2.27	8.4	.213	1.40	26.6	**.000**	3.80
Item 50	17.7	**.038**	1.97	18.1	**.021**	2.26	16.5	.036	2.06
Item 51	7.9	.441	.99	1.2	.176	1.46	21.2	**.007**	2.65
Item 53	22.2	**.001**	**3.70**	3.4	.636	.68	7.2	.208	1.44
Item 54	17.3	**.027**	2.16	7.1	.414	1.01	3.8	.803	.54
Item 55	14.2	**.048**	2.03	4.9	.552	.82	12.0	.101	1.71
Item 56	3.5	.898	.44	4.2	.838	.53	12.6	.125	1.58

Table 3. Item fit statistics for the 1PLM. 2PLM and 3PLM * Items in bold are identified as misfitting for that specific model.

A study of the ICC of each item under the 2PLM supported the misfit of the six items as found in the analysis of the χ^2 values. Based on these results, item 13, 23, 26, 30, 33 and 50 were removed from the 2PLM for further analysis.

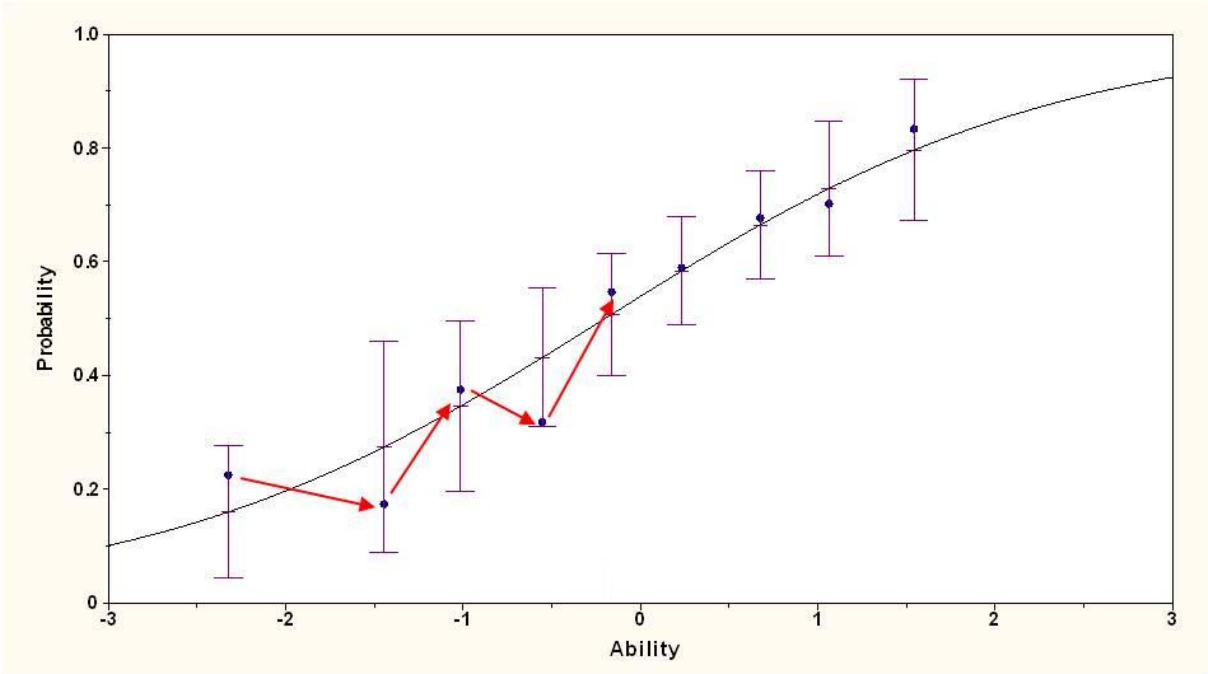

Figure 3. ICC of item 44 illustrating violation of the assumption of monotonicity

Although the χ^2 values indicated that the 45 items were appropriate for further IRT analysis, the residual analysis revealed underlying problems. Four items violated the assumption of monotonicity and were removed from the analysis. It is assumed that with an increase in ability, the probability of getting a correct response does not decrease for a specific item (Reckase, 1997). Figure 3 illustrates for item 44 that the observed proportion of correct answers is not monotonically increasing with an increase of ability. Pupils with an ability of −1.5 have a lower probability of answering this item correctly than pupils with a lower ability of −2.5.

4.4. Local item dependence

In regular unidimensional IRT models, such as the 2PLM, the probability of getting a successful response solely depends on the person's ability and on item characteristics. Items are considered as locally independent when a test taker's responses to different items are statistically independent after taking the latent trait into account (Monseur et al., 2011; Pommerich & Segal, 2008). The results of this study have shown that the developed test is unidimensional, i.e. it is assumed that all items of the test as a whole are intercorrelated solely due to the latent trait of ICT competence. Local independence means that if the underlying trait of ICT competence is controlled, no more items of the test should be related (Monseur et al., 2011).

Yen's Q_3 statistic was used to check the assumption of local independence. Item parameters and pupils' individual abilities were calculated using the 2PLM with expected a posteriori (EAP) estimation in BILOG. Nineteen items had one or more Q_3-values higher than .20, indicating that a large number of items were interrelated with one or more other items. This was partly expected due to the simulation oriented and performance-based nature of the items, and the fact that certain competences were measured by two or three different items. In order to manage the locally dependent items and to establish construct validity, the principle of combined grading of LD items was used (Yen, 1993). Based on this reduction principle, the information of the 41 items was finally combined in 27 items that were retained for the final analysis.

Item	Description higher-order competences and technical skills	b-value	a-value
Item 1	Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver	2.598	0.689
Item 2	Pupils can assess and judge the relevance of the information that was found for answering a question	1.760	0.987
Item 3	Pupils use the title and textual information found in the results of a conducted search	1.309	0.624
Item 4	Pupils use ICT applications to ask a question or deliver a message in a social acceptable way	1.035	0.736
Item 5	Pupils can answer an e-mail to one known person	0.214	0.559
Item 6	Pupils can judge the reliability of digital information	0.181	2.240
Item 7	Pupils can generate a new information product by comparing and synthesizing information that was found elsewhere	0.094	0.855
Item 8	Pupils can send an e-mail to more known persons	-0.028	1.342
Item 9	Pupils can use a search engine by entering more correct search terms derived from a task or question	-0.042	0.981
Item 10	Pupils can add an attachment to an e-mail	-0.093	1.249
Item 11	Pupils can use basic software commands such as copying and pasting a text	-0.163	1.288
Item 12	Pupils can deliver information to others by using a non-structured format such as a e-mail	-0.211	1.377
Item 13	Pupils can react on a forum	-0.304	1.980
Item 14	Pupils can assess and judge the relevance of the information that was found for answering a question	-0.336	1.137
Item 15	Pupils can integrate new information into existing information products	-0.398	1.584
Item 16	Pupils can save and retrieve a file from a specific location	-0.634	1.062
Item 17	Pupils formulate a subject of a mail/forum that refers adequately to its content	-0.810	1.368
Item 18	Pupils can use a search engine by entering one correct search term derived from a task or question	-1.225	1.575
Item 19	Pupils formulate a subject of a mail/forum that refers adequately to its content	-1.350	1.173
Item 20	Pupils can use basic software commands such as copying and pasting an image	-1.405	2.031
Item 21	Pupils can deliver information to others by using a structured format such as a digital form	-1.464	1.572
Item 22	Pupils can deliver information to others by using a structured format such as a digital form	-1.524	2.523
Item 23	Pupils can start a topic on a forum	-1.574	1.145
Item 24	Pupils can configure a search engine to improve an intended search for figures or other media files	-1.592	0.589
Item 25	Pupils can use a search engine by entering one correct search term derived from a task or question	-2.005	1.408
Item 26	Pupils can delete an e-mail	-2.231	0.915
Item 27	Pupils can efficiently use an URL	-3.036	1.127

Table 4. Final items and their discrimination (a-value) and difficulty (b-value) indices

The remaining 27 items and their parameters under the 2PLM are presented in Table 4. The items are renumbered due to the combining of the grading and are ordered according to their difficulty. The zero point of the scale on which the difficulty parameters are expressed was based on the mean ability level of the pupils. The technical ICT skills and higher-order competences are evenly distributed along the ability scale. The data indicate that the item in which pupils must prove that they can use ICT to communicate in an understandable way appears to be the most difficult for pupils, with a *b*-value of 2.598. Consequently, this item is located at the highest point of the ability scale. Item 8 has a *b*-value of −.028 which means that this item measures closest to the average level of the ability scale. Some of the ICT competences that are represented by more than one item are situated in different locations on the ability scale, i.e. different items that measure a specific ICT competence have different difficulty parameters.

4.5. Reliability

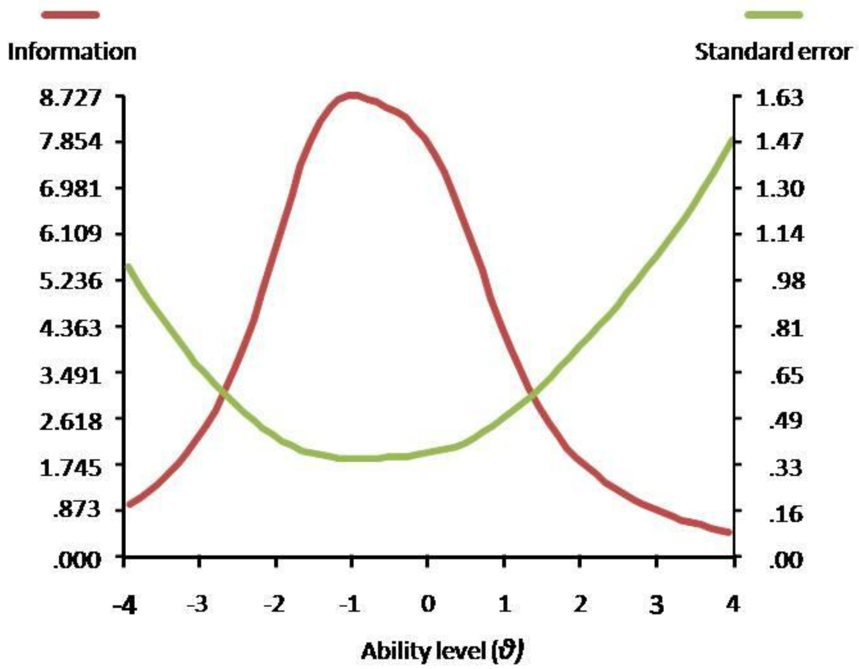

Figure 4. Test information function for ICT competence

Figure 4 shows the test information function. The test takers' ability level on the horizontal axis is plotted against the amount of information provided by the test at a certain ability level on the left vertical axis. The higher the information function of the test at a certain ability, the more precise the test measurement at that specific point

($SE(\theta)=1/\sqrt{I(\theta)}$). The right vertical axis shows the standard error for a specific ability level. The results indicate that our test is most reliable between the ability levels −2 and .5. For example, at $\theta = -1$, the test information value is 8.73, which results in a small SE of .34 and a good reliability of $r = .89$. At $\theta = 1$ the test information decreased to 3.97 resulting in an SE of .50. This means that the test measures less precisely at an ability level of 1, which is reflected in a lower reliability coefficient ($r = .75$). Overall, the instrument shows good reliability for measuring average to lower-ability levels but it is less accurate in measuring the highest ability levels. Finally, the empirical reliability of the overall test was calculated. The value of r was .86, indicating that the scale developed for the direct measurement of pupils' ICT competences shows good internal consistency.

5. Discussion and conclusion

As indicated by various ICT curricula, schools are now responsible for producing ICT-competent pupils. Therefore, a valid assessment of pupils' ICT competences is necessary to determine pupils' ICT competence level in order to investigate the degree to which pupils master the established ICT curriculum, and to evaluate the effectiveness of classroom initiatives that aim to develop pupils' ICT competences. The aim of this study was to develop and validate an assessment instrument for this purpose. With this aim, a direct measure of ICT competence was developed.

The instrument developed in this study measures the degree to which pupils are able to retrieve and process digital information that is appropriate for them as well as the degree to which they are able to use ICT to communicate in a safe, sensible and appropriate way. The results of this study contribute to the literature on the assessment of ICT competences in several ways: whereas previous studies seem to focus on developing indirect measures of ICT self-efficacy, we developed a standardized direct measure of ICT competence. As noted above, the risk of using such indirect measures is that they depend heavily on the pupil's capacity to correctly judge their own competence.

Item response theory (IRT) was used to investigate the item characteristics and to provide evidence of the validity and reliability of the developed instrument. The results of the factor analysis indicate that a single construct underlies the instrument. This is an interesting finding, as we started this study with the belief that information searching and processing, and digital communication could be considered as two theoretically different ICT competences, together with their underlying technical skills. However, the disclosure of such a general underlying trait of ICT competence is not entirely unexpected. Similarly, large scale math assessments that contain domains of algebra, geometry and statistics, are often characterized by one underlying trait of general math ability. At the same time however, the area of tension between the theoretical complex construct of ICT competences and the empirical unidimensional construct that was revealed in this study, questions the methodological approach as a limitation of this study. More specifically, the decision to chose for a unidimensional IRT model was based on the economic principle, the fact that many items load low on a second non-dominant factor and that there were cross-loadings. However, these cross-loadings could possibly indicate within-item multidimensionality i.e. an item measures more than one construct (Edwards & Edelen, 2009). As such, future research could investigate whether the use of a multidimensional IRT model would yield better fitting results. However, if the unidimensional approach is followed, the results of this study undermine the premise that basic technical skills and digital information processing skills are skills associated with completely different domains. Moreover, some of the technical skills appear to be more difficult for pupils than the information processing and communication competences. These findings raise the question as to whether ICT curricula and ICT use in schools should focus more explicitly on certain technical ICT skills, rather than only teaching them in an instrumental way to higher-end competences. However, since other ICT competences exist, e.g., being creative with a computer or being able to collaborate with each other using computers (European Commission, 2007; ISTE, 2007), future research should explore how they relate to the underlying construct found in this study. In this context of the assessment of other ICT competences, the test's single focus on information processing and communication can be considered as a major limitation of this study. A valid assessment of primary-school pupils' ability in active media production and digital creativity could help to shed light on a more comprehensive profile of pupils' ICT competences.

The results of this study indicate that the data fit the 2PLM reasonably well. After filtering out the locally dependent items, the 27 remaining items spread broadly across the lower sections of the ability scale to the relatively higher levels of understanding. The preliminary reliability analysis showed that the instrument offers precise estimations for lower and median ability levels. In future studies, the developed instrument could be improved by increasing the difficulty of existing items or even creating new and more difficult items. Overall, our analyses provide evidence that the developed instrument is a reliable and valid direct measure of pupils' ICT competences.

Although our preliminary analysis provided evidence of validity for the developed test, validation of an instrument through the use of IRT is an intensive process that should be further investigated in future studies. For example, a limitation of this study is that no differential item functioning (DIF) analysis was conducted in order to guarantee test fairness. An item exhibits DIF if individuals from different groups (but with the same ability), have a different probability of answering the item correctly (Hambleton et al., 1991). In this context, Raju's DFIT would be appropriate since differential functioning is not only checked at the item level but also a measure for the entire test is calculated (Raju, van der Linden, & Fleer, 1995). However, the investigation of DFIT for the 2PLM was beyond the scope of this study, as our sample did not reach the required minimum size of 500 pupils for each group (Oshima & Morris, 2008). Future studies should also investigate whether specific items behave differently for males and females, or for certain socio-economic groups. Besides this investigation of internal psychometric features for the validation of the developed direct measure, future research should also focus on external criteria. For example, studies into the relationship between pupils' actual ICT competences and their self-perceived competences, would make an interesting contribution to the external validity of the developed instrument and would shed light on the actual value of direct measurement of ICT competences. Such data already have been collected and we intend to report on this matter in the near future.

It is important to note that technical ICT skills and higher communication and information processing skills are evenly distributed along the ability scale. With regard to retrieving information, search queries that require more precise search terms are more difficult than one-term search queries. Indeed, van Deursen and van Diepen (2013) indicate that students' search queries are often too long and not specific enough. Moreover, judging the reliability and relevance of the information found in the results of a conducted search is the most difficult part of the information seeking process. This is in line with the findings of Kuiper et al. (2005), who state that students encounter problems in evaluating the relevance and reliability of web information. With regard to pupils' competences in using computers for communication, these authors also remark that pupils need to develop their ability more to communicate in non-structured, as opposed to structured, digital environments. Moreover, in our study the most difficult items were those for which pupils had to use ICT applications to formulate a high quality question or message, i.e. a message in which the content was understandable and socially acceptable.

An interesting finding in this study is that different items measuring the same higher-order skill appear to be located at different points on the ability scale. Future research should investigate the degree to which the scores for these items are related to certain characteristics that have not been taken into account here, e.g., software familiarity and experience. It can be assumed that high familiarity with a certain software program used for an item facilitates the possibility of getting the answer correct, whereas low familiarity with a software program hampers this possibility.

The instrument developed in this study can be used to obtain standardized measures of primary pupils' ICT competences that are not sample dependent. At the local level, the results of such assessments can be used to inform teachers and school leaders about the ICT competences they need to focus on in the class. Teachers can use the results of the test to provide their pupils with individualized instruction in order to develop very specific skills. As such, teachers can use this information to create equal possibilities for all their pupils in order to overcome digital inequality. Further, the test can deliver input for professional development at the teacher and school level. If teachers themselves take the test, they can use the results for identifying those competences and skills they need to develop themselves, in order to teach them to their pupils. At the national level, data from the test can direct curriculum developers and policy makers toward ICT competence areas that may need to be addressed in ICT curricula. Moreover, if the items of the test are adapted according to the content of a specific national ICT curriculum, the results give information on how well pupils are mastering the ICT curriculum at the system level.

From a scientific point of view, the use of this test can contribute to research on pupils' ICT competences. First, the test would enable researchers to investigate the relationship between pupils' actual ICT competences and their self-perceived competences. Moreover, it would be interesting to see the degree to which factors related to self-perceived measures correlate with actual ICT competences. Second, future research could investigate how these data are related to pupil, teacher and school characteristics, such as ICT attitudes or the school's availability of an ICT policy plan. Doing so would enable researchers to map effective characteristics that contribute to pupils' ICT competences at different levels.

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Appendix A

Matrix of the higher-order ICT competences and technical ICT skills

Higher-order ICT competences
1. Pupils can use a search engine by entering one correct search term derived from a task or question
2. Pupils can use a search engine by entering more correct search terms derived from a task or question
3. Pupils use a search index in an efficient way to find information
4. Pupils can efficiently use an URL
5. Pupils can efficiently use the menu of a website
6. Pupils can use useful links
7. Pupils use the title and textual information found in the results of a conducted search
8. Pupils can configure a search engine to improve an intended search for figures or other media files (not technical)
9. Pupils can adapt the features of a digital application such as a digital library (e.g. title. author. etc.) in order to narrow and improve their searching process
10. Pupils can assess and judge the relevance of the information that was found for answering a question
11. Pupils can judge the reliability of digital information
12. Pupils can replace information in a text by another representation to make it more understandable for specific purposes
13. Pupils can generate a new information product by comparing and synthesizing information that was found elsewhere
14. Pupils can integrate new information into existing information products
15. Pupils use ICT applications to ask a question or deliver a message in a social acceptable way
16. Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver
17. Pupils formulate a subject of a mail/forum that refers adequately to its content
18. Pupils can deliver information to others by using a structured format such as a digital form
19. Pupils can deliver information to others by using a non-structured format such as an e-mail

Technical ICT skills
1. Pupils can save a file with a specific name
2. Pupils can retrieve a file from a specific location
3. Pupils can use basic software commands such as copying and pasting an image
4. Pupils can use basic software commands such as copying and pasting a text
5. Pupils can send an e-mail to one known person
6. Pupils can send an e-mail to more known persons
7. Pupils can answer an e-mail to one known person
8. Pupils can reply to all persons addressed in an e-mail
9. Pupils can delete an e-mail
10. Pupils can add an attachment to an e-mail
11. Pupils can open an attachment
12. Pupils can fill in a subject
13. Pupils can react on a forum
14. Pupils can start a topic on a forum
15. Pupils can fill in an online form

6

The contribution of pupil, classroom and school level characteristics to primary school pupils' ICT competences: A performance-based approach

This chapter is based on:

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Chapter 6

The contribution of pupil, classroom and school level characteristics to primary school pupils' ICT competences: A performance-based approach

Abstract

The central aim of this study was to investigate which pupil, classroom and school level characteristics are related to primary school pupils' actual ICT competences. A sample of 378 pupils in 58 schools completed a performance-based ICT competence test in order to measure their actual proficiency in retrieving and processing digital information, and in communicating through a computer. To gather information on the factors at each different level, questionnaires were administered to the pupils, their parents (n=378), their teachers (n=83) and the ICT coordinators (n=58) of the schools. Pupils on average have a low to medium score on the developed ICT competence test. The results of a hierarchical regression analysis with multilevel design show that the differences in ICT competences can be mainly attributed to differences in pupil level characteristics. The results indicate that especially non-ICT related pupil characteristics are associated with differences in primary school pupils' ICT competences, such as introjected regulation, controlling learning style, analytic intelligence, sex and socioeconomic status. Furthermore, the final model also indicates that parental ICT attitudes are related to primary school pupils' ICT competences. With regard to the classroom level characteristics, educational use of ICT as an information tool is significantly related to pupils' ICT competences.

1. Introduction

Within the context of 21st century skills and our information society, the importance of being digitally competent is reflected in international and national policies for educational ICT use (European Commission, 2007; ISTE, 2007; Kozma, 2008). These policies for educational ICT use have introduced ICT competences in national and school curricula (Aesaert, Vanderlinde, Tondeur, & van Braak, 2013), i.e., the integration of ICT competences in educational curricula or the development of ICT curricula has formalized the status of ICT competences as educational outcomes. In this regard, Thomas and Knezek (2008) state that ICT competence standards and attainment targets define the achievement expectations for students, and as a consequence ICT competences are considered as educational outcomes.

Educational effectiveness research has shown that pupils' educational outcomes are multilevel in nature (Creemers & Kyriakides, 2008), i.e., differences in pupils' educational outcomes are attributed to factors at different levels, including the pupil, the classroom and the school level. However, with regard to ICT competences as educational outcomes, few studies have taken into account this multilevel aspect. In other words, very few studies have explicitly investigated whether the teacher or the school matters in the development of pupils' ICT competences. Claro et al. (2012) state that besides elaborating on the traditionally used pupil level factors, such as SES, computer access, daily use and confidence in performing ICT-related activities, future research should also focus on the impact of pupils' basic cognitive skills or teachers' particular pedagogical practices that might foster ICT competences.

The purpose of this study is to investigate the degree to which certain factors at the pupil, classroom and school level can explain differences in primary school pupils' ICT competences. As such, we aim to discover whether the teachers and schools play an important part in developing pupils' ICT competences. In order to measure primary school pupils' actual ICT competences – the dependent variable of this study - a performance-and-computer based test was used. As such, this study tackles the problem of self-reported bias that indirect measures of ICT competence or ICT self-efficacy suffer from. The pupil, classroom and school level characteristics that make up the independent variables of this study were drawn from the Extensive Digital Competence (EDC)-model (Aesaert, Van Nijlen, Vanderlinde, & van Braak, 2014). Measurements of ICT competences mostly target students from secondary and higher education (Meelissen, 2008). Moreover, research in terms of national and international curricula for early childhood and primary education indicates that ICT competences should already be taught at an early age. As such, the focus of this study is on primary school pupils' ICT competences.

2. Background

2.1. ICT competences

In his analysis of literacies for the digital age, Martin (2006) explains that the concept of ICT literacy – and the accompanied perception of ICT competences - has gone through a three-stage evolution of *mastery, application* and *reflection.*

In the *mastery* phase (until the mid-1980s) ICT literacy was perceived as knowledge of how the computer works (computer science) and skills on how to master and program it. ICT or computer literacy emphasized learning about information technology rather than learning with or through computers (Carleer, 1984). Tannenbaum and Rahn (1984) expressed this as having a fundamental understanding of the components of the machine, of its history, of the principal application, and as acquiring hands-on skill in programming language.

As operating systems and software applications became more user friendly and products of mass usage, ICT literacy shifted into a more *application* oriented phase (until the late 1990s). Rather than on specialist knowledge, ICT literacy focused on practical basic competences to apply common software in education, work, leisure and home (Martin, 2006). Here it should be noted that skills incorporated in both the mastery and application stage have a technical-procedural dimension. In this context, Hakkarainen et al. (2000) combine the elements of both phases and describe technical ICT skills as students' mastery skills of ICT applications ranging from file management and text processing to authoring tools and programming.

In the third and now dominant *reflective* phase, the focus of ICT literacy has shifted from basic skills and use of applications to a more evaluative and critical use of computers. The acquisition of basic ICT knowledge and skills is considered insufficient in terms of coping with the changes in our ever evolving contemporary society (Voogt, 2008). For instance, retrieving data from the Internet not only requires knowledge of search engines, but it also requires the ability to distinguish between relevant and irrelevant data (Eshet, 2002). From this perspective, ICT competences can be situated in the 21st century skills movement. Rather than mastering basic ICT skills, ICT competence concerns problem solving, information processing, critical thinking, and creative and innovative ICT use (European Commission, 2007). For example, ISTE's National Educational Technology Standards for Students are organized into the following six categories: 1) Creativity and Innovation; 2) Communication and Collaboration; 3) Research and Information Fluency; 4) Critical Thinking, Problem Solving, and Decision Making; 5) Digital Citizenship; and 6) Technology Operations and Concepts (ISTE, 2007). According to Markauskaite (2007), ICT literacy refers to the interactive use of 1) general cognitive capabilities, and 2) technical capabilities in order to successfully complete cognitive information and ICT-based tasks. Definitions of ICT literacy in general cover both sets of capabilities in different areas of problem solving and other generic activities, such as the ability to use technology and communication tools to identify, access, manage, integrate, evaluate and create information, such that individuals can function proficiently in our knowledge society (ETS, 2002; European Commission, 2007).

Furthermore, Markauskaite's (2007) description of ICT literacy is strongly related to the notion that the mastery and application phases are subordinate to the reflective phase (Martin, 2006) i.e., the technical and application oriented skills need to be mastered in order to come to the more critical, higher-order ICT competences. Within the context of the reflective phase, this study perceives ICT competence as a multilayered and complex construct. An ICT competence refers to a higher-order learning-process oriented competence used in complex, authentic and unpredictable situations, and is underpinned by technical and application ICT knowledge and skills (Aesaert et al., 2013).

Research on the assessment of ICT competences can be divided into studies using self-reported measures of ICT competence or ICT self-efficacy (indirect measurement) and studies using an observation or performance-based approach (direct measurement) (Litt, 2013). The literature indicates that most of the research is directed towards self-reported measures of ICT competences or ICT self-efficacy. However, such indirect measures can suffer from validity problems as their results are based on pupils' own judgment and expectations of successfully performing computer and internet related tasks (Hargittai, 2005; Meelissen, 2008; Merritt, Smith, & Di Renzo, 2005). As self-report data do not always accurately reflect pupils' actual ICT competences, conclusions drawn from such studies can be misleading. On the other hand, direct measurement methods gather data on pupils' actual performance by analyzing observable, performance-based data, such as simulation-based tasks or portfolios (Messick, 1994). Such tasks are more authentic and therefore considered as more valid (Wirth, 2008). In order to tackle the validity problem of self-report bias, this study used a direct measure to assess primary school pupils' actual ICT competences. This direct measure is based on an analysis of pupils' performance on simulation-based hands-on tasks with a computer (Aesaert et al., 2014).

2.2. Digital information processing and communication

In order to measure the complexity of an ICT competence in a direct and valid way, a performance-based test with authentic tasks was used in this study. Details on the development and validation of the test can be found in Aesaert et al. (2014). Because the administration of a performance-based test takes time, it was not feasible to measure all of the competences included in the broad construct of ICT competence. For example, the construct of ICT competence not only refers to the ability to locate, manage or process digital information, but also refers to more creative and expressive forms of digital media production and social online activities (Ito et al., 2009). Digital information processing and digital communication were chosen as ICT competences to be measured because these are identified as two essential reoccurring themes in national and international ICT frameworks and curricula (Voogt & Pareja Roblin, 2012).

A literature review was conducted to identify the higher-order competences that make up both of these themes (AASL, 1998; ACRL, 2000; Ananiadou & Claro, 2009; Brand-Gruwel, Wopereis, & Vermetten, 2005; Eisenberg & Johnson, 2002; Eisenberg, 2005; ETS, 2002; Fraillon & Ainley, 2010; ISTE, 2007; Kuiper, 2007; Madden, Ford, Miller, & Levy, 2006; NCREL, 2003; Puustinen & Rouet, 2009; Savolainen, 2002; Somerville, Smith, & Macklin, 2008; Tsai & Tsai 2003; Tsai, 2009). With regard to digital information processing, the higher-order competences in this study concern getting access to digital information, transforming digital information and creating digital information. The higher-order competences for digital communication refer to communicating in a socially acceptable way, communicating in an understandable way and the dissemination of information by the use of computers. An overview of the higher-order competences and the related technical and application oriented ICT skills can be found in Appendix A.

2.3. Factors related to ICT competences: the EDC-model

As mentioned in the introduction, few studies have looked at ICT competences from more than just one level. Zhong (2011) investigated whether the ICT penetration rate of a country and its educational expenditure (context level), the school type and ICT access at school (school level); and the gender, socioeconomic status, previous ICT experience and ICT access at the pupil’s home (pupil level) were related to the self-reported ICT skills of secondary school students. Sackes, Trundle and Bell (2011) found that computer access at school and gender are positively related to the development of young children’s computer skills, whereas SES and computer access at home are not. Furthermore, early research of Compeau and Higgins (1995) and Fagan, Neill and Wooldridge (2003) indicates that factors at the meso level – such as organizational support – can be related to self-perceived computer skills or computer self-efficacy. Although all these studies have great value for the initial identification of factors at different levels related to ICT competences, the majority is conducted using indirect measures of ICT competence.

Similar to the limited number of studies investigating factors related to ICT competences from a multilevel perspective, almost no models exist that indicate which factors at different levels (e.g., pupil, classroom and school level) are related to pupils' ICT competences. In order to cope with this problem and to study pupils' ICT competences from different levels, Aesaert, van Braak, Van Nijlen, & Vanderlinde (2015) developed the Extensive Digital Competence (EDC) model (see Figure 1).

This conceptual model consists of pupil, classroom and school level factors that are expected to relate to primary school pupils' ICT competences. Pupils' ICT competences are considered as the output or dependent variable of the model and refer to the integrated unit of 1) higher-order communication and information processing skills and knowledge; and 2) technical and application ICT knowledge and skills. Within the framework, the output variable of ICT competence is considered as an actual measure as well as a self-reported measure such as ICT-self-efficacy. In this study, only the actual measure of ICT competence is considered as dependent variable. The pupil, classroom and school level characteristics that make up the independent variables of the model are categorized into six clusters: ICT-related school characteristics; ICT-related classroom characteristics; ICT-related pupil characteristics, ICT-oriented home situation characteristics, sociocultural and economic characteristics, and cognitive and motivational pupil characteristics. We will elaborate on the different characteristics of the EDC-model in section 4.2. Instruments.

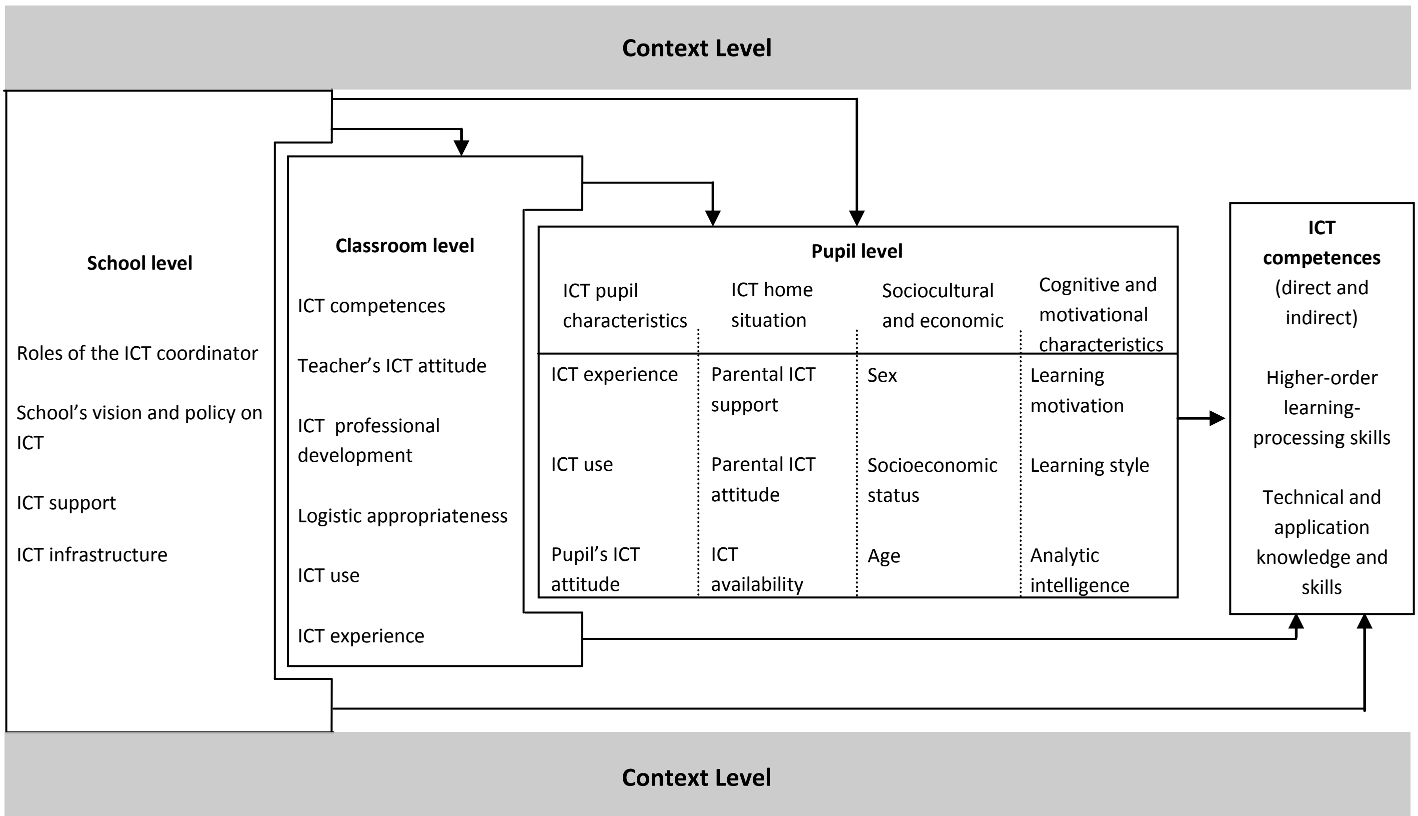

Figure 1. The Extensive Digital Competence (EDC) Model

3. Research aim

The aim of this study is to investigate the degree to which differences in primary school pupils' actual ICT competences can be attributed to differences in certain characteristics at the school, classroom and pupil level. These characteristics make up the independent variables of this study and are based on the EDC-model of Aesaert et al. (2015). Primary school pupils' actual ICT competences were measured using the performance-based ICT competence scale of Aesaert et al. (2014). This study elaborates on earlier research on factors related to ICT competences by using a direct and standardized measure of ICT competence as well as a multilevel approach for the identification of possibly related factors.

4. Methods

4.1. Participants

In order to measure the level of primary school pupils' ICT competences, the performance-based test was administered to a representative sample of 378 sixth graders from 83 classes in 58 schools in Flanders, the Dutch speaking part of Belgium. Schools were stratified for school size (small school<180 pupils; large school≥180 pupils), province and educational network, i.e., official public education, subsidized public-authority education and subsidized private-authority education. Of the pupils, 50.0% were male and 50.0 % were female. Ages ranged from 10.79 to 13.85 years old (M=12.06, SD=0.46).

In order to investigate the effect of the factors at the pupil, classroom and school level, surveys were administered to the pupils that conducted the performance-based test (n=378), their parents (n=378), their sixth grade teacher (n=83) and the ICT coordinator (n=58) of their school. Of the teachers, 31.3% were male and 68.7% were female. Teaching experience ranged from 2 to 38 years (M= 18.15 SD=10.33). Of the ICT coordinators, 78.2% were male and 21.8% were female.

4.2. Instruments

4.2.1 Dependent variable

As mentioned above, this study focuses on ICT competence as the use of a computer to process and communicate digital information. To measure the dependent variable in a direct way, the ICT competence scale of Aesaert et al. (2014), based on the EDC-model, was used. The 27 items of this scale focus on higher-order learning-processing ICT competences as well the underlying technical and application ICT skills that pupils need to process digital information and to communicate in a digital way. All items are performance-based in nature and integrated in a simulation-based computer environment. This means that pupils need to demonstrate their ICT competence by actually interacting with computer applications and software.

Figure 2 shows the interface of a task in which pupils were asked to ask their teacher for information via e-mail. All items of the ICT competence scale have a binary answer-format depending on the pupils answering the items correctly or incorrectly. An extensive outline of the development of the software and the Item Response Theory analysis for the validation of the scale can be found in Aesaert et al. (2014). The items can be found in appendix A. Some items are listed more than once as they were measured through different tasks in the test.

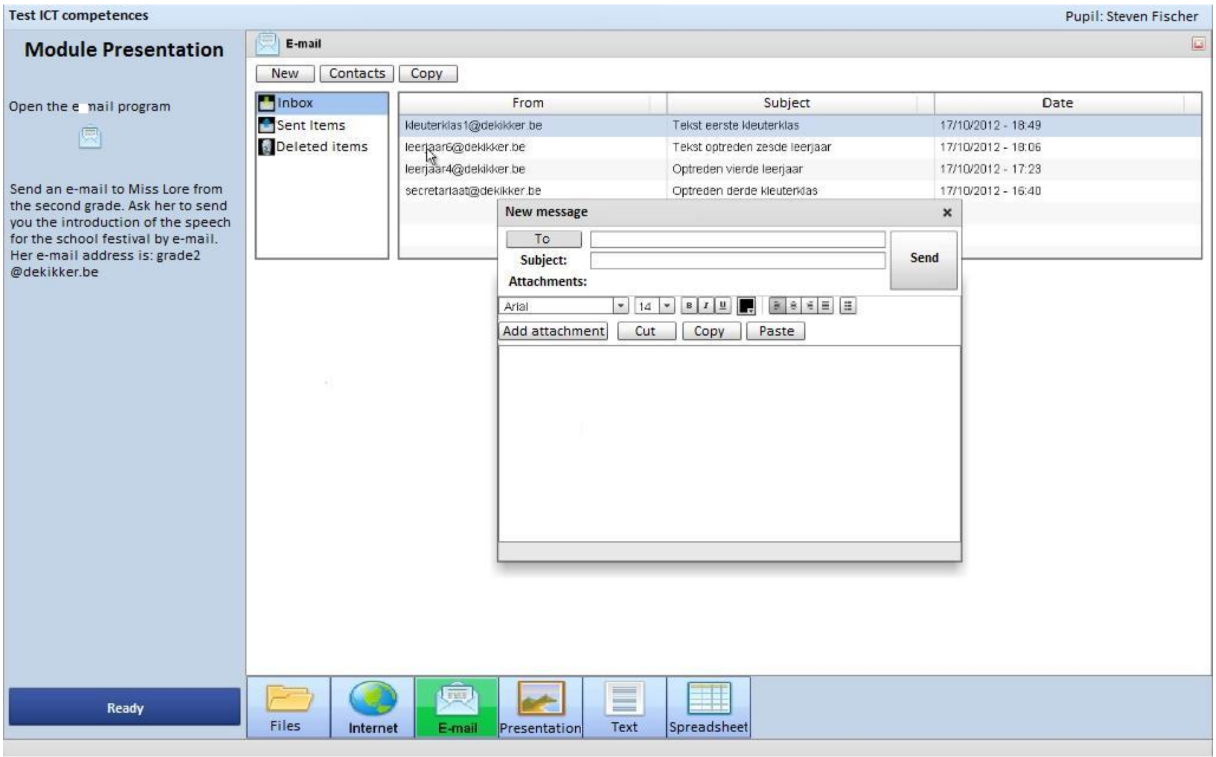

Figure 2. General interface of the performance-based ICT competence test

4.2.2 Independent variables

The independent variables of this study refer to the pupil, classroom and school level characteristics of the EDC-model.

ICT related pupil characteristics refer to the degree to which pupils value the use of ICT outside the school. The following two factors were included in this study:

- *'ICT experience'* is defined as the weekly time spent on a computer/internet outside the school. In the EDC-model this is operationalized as the number of hours per week that children use a computer and the Internet at home.
- The *'pupils' ICT attitude'* (5 items) scale of Aesaert et al. (2015) measures the degree to which pupils perceive 1) themselves as personally interested and confident computer users; and 2) the use of computers as useful.

In the category *ICT oriented home situation characteristics*, factors refer to parental investments that can have an impact on the child's ICT competences. The following three characteristics are integrated in the EDC model:

- The '*parental ICT support*' scales of Aesaert et al. (2015) measure the degree to which parents try to control and socialize their child's ICT use. The first scale *'active ICT support'* (13 items) measures the degree to which parents provide assistance by doing ICT activities together with their child as well as communicate with their child about ICT use. The second scale *'ICT rules'* (5 items) assesses the degree to which parents impose rules to their children about their ICT use and discuss them. Both scales are based on the work of Valcke, Bonte, De Wever and Rots (2010) about Internet parenting styles.
- *'Parental ICT attitude'* is defined as the parents' beliefs about the general importance and usefulness of being able to work with a computer. The '*parental ICT attitude'* (5 items) scale of Aesaert et al. (2015) measures the degree to which parents believe that the development of ICT competences is useful for their child and will result in educational, social and economic profits.
- *'ICT availability'* refers to the opportunities that parents create for their children to develop ICT competences by providing them with the necessary technological infrastructure. In the EDC-model, and in this study, this is operationalized as having no internet access at home, having internet access only through a computer that is shared by all family members, having internet access only through a private computer, and having internet access through both a private and shared computer.

The *cognitive and motivational pupil characteristics* refer to non-ICT-related pupil characteristics that have a cognitive and motivational basis and can have an influence on pupils' outcomes, such as ICT competences. A distinction is made between the following three characteristics:

- *Learning motivation* was measured using the four adapted self-determination theory-scales of Vandevelde, Van Keer and Rosseel (2013). The items of the four scales represent the constructs of *extrinsic regulation* (3 items), *introjected regulation* (4 items), *identified regulation* (4 items) and *intrinsic motivation* (4 items). These were adapted from the academic self-regulation scale (Ryan & Connell, 1989; Vansteenkiste, Sierens, Soenens, Luyckx & Lens, 2009) and validated by Vandevelde et al. (2013) for their use in primary education. Aesaert et al. (2015) adapted the *amotivation* (4 items) scale of the Academic Motivation Scale of Vallerand et al. (1992) as a fifth construct for its use in primary education.
- The *learning style* scales of Aesaert et al. (2015) were adapted from the learning by reading strategy scales of the PISA 2009 student background questionnaire (Schleicher, Zimmer, Evans, & Clements, 2009). The scales include *'control'* (3 items), *'memorization'* (3 items), and *'elaboration'* (3 items) as three ways of learning. The control scale measures the degree to which pupils report whether they learn by planning, monitoring and regulating their learning process. The memorization scale assesses the extent to which pupils indicate whether they learn by repeating the learning material and learning key words. The elaboration scale measures the degree to which pupils report whether they learn by connecting the learning subject to related areas of thinking or by finding alternative solutions (OECD, 2004).
- *Analytic intelligence* refers to a pupil's ability to deal with novelty and to adapt their thinking to a new cognitive problem without relying on declarative knowledge derived from schooling or previous experience (Carpenter, Just, & Shell, 1990). In the EDC-model, analytic intelligence is perceived as a measure of aptitude and assessed with the non-verbal Raven Standard Progressive Matrices Test (60 binary items) (Raven, Raven, & Court, 2003).

The EDC-model includes the *sociocultural and economic characteristics sex, age and socioeconomic status*. SES was coded as the highest educational level of the mother. A distinction was made between having no primary education diploma, having a primary education diploma, having a lower secondary education diploma, having a higher secondary education diploma, and having a college or university degree.

ICT related classroom characteristics can be divided in two types. The first set of characteristics refers to the teacher's own ICT knowledge, skills, attitudes and the degree in which he takes initiative in developing them. The second set of characteristics focuses on the conditions that the teacher creates in the classroom in order for pupils to develop ICT competences.

- The '*Teachers' ICT competencies* (5 items) scale of Vanderlinde and van Braak (2010) was used in this study. The items express the degree to which teachers consider themselves technical, organizational and pedagogically-didactically competent for integrating ICT into the classroom.
- The *'Teacher's ICT attitude'* (5 items) scale of Aesaert et al. (2015) is similar to the parental ICT attitude scale. As such, these items measure the degree to which teachers believe that the development of ICT competences will result in educational, social and economic profits for pupils.
- *'Teachers' ICT professional development'* (4 items) is defined as the initiatives that teachers take in order to improve their ICT competences and the integration of ICT in education (Vanderlinde & van Braak, 2010).
- *'Logistic appropriateness'* was measured using the ICT -infrastructure (4 items) scale of Vanderlinde and van Braak (2010). This scale measures the degree to which teachers are pleased and satisfied with the ICT equipment available in the class and in the school.
- *'ICT use'* refers to the way in which pupils use ICT in the classroom. Vanderlinde and van Braak (2010) revised the '*computer use in primary education'* scales of Tondeur, van Braak and Valcke (2007). The scales make a distinction between three types of ICT use in the classroom (i.e., the use of ICT as an information tool, the use of ICT as a learning tool and the use of basic ICT skills).
- *'ICT experience'* as an ICT-related classroom characteristic refers to the number of lessons in which children are given the opportunity to work with a computer in the classroom.

ICT-related school characteristics refer to organizational factors that could affect the teaching and learning of ICT competences at school. Four ICT-related school factors are included in the EDC-model:

- The *'roles of the ICT coordinator'* (19 items) scales of Devolder, Vanderlinde, van Braak and Tondeur (2010b), refer to the tasks that the ICT coordinator can fulfill in a school. A distinction is made between the ICT coordinator as a planner, budgeter, educationalist and technician.
- The *'school's ICT vision and policy'* (7 items) scale of Vanderlinde and van Braak (2010) was used to measure the degree to which the school has 1) a clear vision on the place of ICT in education; and 2) a policy and policy plan with regard to ICT integration.

- *'ICT support'* at the school level is defined as the degree to which technical and pedagogical ICT support, and ICT coordination are arranged at the school. The ICT support and coordination (7 items) scale of Vanderlinde and van Braak (2010) were used in this study.
- *'ICT infrastructure'* is operationalized as the ratio between the total number of computers available to the pupils at the school and the number of pupils at the school.

4.3. Data analysis

The pupils of the sample (level 1) are nested in classes (level 2), which are in turn nested within schools (level 3). In order to take this hierarchical structure of nested variables into account, multilevel modeling in which the dependent variable is allowed to vary at three levels - i.e., the pupil, classroom and school level - would be advised. However, the level 2 sample size (of maximum three teachers per school) is too small and would produce inaccurate estimates and standard errors. Consequently, it was decided to use a two-level design (pupil and teacher level) to investigate the effects of the different characteristics of the EDC-model.

Considering the EDC-model, eight models are tested in this study. First, an unconditional null model (model 1) was tested in order to investigate whether a multilevel approach is advisable compared to a single level linear regression. Following this, ICT related pupil characteristics (model 2), ICT oriented home situation characteristics (model 3), cognitive and motivational pupil characteristics (model 4), sociocultural and economic characteristics (model 5), ICT related classroom characteristics (model 6) and ICT related school characteristics (model 7) were added to the following six models. Finally, the pupil level factor ICT self-efficacy was added to the final model (model 8). This was considered necessary as previous research indicates that ICT self-efficacy is positively related to ICT use and performance (Barbeite & Weiss, 2004; Torkzadeh, Chang, & Demirhan, 2006). Nevertheless, this was done in a separate model because ICT-self efficacy is considered as an indirect measure of ICT competence and as a dependent variable within the EDC-model. The ICT-self-efficacy scale (18 items) of Aesaert et al. (2015) was used for this purpose. Factors that did not significantly contribute to the model were removed from the analysis of the subsequent models. Using this stepwise approach enabled us to check for the additional value of each subset of variables to the model as well as to the proportion of explained variance (Gorard, 2003). The difference in deviance of two models – a test statistic having a chi-squared distribution (Snijders &

Bosker, 2012) - is used to check model improvement. More specifically, a decrease in the deviance between consecutive models indicates model improvement.

5. Results

5.1. Primary school pupils' ICT competences

Ability interval	Ability scale		Visual representation (x=3 pupils)	Pupils *(%)*
]2.8, 3.0]	|	3		0 *(0.00)*
]2.6, 2.8]	|			0 *(0.00)*
]2.4, 2.6]	|			0 *(0.00)*
]2.2, 2.4]	|			0 *(0.00)*
]2.0, 2.2]	|	2		0 *(0.00)*
]1.8, 2.0]	|			1 *(0.26)*
]1.6, 1.8]	|		x	5 *(1.32)*
]1.4, 1.6]	|		xxx	9 *(2.37)*
]1.2, 1.4]	|		xx	8 *(2.11)*
]1.0, 1.2]	|	1	xxxxxxx	21 *(5.54)*
]0.8, 1.0]	|		xxxxxx	20 *(5.28)*
]0.6, 0.8]	|		xxxxxxxxx	29 *(7.65)*
]0.4, 0.6]	|		xxxxxxxxx	27 *(7.12)*
]0.2, 0.4]	|		xxxxxxxxxxxxxx	42 *(11.08)*
]0.0, 0.2]	|	0	xxxxxxxxxx	31 *(8.18)*
]-0.2, 0.0]	|		xxxxxxxxxxxxx	41 *(10.82)*
]-0.4, -0.2]	|		xxxxxxxx	24 *(6.33)*
]-0.6, -0.4]	|		xxxxxxxx	26 *(6.86)*
]-0.8, -0.6]	|		xxxxxxx	21 *(5.54)*
]-1.0, -0.8]	|	-1	xxxx	12 *(3.17)*
]-1.2, -1.0]	|		xxxx	14 *(3.69)*
]-1.4, -1.2]	|		xxxx	13 *(3.43)*
]-1.6, -1.4]	|		xx	7 *(1.85)*
]-1.8, -1.6]	|			2 *(0.53)*
]-2.0, -1.8]	|	-2	xx	7 *(1.85)*
]-2.2, -2.0]	|			5 *(1.32)*
]-2.4, -2.2]	|		xx	6 *(1.58)*
]-2.6, -2.4]	|		x	5 *(1.32)*
]-2.8, -2.6]	|			0 *(0.00)*
]-3.0, -2.8]	|	-3		2 *(0.53)*

Table 1. Frequencies of primary school pupils on the ICT competence scale

The dependent variable 'primary school pupils' ICT competence' was measured using the ICT competence scale of Aesaert et al. (2014). This unidimensional scale was developed using Item Response Theory. This measures the degree to which primary school pupils are competent at locating and processing digital information, and communicating through a computer. Pupils who are less competent in ICT are located at the bottom of the scale whereas the more competent pupils are located at the top of the scale (see Table 1). The unit and origin of the scale are fixed at zero mean and one unit variance. Each bar on the histogram represents the frequency of pupils within a certain ability score interval of 0.2 points on the ICT competence scale, i.e., each bar covers the number of pupils with a certain ICT competence level.

The average ability score of the 378 pupils is -0.08 (SD= 0.06) with a maximum ability score of 1.90 and a minimum score of -2.96. The results in Table 1 indicate that the majority of pupils have a medium to low-medium score on the ICT competence scale. No pupils are located in the highest ability intervals, whereas about 10 % seem to be located in the lowest levels of the scale.

5.2. Factors related to ICT competences

5.2.1. Descriptive statistics and reliability of the instruments

In order to check the psychometric quality of the independent variables that were integrated in the regression model, Cronbach's alphas are presented in Table 2. Except for the learning style scales, all instruments have an acceptable to good internal consistency with alphas varying between .68 and .91. This means that the findings with regard to the learning style items should be interpreted with caution. As can be seen in Table 2, the correlation coefficients between the exploratory variables were rather low, indicating that the assumption of no perfect multicollinearity was not violated. As such, the measures were acceptable for use in a regression analysis.

With exception of age, ICT experience and ICT infrastructure, all means are located on a scale with a theoretical minimum of 0 and a maximum of 100. Analytic intelligence (minimum= 0; maximum=60) and the dependent variable ICT competence (minimum= -3; maximum=3) were expressed on their original scale. Because the factor ICT support (school level) was measured at the teacher level, an aggregated measure at the school level was calculated using the mean over teachers within a school. In order to check whether teachers' reported ICT support was shared at the school level, the intraclass correlation coefficient (ICC= (between mean square–within mean square)/between mean square) was calculated as an index of mean rater reliability (Van Houtte, 2004). As the ICC had a value of .60, it did not meet the cutoff score of .70 (Dixon & Cunningham, 2006). Consequently, the aggregated measure of ICT support was not considered as a reliable school level factor and was removed from further analysis. This was to be expected since the number of teachers per school only varies between 1 and 3.

According to Snijders and Bosker (2012) the reliability of aggregated variables decreases as the number of micro-units per macro-unit decreases.

	M	α	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Factors at the pupil level																		
1. Sex	-	-	1.00															
2. Age	12.06	-	.12*	1.00														
3. Amotivation	24.47	.79	-.18**	.01	1.00													
4. Extrinsic regulation	44.29	.86	-.10	.06	.42**	1.00												
5. Introjected regulation	44.70	.71	-.11*	.08	.23**	.38**	1.00											
6. Identified regulation	82.92	.81	.15**	-.02	-.54**	-.25**	.00	1.00										
7. Intrinsic motivation	61.87	.88	.20**	.01	-.43**	-.27**	.14**	.63**	1.00									
8. Control	71.63	.60	.16**	-.11	-.28**	-.14*	.07	.40**	.34**	1.00								
9. Memorization	53.73	.57	.11*	-.04	-.13*	-.03	.09	.32**	.20**	.33**	1.00							
10. Elaboration	34.87	.66	-.11*	-.03	.05	.01	.19**	.21**	.20**	.23**	.20**	1.00						
11. Analytic intelligence	45.32	.81	.01	-.06	-.10	-.13*	-.12*	-.02	-.01	.04	-.14**	-.19**	1.00					
12.Parental active ICT support	54.51	.91	.02	-.11	-.04	-.07	.05	.03	.11	.04	.00	.03	-.01	1.00				
13. Parental ICT rules	74.56	.85	.04	-.12	-.02	.01	.03	.07	.07	.05	-.03	.03	.07	.53**	1.00			
14. Parental ICT attitude	73.58	.82	.05	-.04	.01	.04	-.07	-.05	-.04	.00	-.04	-.09	.06	.12*	-.06	1.00		
15. ICT experience	7.75	-	-.02	.15*	-.04	-.09	-.13*	.05	.03	-.01	.09	.06	-.08	-.01	-.21**	.16**	1.00	
16. Pupil's ICT attitude	68.53	.83	-.34**	-.08	.12*	.09	.15**	.06	.00	.02	.06	.10	-.07	.04	.01	.09	.09	1.00
Factors at the classroom level																		
17. ICT competences	69.18	.83	-.02	-.04	.04	-.07	.00	-.06	-.03	.03	-.05	-.07	.13*	.05	-.01	.12*	-.03	.05
18. Teacher's ICT attitude	66.27	.80	.03	.08	-.12*	-.04	.04	.15**	.11*	.08	.14**	.02	.03	-.01	.03	-.05	-.09	.04
19. Professional development	58.07	.84	.03	-.10	-.08	-.02	.01	.06	.03	.04	.02	-.06	.14**	.05	-.03	.08	-.11	.02
20. Logistic appropriateness	66.30	.82	.01	-.20**	-.02	-.05	-.06	-.06	-.07	.07	-.04	-.08	.14**	-.05	-.03	-.04	-.15**	-.03
21. ICT use as information tool	45.00	.68	.04	-.01	-.07	-.02	.05	.03	.05	.03	.00	-.02	.08	.01	-.03	.06	-.16**	.04
22. ICT use as learning tool	53.23	.78	-.04	-.08	-.01	-.02	-.03	.07	.12*	.04	.03	.04	.00	.06	.11	.02	.01	-.02
23. ICT use basic skills	46.04	.70	.07	-.07	.00	-.05	.01	.01	.11*	.07	.05	.02	.04	.01	.05	.09	-.13*	-.01
24. ICT experience	3.53	-	.02	-.05	-.06	.02	-.02	.08	.10	.04	-.10*	.00	.13*	.04	.14*	.01	-.09	.03
Factors at the school level																		
25. ICT coordinator: planner	61.04	.91	.04	-.19**	-.01	-.08	-.09	-.02	-.05	.13*	-.05	-.10	.10	.02	.02	-.01	-.13*	-.01
26. ICT coordinator: budgeter	48.94	.82	.03	-.06	.02	-.08	-.12*	-.09	-.08	-.06	-.10	-.08	.06	.04	-.11	-.02	-.06	-.06
27. ICT coordinator: technician	83.33	.91	.03	.01	-.02	-.09	-.07	.02	.12*	-.06	.01	-.03	-.01	.11	-.02	.00	.12*	-.03
28.ICT coordinator: educationalist	63.27	.89	.00	-.10	-.03	-.12*	-.10	-.08	-.13*	.08	-.13*	-.06	.09	-.02	-.03	-.09	-.08	-.03
29. Vision and policy on ICT	62.67	.89	.06	-.04	-.11	-.11	-.07	.00	-.05	.08	-.05	-.11	.09	.01	-.03	-.04	-.06	-.02
30. ICT infrastructure	.23	-	-.02	-.02	.02	.00	-.05	.00	-.04	-.07	.00	.01	-.05	.06	-.03	-.06	.07	-.02
31. Pupils' ICT competences	-.08		.20**	-.10	-.12*	-.15**	-.22**	.08	.05	.16**	-.04	-.16**	.43**	.07	.03	.16**	.04	-.02
32. ICT self-efficacy	80.98	.88	-.09	-.05	-.12*	-.06	-.04	.13*	.01	.08	.10	.15**	.11*	.02	.03	.09	.21**	.38**

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Factors at the classroom level																
17. ICT competences	1.00															
18. ICT attitude	.18**	1.00														
19. Professional development	.51**	.30**	1.00													
2.ICT infrastructure	.38**	.16**	.44**	1.00												
21. ICT use as information tool	.26**	.30**	.46**	.41**	1.00											
22. ICT use as learning tool	.20**	.28**	.26**	.24**	.34**	1.00										
23. ICT use basic skills	.29**	.25**	.31**	.27**	.49**	.54**	1.00									
24.Computer experience	.14**	-.04	.09	.03	.18**	.25**	.27**	1.00								
Factors at the school level																
25. ICT coordinator: planner	.19**	-.01	.32**	.54**	.36**	.17**	.32**	.21**	1.00							
26. ICT coordinator: budgeter	-.07	-.29**	.22**	.21**	.15**	-.02	-.10	-.01	.40**	1.00						
27. ICT coordinator: technician	-.09	-.13*	.11*	-.27**	-.12*	.10	-.07	-.03	-.06	.34**	1.00					
28. ICT coordinator: educationalist	.09	-.21**	.07	.26**	.05	-.19**	.02	.22**	.70**	.51**	-.11*	1.00				
29. Vision and policy on ICT	.22**	-.03	.26**	.16**	.17**	-.24**	-.01	.06	.32**	.09	-.19**	.44**	1.00			
30. Infrastructure	-.05	-.09	-.05	.10	-.10	.03	-.23**	-.23**	-.03	.12*	.16**	-.09	.06	1.00		
31. Pupils' ICT competences	.15**	.02	.09	.18**	.15**	-.01	.07	.09	.14**	.00	-.17**	.12*	.18**	-.02	1.00	
32. ICT self-efficacy	-.04	.03	-.04	-.07	-.05	-.14*	-.11*	-.11*	-.08	-.13*	-.07	-.02	.04	-.04	-22**	1.00

Table 2. Descriptives, reliability coefficients and and correlates of the used scales,* correlation significant at the .05 level, ** correlation significant at the .01 level

5.2.2. The regression model

5.2.2.1. Model 1: the null model

As mentioned above, the level 2 sample size was too small to allow ICT competence to vary at three levels. As such, the null model was only allowed to vary at the classroom and pupil level. No independent pupil (level 1), classroom (level 2) and school (level 3) variables were added to the two-level random intercepts model. As such, the intercept of this model -0.079 represents the overall mean ability in ICT competence of all pupils in all classes. The results in Table 3 indicate that the within-class variance (pupil level; σ^2_{e0}=.803, χ^2= 152.144 d*f*=1, p<.001) significantly differs from zero, but the between-class variance (classroom level; σ^2_{u0}=.069, χ^2= 3.021 d*f*=1, p=.082) does not. Only 7.91 % of the total variance is attributed to differences between classes and 92.09 % to differences between pupils. Although the between class variance is not significant, the ICC has a value .079. As this is above .05, it supports the use of multilevel modeling (Snijders & Bosker, 1999). Moreover, the difference in deviance between the single level model and the two level null model, indicates that the null model fits the data better(χ^2=4.50, d*f*=1, p<.005). As such, multilevel analysis was used to model the data adequately.

5.2.2.2. Model 2: ICT related pupil characteristics

In the second model, the ICT related pupil characteristics, ICT experience and pupil's ICT attitude, were added as extra explanatory variables to the fixed part of the model. However, both ICT experience and pupils' ICT attitude did not lead to a significantly higher mean level of ICT competence (χ^2= .677, d*f*=1, p=.411 and χ^2=.095 = d*f*=1, p=.758 respectively). Consequently, both factors were omitted for the subsequent analyses.

5.2.2.3. Model 3: ICT oriented home situation characteristics

In the third stage of model specification, the model was extended by adding the factors: parental active ICT support, parental ICT rules, parental ICT attitude and ICT availability at home. With regard to ICT availability, 'having no internet access at home' was chosen as the reference category. As such, model 3 allows us to investigate whether the degree to which the home situation as ICT oriented affects pupils' score on the ICT competence test.

Because there was no significant effect of parental active ICT support (χ^2=.053, d*f*=1, p=.820), parental ICT rules (χ^2=.920, d*f*=1, p=.337), and ICT availability (i.e., shared computer: χ^2=.394, d*f*=1, p=.530; private computer: χ^2=1.190, d*f*=1, p=.275; shared and private: χ^2=.729, d*f*=1, p=.393) in model 3a, these factors were not used in model 3b. Parental ICT attitude significantly contributed to the model (χ^2=9.620, d*f*=1, p<.01).

In model 3b, the intercept -0.102 represents the overall mean ICT competence of pupils who have parents with an average score on the ICT attitude scale. The positive slope of parental ICT attitude indicates that with every increase of one unit, the mean level of ICT competence slightly but significantly increases by 0.009. Adding parental ICT attitude resulted in a significantly better fit of model 3b over the null model (χ^2=101.030, d*f*=1, p<.001).

5.2.2.4. Model 4: cognitive and motivational pupil characteristics

Subsequently, the subscales with regard to learning motivation and learning style, as well as analytic intelligence were added to the model. With regard to learning motivation, introjected regulation was the only factor that made a significant contribution and was retained in model 4b. The results indicate that the more students' learning is driven by negative feelings of shame and guilt, or positive feelings of pride towards others, the lower their score on the ICT competence scale (mean=-0.092 - 0.008= -0.100, χ^2= 14.211, d*f*=1, p<.001).

With regard to learning style, the techniques of memorization and elaboration were not significantly related to pupils' ICT competences, and thus removed from further analysis. On the other hand, planning, monitoring and regulating the learning process (control) leads to a significantly higher mean level of ICT competence (mean= -0.092 +0.007=-0.085, χ^2= 9.590, d*f*=1, p<.01). We stress that these results should be interpreted with caution, as the internal consistency of the learning style scales was rather low.

Finally, a significant positive relation was found for analytic intelligence. The positive slope indicates that every increase with one point on the Raven Progressive Matrices Test is reflected in a substantial increase of the mean level of ICT competence by 0.059 (mean= -0.092 +0.059=-0.033, χ^2= 58.380, d*f*=1, p<.001). The intercept -.092 of model 4b represents the overall mean for ICT competence across pupils with an average score on parental ICT attitude, introjected regulation, control and analytic intelligence. Compared to model 3b, the addition of these factors resulted in a significantly better model fit (χ^2=138.28, d*f*=3, p<.001).

5.2.2.5. Model 5: sociocultural and economic characteristics

In the fifth model, the demographic factors sex, age and highest educational level of the mother (reference category: no primary education diploma) were added as final pupil level variables to the fixed part of the model.

Because age did not make a significant contribution (χ^2=.481, d*f*=1, p=.488), it was no longer integrated in model 5b. However, sex was related to pupils' ICT competences in favor of girls. Girls have a significantly higher mean level of ICT competence than boys (mean=-1.119 + 0.287=-0.832, χ^2=10.263, d*f*=1, p<.01). A significant relationship with socioeconomic status was observed in favor of pupils having a mother with a lower secondary education diploma (mean= -1.119 +0.766=-0.353, χ^2= 5.207, d*f*=1, p<.05), of pupils having a mother with a higher secondary education diploma (mean=-1.119 +.826=-.293, χ^2= 6.480, d*f*=1, p<.01), and of pupils having a mother with a higher education degree (mean=-1.119 +1.063=-0.056, χ^2= 10.667, d*f*=1, p<.01) as compared to pupils having a mother without any degree. ICT competences of pupils having a mother with a primary school degree did not significantly differ from the competences of pupils having a mother without any educational degree. These results indicate that the higher the educational degree of the mother, the higher is the mean level of ICT competence of the pupils. Model 5b was a significant improvement to model 4b (χ^2= 40.595, d*f*=5, p<.001).

5.2.2.6. Model 6: ICT related classroom characteristics

In this stage of model specification, the ICT related classroom characteristics, i.e. ICT competences, teacher's ICT attitude, ICT professional development, logistic appropriateness, ICT use as information tool, ICT use as a learning tool, ICT use for basic skills and ICT experience were integrated into the model. With exception of ICT use as an information tool, none of these factors made a significant difference to the model. Consequently, all of them were eliminated for further use in model 6b. The positive slope 0.008 indicates that pupils who are regularly given the opportunity to use ICT in the classroom as an information tool have a higher score on the ICT competence scale (χ^2= 6.169, d*f*=1, p<.05). Adding the factor ICT use as an information tool leads to a significant improvement of the model fit in comparison with model 5b (χ^2= 42.155, d*f*=1, p<.001).

5.2.2.7. Model 7: ICT related school characteristics

In the seventh model, ICT related school characteristics were added as explanatory variables to the fixed part of the model. As can be seen in Table 3, none of the added variables contributed to the model in a significant way (ICT coordinator as planner: χ^2= 0.011, d*f*=1, p=.92; ICT coordinator as a budgeter: χ^2= 2.900, d*f*=1, p=.089; ICT coordinator as a technician: χ^2= 1.519, d*f*=1, p=.218; ICT coordinator as an educationalist: χ^2= 0.720, d*f*=1, p=.396; school's vision and policy on ICT: χ^2= 1.813, d*f*=1, p=.178; ICT infrastructure: χ^2= 0.635, d*f*=1, p=.426). Consequently, all ICT related school factors were removed from the model.

5.2.2.8. Model 8: adding ICT self-efficacy

In the final stage, ICT self-efficacy was added to the model. Although this factor is situated at the pupil level, it was integrated at the end of the analysis. The reason for doing this was because within the EDC-model, ICT self-efficacy is considered as a dependent variable, i.e., an indirect measure of ICT competence. The positive slope 0.013 indicates that sixth-grade pupils who consider themselves as more competent in ICT have higher actual ICT competences (χ^2=13.023, d*f*=1, p<.001). Compared with model 6b, the addition of ICT self-efficacy leads to significant model improvement (χ^2=61.890, d*f*=1, p<.001).

In order to explore the proportion of variance explained by each model, the squared multiple correlation coefficient R^2 was calculated (see Table 4). ΔR^2 was used to investigate the proportion of variance explained by each subset of variables that was integrated in the subsequent models. As a two level model was used, the proportion of explained variance is divided into the explained variance at the student level and at the classroom level. R^2_1 at the student level is defined as the proportional reduction of error for predicting an individual outcome with $[R^2_1=1-((\sigma^2_{e0}+\sigma^2_{u0})_{\text{conditional model}}/(\sigma^2_{e0}+\sigma^2_{u0})_{\text{unconditional model}}))]$. R^2_2 at the classroom level is defined as the proportional reduction of error for predicting a group mean $[R^2_2=1-(((\sigma^2_{e0}/\tilde{n})+\sigma^2_{u0})_{\text{conditional model}}/((\sigma^2_{e0}/\tilde{n})+\sigma^2_{u0})_{\text{unconditional model}}))]$ (Jee-Seon, 2009; Snijders & Bosker, 1999).

As the variance at the classroom level was not significant, we are only interested in the variance at the student level R^2_1. As can be seen in Table 4, model 3b only accounted for 0.92% of the variance in primary pupils actual ICT competences. Adding the educational pupil factors introjected regulation, controlling learning style and analytic intelligence resulted in a substantial increase of 24.08% of variance explained. Compared to the model 4b, the proportion of explained variance rises with 6.31% in model 5b, due to the addition of sex and SES. Adding the classroom characteristic ICT use as an information tool increased the proportion of variance explained with 2.29%. In the end, ICT self-efficacy added another 2.64%, leading to a final model that explains 36.23% of the variance in primary pupils ICT competences.

	Model 1 (null)	Model 2	Model 3a	Model 3b	Model 4a	Model 4b
Fixed						
Intercept (cons)	-.079 (.056)	-.061 (.061)	-.368(.406)	-.102 (.059)	-.072 (.050)	-.092(.050)
Pupil						
ICT experience		.007 (.009)	-	-	-	-
Pupil's ICT attitude		.001 (.002)	-	-	-	-
					-	-
Parental active ICT support			.001 (.003)	-	-	-
Parental ICT rules			.003 (.003)	-	-	-
Parental ICT attitudes			.010 (.003)**	.009 (.003)**	.010 (003)***	.009 (.003)**
ICT availability (categ)						
- Internet shared computer			.257 (.409)	-	-	-
- Internet private computer			.606 (.556)	-	-	-
- Internet shared & private			.353 (.414)	-	-	-
Amotivation					.001 (.003)	-
Extrinsic regulation					-.001 (.002)	-
Introjected regulation					-.006 (.002)*	-.008 (.002)***
Identified regulation					.002 (.004)	-
Intrinsic motivation					.000 (.003)	-
Control					.010 (.003)***	.007 (.002)**
Memorization					-.003 (002)	-
Elaboration					-.003 (.002)	-
Analytic intelligence					.058(.008)***	.059 (.008)***
Sex (categ)						
Age						
SES education mother						
- Primary						
- Lower secondary						
- Higher secondary						
- Higher education						
Classroom						
ICT competences						
Teacher's ICT attitude						
Professional development						
Logistic appropriateness						
ICT use as information tool						
ICT use as learning tool						
ICT use basic skills						
ICT experience						
School						
ICT coordinator: planner						
ICT coordinator: budgeter						
ICT coordinator: technician						
ICT coordinator: educationalist						
Vision and policy on ICT						
ICT Infrastructure						
Random						
Classroom level σ^2_{u0} (between)	.069(.040)	.096	.077	.083	.044	.043
	7.91%	(.047)*	(.045)	(.044)	(.032)	(.032)
Pupil level σ^2_{e0} (within)	.803(.065)***	.725	.741	.781	.530	.611
	92.09%	(.066)***	(.068)***	(.067)***	(.051)***	(.054)***
Model Fit						
Deviance (2-log)[a]	1016.386	819.757	802.730	915.353	650.028	777.068
χ^2	4.50			101.03		138.28
df	1			1		3
p	<.005			<.001		<.001
Reference	Single level model			Null model		Model 3b

Table 3. Estimates and standard errors from the random intercept model (dependent variable: pupils' ICT competences)

* significant at the .05 level; ** significant at the .01 level; *** significant at the .001 level

	Model 5a	Model 5b	Model 6a	Model 6b	Model 7	Model 8
Fixed						
Intercept (cons)	-1.123 (.310)***	-1.119 (.319)***	-1.134 (.316)***	-1.121 (.313)***	-1.199 (.311)***	-.981 (.337)**
Pupil						
ICT experience	-	-	-	-	-	-
Pupil's ICT attitude	-	-	-	-	-	-
Parental active ICT support	-	-	-	-	-	-
Parental ICT rules	-	-	-	-	-	-
Parental ICT attitudes	.008 (.003)**	.008 (.003)**	.007(.003)	.007(003)*	.007 (.003)**	.006 (.003)*
ICT availability (categ)						
- Internet shared computer	-	-	-	-	-	-
- Internet private computer	-	-	-	-	-	-
- Internet shared & private	-	-	-	-	-	-
Amotivation	-	-	-	-	-	-
Extrinsic regulation	-	-	-	-	-	-
Introjected regulation	-.005 (.002)*	-.007 (.002)***	-.008 (.002)***	-.008 (.002)***	-.007 (.002)***	-.006 (.002)**
Identified regulation	-	-	-	-	-	-
Intrinsic motivation	-	-	-	-	-	-
Control	.005 (.002)*	.006 (.002)*	.006 (.002)**	.006 (.002)**	.005 (.002)*	.005 (.002)*
Memorization	-	-	-	-	-	-
Elaboration	-	-	-	-	-	-
Analytic intelligence	.054 (.008)***	.058 (.008)***	.057 (.008)***	.057 (.008)***	.058 (.008)***	.049 (.008)***
Sex (categ)	.310 (.095)***	.287 (.090)**	.263 (.093)**	.253 (.091)**	.255 (.091)**	.279 (.093)**
Age	-.072 (.104)	-	-	-	-	-
SES education mother						
- Primary	.602 (.436)	.701 (.432)	.635 (.430)	.669 (.427)	.725 (.419)	.557 (.457)
- Lower secondary	.756 (.329)*	.766 (.336)*	.833 (.334)*	.803 (.331)*	.928 (..329)**	.685 (.353)
- Higher secondary	.826 (.317)**	.826 (.325)**	.891 (.324)**	.885 (.319)**	.946 (.318)**	.742 (.342)*
- Higher education	1.132 (.318)***	1.063 (.325)**	1.051 (.324)***	1.049 (.320)**	1.118 (.320)***	.931 (.343)**
Classroom						
ICT competences			.003 (.003)	-	-	-
Teacher's ICT attitude			.001 (.003)	-	-	-
Professional development			-.005 (.003)	-	-	-
Logistic appropriateness			.003 (002)	-	-	-
ICT use as information tool			.010 (.004)*	.008 (.003)*	.008 (.004)*	.011 (.004)**
ICT use as learning tool			-.005 (.003)	-	-	-
ICT use basic skills			.001 (.003)	-	-	-
ICT experience			-.006 (.024)	-	-	-
School						
ICT coordinator: planner					.000 (.003)	-
ICT coordinator: budgeter					-.005 (.003)	-
ICT coordinator: technician					-.003 (.002)	-
ICT coordinator: educationalist					.004 (.004)	-
Vision and policy on ICT					.004 (.003)	-
ICT Infrastructure					.481 (.604)	-
ICT self-efficacy						.013 (.004)***
Random						
Classroom level σ^2_{u0} (between)	.000 (.000)	.019 (.027)	.000 (.000)	.004 (.024)	.000 (.000)	.000 (.000)
Pupil level σ^2_{e0} (within)	.566 (.048)***	.580 (.052)***	.574 (.047)***	.575 (.052)***	.549 (.046)***	.556 (.047)***
Model Fit						
Deviance (2-log)[a]	635.356	736.473	673.408	694.318	644.721	632.428
χ^2		40.595		42.155		61.916
d*f*		5		1		1
p		<.001		<.001		<.001
Reference		Model 4b		Model 5b		Model 6b

Table 3 (continued)

	Model 3b	Model 4b	Model 5b	Model 6b	Model 8
R^2_1 (proportion of variance explained at the student level)	0.92	25.00	31.31	33.60	36.24
ΔR^2_1		24.08	6.31	2.29	2.64
R^2_2 (proportion of variance explained at the classroom level)	3.73	27.28	40.33	46.89	50.22
ΔR^2_2		23.55	13.05	6.56	3.33

Table 4. Proportion of variance explained

5. Discussion and conclusion

The main aim of this study was to explore the degree to which differences in primary school pupils' actual ICT competences are related to differences in certain pupil, classroom and school level factors. The results indicate that the majority of sixth graders have a medium to low score on the developed ICT competence test, with only a slight minority performing at a more advanced level. These findings support the results of van Deursen and van Diepen (2013) who found that secondary students' level of information and strategic Internet skills have much room for improvement. It is interesting to consider these findings within the context of the debate about pupils as digital natives. The widely accepted and popular claims that a generation of digital natives exists, and that education must make fundamental adaptations in order to cope with the needs of this generation, are merely based on assumptions with a weak empirical foundation (Bennett, Maton, & Kervin, 2008; Jones, Ramanua, Cross, & Healing, 2010). One of these assumptions is that digital natives possess sophisticated ICT knowledge and competences. However, according to Bennet et al. (2008) these ICT competences are far from universal among young people and its complexity and diversity should be studied more intensively. The results of this study show that the majority of primary school pupils have a medium to low score on the performance-based ICT competence test with regard to retrieving, processing and communicating digital information. This indicates that digital natives are perhaps not as computer and internet savvy as it is often assumed. Moreover, this indicates that pupils do not develop high levels of ICT competence simply by using ICT at home or in informal settings, and that formal education in this matter is required. If education must make fundamental adaptations to the needs of this generation, the content of these needs should be reconsidered. Educational adaptations should not only reflect the skills that teachers do not yet possess, but especially the higher-order skills and competences that pupils do not yet possess. As such, professional development should not only focus on teachers' ICT competences, but also – and perhaps primarily - on initiatives that help teachers develop the ability to identify low levels of specific ICT competences of their pupils.

The results of the regression analysis indicate that a large proportion of the variance is situated at the pupil level, while only small and non-significant differences can be observed between classes. These results suggest that no shared levels of ICT competences exist for particular classes and that ICT competences mainly can be considered as a pupil phenomenon. A possible explanation is that pupils, in general, still do not use ICT intensively enough in the classroom in order for it to make a difference in the development of their ICT competences. For example, the results of this study indicate that primary school sixth graders on average are given the opportunity to use ICT in only three to four lessons per week and that this frequency of opportunity is not related to pupils' ICT competences. Consequently, it would be interesting to conduct a similar study in which the frequency or intensity of ICT use in the classroom is being controlled. More specifically, future research could investigate the degree to which the effect of certain classroom and school level characteristics is being mediated through the intensity of ICT use in the classroom. For example, it can be expected that pupils that have a very ICT competent teacher and that are given enough opportunities to learn from the teacher, will have better ICT competences compared to pupils that also have a very ICT competent teacher but are not given the opportunity to benefit from his or her competence.

The stepwise approach in the regression model made it possible to identify the specific pupil and classroom level factors of the EDC-model that relate to primary school pupils' ICT competences. With regard to ICT related pupil factors, ICT self-efficacy seems to explain a part of the variance in primary school pupils' ICT competences. The higher primary school pupils' ICT self-efficacy, the better they score on the ICT competence test. Similarly, Hargittai and Shafer (2006) found that Actual Net Skills are positively related to Self-Assessed Net Skills. Similarly, Tsai and Tsai (2003) found that pupils with higher ICT self-efficacy also have better online information processing strategies. However, this relationship between the directly and indirectly measured ICT competences of pupils requires more detailed investigation. For example, future research could explore whether the discrepancy between pupils' self-perceived and actual ICT competences is related to their actual level of ICT competence. More specifically, can it be assumed that the degree to which pupils are able to make a valid judgment of their own ICT competences is related to their actual competences?

With respect to motivation to learn, the results of this study indicate that pupils whose learning is driven by negative feelings of shame and guilt, or positive feelings of pride towards others, are less proficient in digital information processing and communication. These results are in line with other findings that indicates that introjected regulation is linked to less positive outcomes in other domains (Boiché, Sarrazin, Grouzet, Pelletier, &

Chanal, 2008). As these pupils put pressure on themselves, their behavior is associated with feelings of compulsion and conflict. These pupils' lower proficiency in ICT competence can possibly be explained by the fact that introjected regulation predicts a set of undesirable outcomes such as superficial cognitive processing, lower achievement and less engagement in adaptive metacognitive strategies such as concentration (Vansteenkiste et al., 2009).

With regard to these metacognitive strategies, the results of this study also indicate a positive relation between the 'control' learning style and pupils' ICT competence. The more pupils report that they plan, monitor and regulate their learning process while learning, the higher their ability in digital information processing and communication. The fact that these pupils have better scores is possibly explained by the fact that different aspects of information processing, such as locating and judging information, require metacognition (Eisenberg, 2005). These results indicate that in order to produce ICT competent pupils, schools should go further than addressing basic ICT skills and even higher-order ICT competences. Just as it is the case with other subjects, cognitive and motivational pupil characteristics such as learning style and learning motivation seem to be related to pupils' ICT competences, and should therefore also be stressed within educational ICT use. For example, in order to diminish pupils' introjected regulation, teachers must create conditions that allow their pupils to feel ICT competent. In this context, Ryan and Deci (2000) state that pupils who are directed to perform tasks they are not developmentally ready to master, will remain introjectedly regulated. As such, it is important that teachers can analyze the ICT competence level of their pupils and provide them with challenging but feasible ICT exercises. Pupils who successfully complete these tasks will perceive themselves as more competent. This perceived competence will lead to internalization of regulation, i.e., to more intrinsic motivation, which in turn will yield better ICT competences.

Furthermore, the results of this study indicate that analytic intelligence is related to pupils' level of ICT competence. The better a pupil can deal with novelty and adapt his or her thinking to new cognitive problems, the higher he or she scored on the test. Although this was to be expected, we did not find any other empirical study in the literature that provides evidence for the relationship between cognitive ability and ICT competences. Moreover, we consider it an advantage that analytic intelligence was taken into account in the conducted analyses, as this likely produces more accurate estimates for the other relationships that were found.

With regard to the sociocultural and economic pupil characteristics, both SES and sex were related to pupils' ICT competences, taking their cognitive ability into account. With respect to sex, girls seem to have the upper hand when it comes to digital information processing and communication. As such, this study provides evidence that tackles the traditional assumption of the gender gap in which computer and Internet use has been deemed a more male activity. Looking at the specific type of ICT competences that were tested in this study, our results are supported and possibly explained by earlier findings that state that e-mailing and online communication are the most popular computer activities for girls (Tsai & Tsai, 2010; Volman, Van Eck, Heemskerk, & Kuiper, 2005). Tsai and Tsai (2010) found that girls have about the same confidence as boys in their Internet exploration ability, but significantly higher confidence in their online communication ability. Our results confirm and elaborate the validity of these findings, through measuring ICT competences in a direct way. Moreover, the results of Hohlfeld, Ritzhaupt and Barron (2013) show that secondary school female students produced higher results than their male counterparts on the Student Tool for Technology Literacy, a performance-based assessment. The current study provides evidence that direct assessments can shed a different light on the gender issues concerning ICT competences and that future research should (re)address this subject as more valid assessment techniques and instruments become available. With regard to SES, the results of this study indicate that the higher the educational degree of the mother, the higher the mean level of pupils' ICT competence in digital information processing and communication. These results are in line with other studies indicating a significant positive relationship between pupils' ICT competences and SES (Vekiri, 2010; Volman, 2005). However, the results of this study elaborate on these previous findings, as they show a significant relationship between SES and ICT competence, taking the pupil's cognitive ability into account. As such, these results stress the importance of taking SES - e.g. parents' educational level - into account when studying pupils' ICT competences.

Finally, the degree to which pupils use ICT as an information tool in the classroom is positively related to pupils' digital information processing and communication skills. Although significant variance was only situated at the pupil level, this demonstrates that the type of technological activities that teachers organize in the classroom *do* matter in the establishment of ICT competences. Further research should investigate whether other specific types of technology use in the classroom are also related to other corresponding types of ICT competences. Findings from such studies could inform teachers about how to adapt their technology use in the classroom, such that pupils can learn the specific ICT competences they do not yet possess.

It is advised to replicate this study with a larger sample size in which the ratio between pupils, teachers and schools is taken into account. This will not only improve the reliability and validity of the results, but also permit a three-level analysis in which ICT competences are allowed to vary at the pupil, classroom and school level. Although this study is hindered by its relatively small sample size, we believe that the results are an important step forward into the identification of factors related to differences in pupils' ICT competences. As the results are based on the analysis of performance-based rather than self-perceived ICT competence data, they add to the literature on ICT competences. Moreover, this study yielded results that contrast with research on self-perceived ICT competences. For example, most of the research on self-perceived ICT competences has identified significant relationships between pupils' ICT attitude (or dimensions of it) and ICT self-efficacy (Compeau & Higgins, 1995; Durndell & Haag, 2002; Pamuk &Peker, 2009; Wu & Tsai, 2006). However, in this study no such relationship was found between pupils' ICT attitude and their actual ICT competence. These results support the findings of Bunz, Curry and Voon (2007), which indicate that students' computer anxiety is negatively related to their self-perceived computer-e-mail-WEB-fluency, but not to their actual computer-e-mail-WEB-fluency. This illustrates that accurate, direct and valid measures of ICT competence are required when studying ICT competences and factors related to them. By conducting this study, we hope to contribute to unraveling differences in pupils' ICT competences and encourage other researchers to use a performance-based approach.

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Appendix A

Items of the ICT competence scale of Aesaert et al. (2014)

Item	Description higher-order competences and technical skills
	Higher-order learning-process oriented competence
Item 1	Pupils use ICT applications to ask a question or deliver a message of which the content is understandable for the receiver
Item 2	Pupils can assess and judge the relevance of the information that was found for answering a question
Item 3	Pupils use the title and textual information found in the results of a conducted search
Item 4	Pupils use ICT applications to ask a question or deliver a message in a social acceptable way
Item 5	Pupils can judge the reliability of digital information
Item 6	Pupils can generate a new information product by comparing and synthesizing information that was found elsewhere
Item 7	Pupils can use a search engine by entering more correct search terms derived from a task or question
Item 8	Pupils can deliver information to others by using a non-structured format such as a e-mail
Item 9	Pupils can assess and judge the relevance of the information that was found for answering a question
Item 10	Pupils can integrate new information into existing information products
Item 11	Pupils formulate a subject of a mail/forum that refers adequately to its content
Item 12	Pupils can use a search engine by entering one correct search term derived from a task or question
Item 13	Pupils formulate a subject of a mail/forum that refers adequately to its content
Item 14	Pupils can deliver information to others by using a structured format such as a digital form
Item 15	Pupils can deliver information to others by using a structured format such as a digital form
Item 16	Pupils can configure a search engine to improve an intended search for figures or other media files
Item 17	Pupils can use a search engine by entering one correct search term derived from a task or question
Item 18	Pupils can efficiently use an URL
	Technical and application oriented ICT skills
Item 19	Pupils can answer an e-mail to one known person
Item 20	Pupils can send an e-mail to more known persons
Item 21	Pupils can add an attachment to an e-mail
Item 22	Pupils can use basic software commands such as copying and pasting a text
Item 23	Pupils can react on a forum
Item 24	Pupils can save and retrieve a file from a specific location
Item 25	Pupils can use basic software commands such as copying and pasting an image
Item 26	Pupils can start a topic on a forum
Item 27	Pupils can delete an e-mail

7

Exploring factors related to primary school pupils' ICT self-efficacy: A multilevel approach

This chapter is based on:

Aesaert, K., & van Braak, J. (2014). Exploring factors related to primary school pupils' ICT self-efficacy: A multilevel approach. *Computers in Human Behavior, 41,* 327-341.

Chapter 7

Exploring factors related to primary school pupils' ICT self-efficacy: A multilevel approach

Abstract

The aim of this study was to identify factors that are related to pupils' ICT self-efficacy. More specifically, a multilayered framework was used to identify which pupil, classroom and school level factors are associated with primary school pupils' self-perceived competence in digital information processing and communication. Information on pupils' ICT self-efficacy and the pupil level factors was gathered through a questionnaire administered to 2421 sixth grade pupils (and their parents) in 92 Flemish primary schools. A questionnaire was also administered to the teachers (n = 141) and the schools' ICT coordinators (n = 86) in order to gather information on classroom and school level factors. The results of the multilevel analysis indicate that ICT self-efficacy can be considered as a pupil, rather than a class or school, phenomenon. The results indicate that the pupil level factors ICT experience, ICT attitude, parental ICT attitude, controlling learning style, analytic intelligence and amotivation, are related to primary school pupils' ICT self-efficacy.

1. Introduction

In the last decades, computers and the internet have increasingly permeated virtually all aspects of our daily lives. As our contemporary information and knowledge society depends more and more on information technology, people must possess a set of ICT competences and skills to cope with associated educational, social and economic challenges (Kozma, 2008; Sieverding & Koch, 2009). In terms of education, research stresses the potential of computer and internet based learning environments to foster students' learning (Moos & Azevedo, 2009; Tsai, Chuang, Liang, & Tsai, 2011). In order to profit from the learning benefits of computer and internet based learning environments, pupils must master ICT skills and competences. Research focusing on factors associated with students' ICT competences indicates that their perception of their own ICT-abilities i.e. their ICT self-efficacy, is positively related to computer and internet use and performance (Barbeite & Weiss, 2004; Sam, Othman, & Nordin, 2005; Torkzadeh, Chang, & Demirhan, 2006). ICT self-efficacy is rooted in Bandura's broader concept of self-efficacy, which generally refers to a person's belief in his capability to successfully perform a certain task (Marakas, Yi, & Johnson, 1998). With regard to the relationship between pupils' ICT competences and their belief to perform ICT related tasks (i.e. ICT self-efficacy), pupils with high internet self-efficacy tend to have better information-searching strategies, which, in turn might explain why these students tend to learn better in web-based learning tasks (Tsai & Tsai, 2003). Furthermore, Johnson (2005) indicates that application specific computer self-efficacy is positively related to data task performance. The author describes this relationship between computer self-efficacy and actual computer performance as reciprocal; it is mediated and reinforced by successful task experiences.

Aside from the relation between ICT self-efficacy and actual ICT competences, research has also focused on ICT self-efficacy in terms of a more motivational and attitudinal point of view. Individuals with higher computer self-efficacy have a greater penchant for technology, exhibit more frequent use of computers, and have lower anxiety around technology (Chou, 2001; Compeau & Higgins, 1995; Wilfong, 2006). More recently, in the context of technology acceptance research, studies indicate that an individual's computer self-efficacy has a strong effect on behavioral intention to use technology, perceived ease of use and perceived usefulness of the technology (Gong, Xu, & Yu, 2004; Ong & Lai, 2006; Teo, 2009; Venkatesh, Morris, Davis, & Davis, 2003). These data not only stress the importance of stimulating pupils' ICT self-efficacy, such that their ICT competences and general acceptance of technology can be enhanced, the data also illustrate belief in the overall importance of this kind of research. Nevertheless, there remains a dearth of research into factors related to ICT self-efficacy (i.e. the factors that possibly foster or hamper pupils' judgment of their own ICT competences). Indeed, research that has investigated such factors appears to have been mostly conducted in post-primary schools and from a single-level perspective (Aesaert, Van Nijlen, Vanderlinde, & van Braak, 2014). These single-level studies do not take into account the complexity of the educational context in which pupils interact (i.e. pupils nested in classrooms, which are in turn nested in schools). In other words, these studies treat pupils as if they are independent of the classroom and school to which they belong and wrongly assume that pupils do not share common characteristics. Ignoring the variability that likely exists at each of the said levels may lead to erroneous regression coefficients and standard errors (Creemers & Kyriakides, 2008; Snijders & Bosker, 2012). As such, the aim of this study is to use a multilevel approach in order to identify pupil, class and school level factors that might be associated with primary school pupils' ICT self-efficacy. In this study, ICT self-efficacy is considered as a self-perceived measure of pupils' ICT competence (i.e. pupils own assessment of successfully performing computer- and internet-based tasks (Meelissen, 2008). It is operationalized as self-perceived competence in digital information processing and communication. Pupil, class and school level factors are derived from the EDC-model (Aesaert, Vanderlinde, Van Nijlen, & van Braak, 2015).

2. Background

2.1. ICT self-efficacy

ICT self-efficacy originates from the concept of self-efficacy, derived from Bandura's Social Cognitive Theory. Bandura (1986) defines self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 391), i.e., a person's belief in or expectation of his/her ability to successfully perform a certain behavior. Over the years, pupils' self-efficacy has been studied in a variety of academic subject areas, producing a range of domain-specific measures of self-efficacy, such as mathematical self-efficacy, reading self-efficacy and ICT self-efficacy (Baker & Wigfield, 1999; Moos & Azevedo, 2009; Pajares & Miller, 1994; Tsai et al., 2011). As research indicates that domain-specific measures of self-efficacy deliver more accurate predictions for performance than general measures (Saleem, Beaudry, & Croteau, 2011), the use of ICT self-efficacy measures is preferred over the use of general efficacy measures.

In general, ICT self-efficacy comprises computer self-efficacy and internet self-efficacy (Papastergiou, 2010). For Compeau and Higgins (1995) computer self-efficacy is the individual's judgment of his/her ability to apply computer skills to broader tasks in the future. Through the years, this initial definition of computer self-efficacy has been frequently adapted and modified. Marakas et al. (1998) define computer self-efficacy as an individual's belief in his or her ability to perform specific computer tasks. The authors divide computer-self efficacy into two parts: general computer self-efficacy and task-specific self-efficacy. Whereas general computer self-efficacy refers to the person's judgment of his/her capabilities in multiple computer application domains, task-specific computer self-efficacy concerns the perception of successfully completing computer-specific tasks in the domain of general computing (Agarwal, Sambamurthy, & Stair, 2000; Marakas et al., 1998). In this context, general computer self-efficacy is often considered more important than competence in specific ICT applications, given that pupils with high computer self-efficacy can more easily adapt to continuously changing technological applications and environments (Papastergiou, 2010; Sam et al., 2005). Next to computer self-efficacy, ICT self-efficacy includes Internet self-efficacy. Similar to computer self-efficacy, internet self-efficacy is often defined as a person's belief in his/her ability to use the internet to accomplish certain goals (Sun, 2008). For example, Papastergiou, Gerodimos, and Antoniou (2011) perceive internet self-efficacy as students' individual beliefs regarding their ability to use the internet and multimedia blogging. Liang and Tsai (2008) divide internet self-efficacy into general internet self-efficacy (GISE) and communicative internet self-efficacy (CISE). Whereas GISE refers to the self-perceived competence in using the internet in general, CISE addresses students' competence for Internet-based interaction and communication. Similarly, Tsai and Tsai (2010) use a less general definition and operationalize internet self-efficacy as the perceived ability to 1) navigate and search for information on the internet (online exploration), and 2) communicate via the internet (online communication). Torkzadeh and Van Dyke (2002) developed an instrument in which Internet self-efficacy is defined in terms of browsing, encryption/decryption, and system manipulation.

In this study ICT self-efficacy refers to pupils' judgment of their ability to process digital information and to communicate with others by using a computer and the internet. More specifically, it concerns the intensity of a pupil's belief in his ability to successfully perform specific digital tasks with regard to 1) retrieving and processing appropriate digital information; and 2) communicating in a safe, sensible and appropriate way. Research indicates that pupils still experience difficulties with information retrieval and processing, such as defining search queries, evaluating online information; and with online communication skills (Kuiper, Volman, & Terwel, 2005; van Deursen & van Diepen, 2013). Moreover both themes of digital communication and information processing are identified as two essential competences that pupils should possess in national and international ICT curricula (Aesaert, Vanderlinde, Tondeur, & van Braak, 2013; Voogt & Pareja Roblin, 2012). As ICT self-efficacy strongly affects ICT competences, it is important to identify factors that are related to pupils' ICT self-efficacy on both sides. Because digital communication as well as retrieving and processing digital information is not solely done by means of the Internet but also by using ICT skills in stand-alone software, such as a text processing programs, ICT self-efficacy is preferred over the concept of internet self-efficacy.

2.2. Factors related to self-perceived measures of ICT competences

Below we review the empirical literature grounding the importance of the variables integrated in the EDC-model (Aesaert et al., 2015), used as a reference framework for setting up this study (see Figure 1). The dependent variable, ICT competence, is integrated in the model as both a direct and an indirect measure. Whereas the direct measure refers to pupils' actual ICT competences, the indirect measure refers to self-perceived ICT competence (i.e. ICT self-efficacy). In the model, ICT competence is perceived as a higher-order learning-process skill that children use to solve problems in a digital context, underpinned by technical and application skills. These latter (basic) ICT-skills are considered to be instrumental to the former higher-order learning-processing skills. This study focuses only on ICT self-efficacy as the dependent variable of the model and not on the direct measure of ICT competences. The independent variables of the model refer to school level, classroom level and pupil level factors that might be related to primary school pupils' actual and perceived ICT competences.

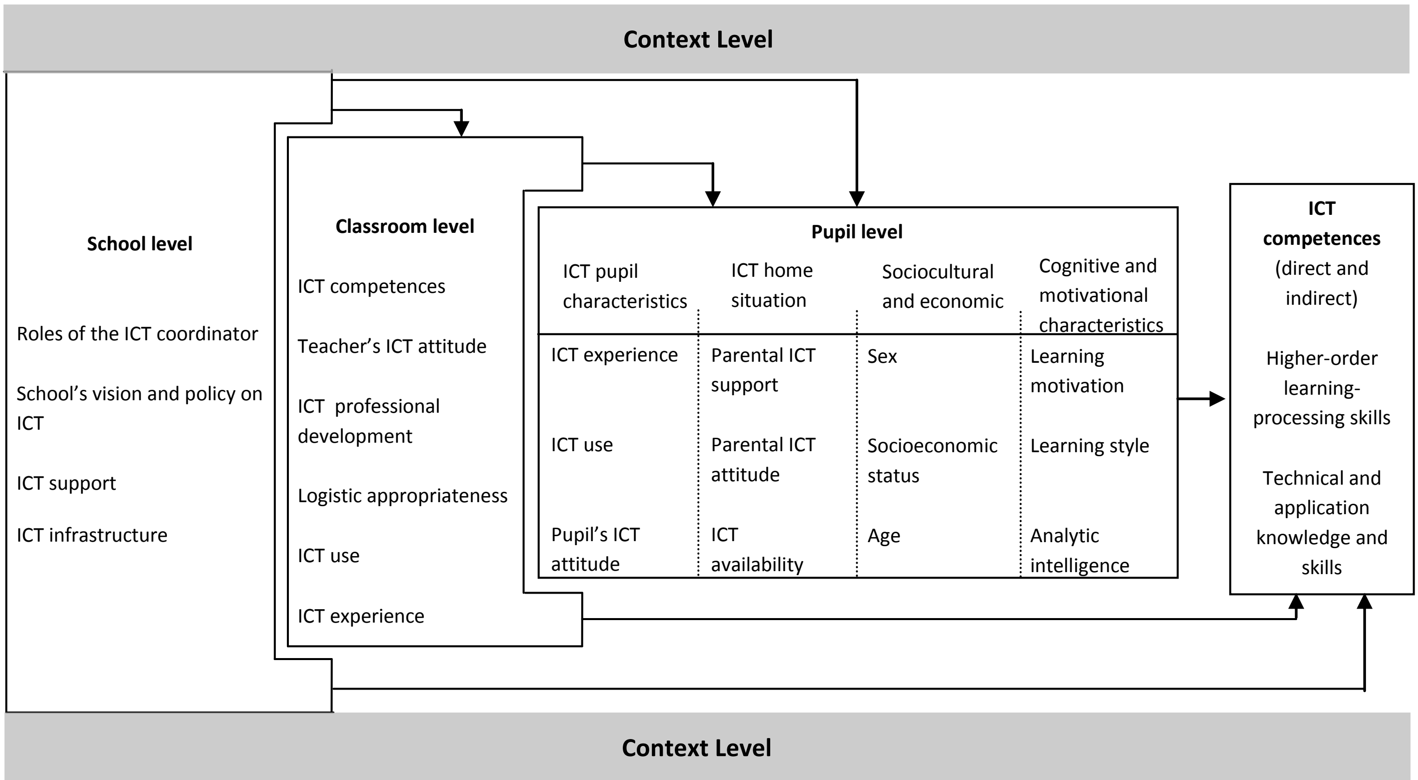

Figure 1. The Extensive Digital Competence (EDC) Model

2.2.1. Pupil level factors

2.2.1.1. ICT related pupil characteristics

In the literature, a range of ICT related pupil characteristics can be found that are expected to be related to pupils' ICT-self efficacy, such as *ICT experience, ICT use* and *ICT attitude.* As a measure of frequency, *ICT experience* is mostly defined as the number of months/years that a child has already been using the computer and/or the internet or as the daily/weekly time spent on offline and online computer activities (Durndell & Haag, 2002; Tsai & Tsai, 2010). The empirical findings with regard to the relationship between ICT experience and ICT self-efficacy are mixed. Although many studies indicate a positive relationship, other studies found only a partial or no significant effect of ICT experience on ICT self-efficacy (Fagan, Neill, & Wooldridge, 2003; Hasan, 2003). *ICT use* refers to pupils' use of specific ICT applications. Mcilroy, Sadler, & Boojawon (2007) indicate that the degree to which pupils use certain applications, such as a text processor, spreadsheets, presentation software or e-mail, is positively related to their ICT self-efficacy. Moreover, Hasan (2003) found that experience with specific types of computer use, such as programming and computer graphics applications, have stronger effects on computer self-efficacy than experiences with other types of ICT use, such as spreadsheet and database applications. Furthermore, it is acknowledged that pupils' *ICT attitudes* are related to their ICT self-efficacy. For example, pupils who perceive computers and the internet as useful; who are less anxious to use computers and the internet; and who have more confidence about independent control with internet use, express higher levels of computer and internet self-efficacy (Durndell & Haag, 2002; Pamuk & Peker, 2009; Wu & Tsai, 2006).

2.2.1.2. Sociocultural and economic characteristics

Studies on ICT self-efficacy have placed much emphasis on sociocultural and economic factors, such as *sex*, *socioeconomic status* (SES) and *age* (Meelissen, 2008). However, research has not produced conclusive results with regard to the relationship between those factors and ICT self-efficacy. For example, whereas Bunz, Curry, and Voon (2007) found a significant relationship between sex and self-perceived computer–email–web fluency, in favor of males, Imhof, Vollmeyer, and Beierlein (2007) did not find a significant difference between male and female students' ICT self-efficacy. Other research indicates that the relationship between sex and ICT self-efficacy is determined by the kind of ability the ICT self-efficacy measure is referring to. For example, Tsai and Tsai (2010) found an association between sex and online communication self-efficacy in favor of females. Similarly, Bunz et al. (2007) indicate that girls perceive themselves as having relationship-and communication-focused ICT abilities, whereas boys perceive themselves as skilled in the more technical aspects of ICT use. Moreover, studies with regard to socioeconomic status do not offer consistent results. Whereas Vekiri (2010) indicates that pupils with a high-SES express higher ICT self-efficacy, Tondeur, Sinnaeve, Van Houtte, and van Braak (2011) show that this relationship is not strong enough to conclude that those from lower SES have lower ICT self-efficacy. Furthermore, findings with respect to age are also inconsistent. For example, whereas Hargittai and Hinnant (2008) found no relationship between age and self-perceived knowledge of internet-related terms, Liang and Tsai (2008) indicate that older college students tend to have lower communicative Internet self-efficacy.

2.2.1.3. ICT oriented home situation

The EDC-model also contains factors that emerge from the home situation, which are expected to be related to pupils' ICT self-efficacy, such as *parental ICT support, parental ICT attitude* and the *ICT availability* at home. In the EDC-model, parental ICT support refers to the degree to which parents try to control and guide their children's ICT use by imposing ICT rules onto them, talking to them about their ICT use and doing ICT activities with them. Parental ICT attitudes refer to the parental values about their children's ICT use, i.e., the degree into which parents believe that their children will economically, socially and educationally benefit from developing ICT competences. In this context, Vekiri (2010) and Vekiri and Chronaki (2008) found that pupils who perceive their parents as supportive and encouraging in terms of using ICT and developing ICT skills consider themselves better at solving computer tasks. A final ICT-related home characteristic is 'ICT availability,' i.e. the opportunities that parents offer their children to develop ICT competences by providing them with the necessary ICT infrastructure. In this regard, Tsai and Tsai (2010) found that computer ownership is related to student internet self-efficacy. Similarly, Zhong (2011) found that pupils with a computer, educational software and internet access at home perceive themselves as having better ICT skills.

2.2.1.4. Cognitive and motivational factors

The EDC-model also refers to a set of personal pupil level factors that have a more cognitive and motivational basis, i.e., *learning motivation, learning style and analytic* *intelligence.* In the EDC-model, learning motivation is perceived as the degree to which the motivation to learn or study is autonomous rather than controlled in nature. This more qualitative approach to motivation (Vansteenkiste, Sierens, Soenens, Luyckx, & Lens, 2009) has strong links with the well-known concepts of extrinsic and intrinsic motivation. Research indicates that students who value intrinsic learning motivation factors (e.g. individual attitudes and expectations) as more important, have a higher level of computer programming self-efficacy. With regard to extrinsic learning motivation factors, only 'social pressure and competition' is positively related to self-efficacy (Law, Lee, & Yu, 2010). Another factor in this category is *learning style.* Research indicates that pupils with a more meaning-directed learning style perceive themselves better able to use basic ICT skills, but less so at using the internet, whereas application-directed learners consider themselves to have equally good basic and internet use skills (Verhoeven, Heerwegh, & De Wit, 2012). *Analytic intelligence* is incorporated in the model as a final pupil level characteristic. In the EDC-model analytic intelligence is perceived as a measure of aptitude, which is believed to affect pupils' achievements (Aesaert et al., 2015). With regard to self-perceived ICT competence, the relationship between analytic intelligence (aptitude) and ICT self-efficacy has not yet been investigated. However, some studies indicate that there is a significant relationship between aptitude and other types of self-efficacy, such as in writing (Pajares, Miller, & Johnson, 1999). As such, it might be useful to investigate whether primary pupils' ICT-self-efficacy is related to their analytic intelligence.

2.2.2. Classroom level factors

At the classroom level the EDC-model only embraces ICT related characteristics (Aesaert et al., 2015). These characteristics refer to the teacher's personal ICT profile and to classroom conditions that the teacher creates in order to improve educational ICT use and, as such, the (self-perceived) ICT competences of pupils. At this level, *ICT experience* may be defined as the frequency of using the computer in the classroom. Whereas several studies have reported on the relationship between ICT self-efficacy and ICT experience in general or at home (Durndell & Haag, 2002; Mcilroy et al., 2007), fewer studies have explored the relationship with computer experience in the classroom. Levine and Donitsa-Schmidt (1998) found that the extent of computer use at school correlates with pupils' computer confidence and their self-perceived computer knowledge. Another factor of the EDC-model is *logistic appropriateness*. Whereas research into ICT self-efficacy and ICT competences has explored ICT availability and access, few studies have focused on the appropriateness of the available software and hardware. Hew and Brush (2007) state that ICT infrastructure is one of the most important factors in promoting or hampering ICT implementation in the classroom. Vanderlinde and van Braak (2010) elaborate on this and argue that the availability of technology alone is not enough. Teachers must also feel satisfied with the available technology resources in order to use them for the promotion of their pupils' ICT competences. With regard to *ICT use*, several studies indicate that specific software and internet use is related to pupils' computer and internet self-efficacy. For example, Sam et al. (2005) indicate that pupils with higher computer self-efficacy use the internet more frequently for product and service information. Furthermore, it appears that pupils' ICT self-efficacy is associated with the use of a wider variety of computer activities (Vekiri, 2010). However, most of these studies focus on computer and ICT use in general or at home. Similarly, it can be expected that certain types of educational ICT use are related to pupils' ICT self-efficacy. In the EDC-model, ICT use at the classroom level embraces the three types of educational computer use as developed by Tondeur, van Braak, and Valcke (2007), i.e., basic computers skills, the use of computers as an information tool, and the use of computers as a learning tool. To our knowledge, no studies have investigated the relationship between these types of educational ICT use and pupils' ICT self-efficacy.

In the EDC-model, teachers' *ICT competences* are limited to their self-perceived technical, organizational and pedagogical–didactical ability to use ICT in the classroom (Aesaert et al., 2015). These self-perceived ICT competences can be considered as a form of teacher efficacy (Ross, Hogaboam-Gray, & Hannay, 2001). Research suggests that high teacher efficacy is positively related to pupils' cognitive and emotional achievement, as well as their own self-efficacy (Leithwood, 2007; Ross, 1998). With regard to teachers' self-perceived ICT competences, Ross et al. (2001) show that teachers' confidence in their ability to teach pupils how to use computers and reach personal goals is positively related to pupils' computer self-efficacy. In the literature, teachers' *ICT attitudes* have been operationalized in several ways, focusing on different dimensions, such as computer anxiety, perceived relevance of computers, etc. (Meelissen, 2008; Torkzadeh & Van Dyke, 2002). In the EDC-model, ICT attitudes refer to the teacher's perception of the importance and usefulness of being ICT competent (Aesaert et al., 2015). Teachers' attitudes and beliefs toward computers have a significant impact on the degree to which they integrate technology into the classroom (Gibson et al., 2014 and Hermans, van Braak, & van Keer, 2008). As such, it can be expected that teachers who perceive ICT as useful and important provide their pupils with more challenging opportunities to engage with technology, which in turn will lead to better ICT self-efficacy. A final teacher characteristic embedded in the EDC-model is *ICT professional development,* which refers to the degree to which teachers take the initiative to keep informed about technology and engage in ICT-related professional development initiatives (Vanderlinde & van Braak, 2010). Research regards the dearth of professional development as one of the biggest reasons for the lack of ICT integration in the classroom (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). ICT professional development can improve teachers' ICT attitudes as well as their ICT knowledge and skills (Hew & Brush, 2007). As such, it can also be expected that ICT professional development is positively related to pupils' self-perceived ICT competences.

2.2.3. School level factors

Research investigating the relationship between school level factors and pupils' ICT self-efficacy is scarce. The school level factors incorporated in the EDC-model refer to organizational factors that could be related to the teaching and learning of pupils' (self-perceived) ICT competences. The first school level factor of the EDC-model is *ICT support*, defined as the technical and educational support that teachers receive in order to use technology in the classroom. In their overview of quality support for ICT in schools, Strudler and Hearrington (2008) stress the importance of support and professional development for effective ICT integration, which, in turn, can lead to an improvement of pupils' ICT self-efficacy. A second school level factor in the EDC-model elaborates ways to provide teachers with ongoing support and training i.e. the supportive *roles of ICT coordinators*. Devolder, Vanderlinde, van Braak, and Tondeur (2010) have identified four supportive roles of ICT coordinators i.e. the ICT coordinator as a planner, technician, budgeter and educationalist. In this context, research indicates that support focusing on teaching and the specific needs of teachers increases the use of ICT in the classroom (Skues & Cunningham, 2013; Tondeur, Cooper, & Newhouse, 2010). As such, it can be expected that teachers in schools with an ICT coordinator that mainly take up this educational role use ICT in a more advanced way, which in turn may be positively related to the ICT self-efficacy of the pupils.

Research has identified a *school's vision and policy on ICT* (often part of an ICT policy plan) as an important incentive for ICT use in the classroom (Tondeur, Van Keer, van Braak, & Valcke, 2008b). Vanderlinde, van Braak, and Tondeur (2010) consider prioritizing ICT attainment targets an essential component of ICT policy planning, as it facilitates the integration of ICT and develops pupils' ICT skills in a structured way. Because teachers who share goals and values of a well-considered ICT policy plan tend to integrate ICT more frequently and in more advanced ways (Tondeur, Valcke, & van

Braak, 2008a; Tondeur et al., 2008b), it can be expected that their pupils develop better ICT skills and consider themselves as better ICT users. Finally, previous research has investigated the relation between the variation in pupils' ICT self-efficacy and the *ICT infrastructure* of the school. For example, Zhong (2011) indicates that students of schools with more computers connected to the internet and which are made available to students and teachers report higher self-perceived ICT skills than pupils from schools with fewer computers available.

3. Research aim

The aim of this study is to identify factors related to primary school pupils' self-perceived ICT competences or ICT self-efficacy. More specifically, we investigate which school, classroom and pupil characteristics are related to primary school pupils' judgment of how successful they are in completing tasks that focus on digital communication and information processing. These characteristics make up the independent variables of this study and were drawn from the EDC-model (Aesaert et al., 2015). The ICT self-efficacy scale for primary education of Aesaert et al. (2015) was used to measure primary pupils' ICT self-efficacy, the dependent variable of this study. This study distinguishes itself from previous research by using a multilevel approach and gathering information from a variety of participants, such as pupils, parents, teachers and ICT coordinators.

4. Methods

4.1. Participants

A sample of 92 primary schools in Flanders (the Dutch speaking region of Belgium), their sixth grade pupils, their parents, their teachers and the ICT coordinators of the school took part in this study. The schools are representative to the total school population in Flanders with respect to school size, educational network and province. A sample of 2421 sixth grade pupils in 141 classes took part in this study, 48.8% male and 51.2% female (age: M = 12.08, SD = 0.50, min = 10.11, max = 14.42). All pupils' parents received a request for participation in this study from the teachers. The response rate of the pupils' parents was high (93.2%). The 141 teachers of the pupils and 86 ICT coordinators of the 92 schools were also involved in this study, in order to collect relevant data on the classroom and school level. Of the teachers, 31.9% were male and

68.1% were female. On average, the teachers had 17.85 (SD = 10.55) years of teaching experience, with a minimum of 1 and a maximum of 38 years. Of the ICT coordinators, 81.4% were male and 18.6% were female. The age of the ICT coordinators ranged between 22 and 59 years (M = 37.41, SD = 9.59).

4.2. Instruments

A questionnaire was administered to the pupils in order to gather information on the dependent variable of ICT self-efficacy and also for ICT-related pupil characteristics, sociocultural and economic factors, and the cognitive and motivational pupil characteristics. With regard to primary school pupils' ICT self-efficacy, the instrument of Aesaert et al. (2015) was used (18 items) to measure pupils' judgment of their own competence in communicating, and locating and processing information with a computer and the internet, as well as their technical skills. All items were rated on a 4-point Likert scale (1 = not good at all, to 4 = very good). The items reflect a functional rather than a technical perspective, i.e. they describe activities for which pupils must engage in using specific software (e.g. a search engine, a blog). In order to make the items understandable for the young pupils, some of them were accompanied by a screenshot of the software that the pupils would need in order to solve the task described by the item. See Appendix A for an overview of all items. A separate questionnaire was administered to the pupils' parents in order to gather information about ICT-related home characteristics. More detailed information about the scales used to measure the independent pupil level factors can be found in Table 1. The ICT-related pupil characteristic 'ICT use' was not measured in this study. A questionnaire was administered to the teachers in order to investigate the degree to which the classroom level factors of the EDC-model are associated with primary school pupils' ICT self-efficacy. Using aggregated data, information from the teachers was also used to measure the school level factor 'ICT support'. In addition, the ICT coordinators of the schools completed a questionnaire to assess the school level factors. According to Tondeur et al. (2008a), ICT coordinators are the professionals best positioned to deliver information on ICT-related school level factors such as a school's vision and policy on ICT or a school's ICT infrastructure. Additional information on the measurement instruments used for gathering information on the class and school level can be found in Table 1.

4.3. Data analysis

In order to take the hierarchical structure of the nested data into account (2421 pupils in 141 classes in 92 schools), multilevel modeling was used to explore differences in primary school pupils' ICT self-efficacy (Snijders & Bosker, 2012). As pupils' ICT self-efficacy could also be related to differences between classes of the same school, or to differences between schools, a three-level model would be advised. However, the average level 2 sample size is only 1.52 teachers per school. Because such a small sample size leads to confounding of levels and increases the risk of less accurate estimates and standard errors (Hox, 2002), a two-level model was conducted in which ICT self-efficacy was allowed to vary at the pupil and classroom level. The iterative generalized least squares (IGLS) procedure in MLwiN 2.25 was used to investigate the relationships between the pupil, classroom and school characteristics of the EDC-model and primary school pupils' ICT self-efficacy.

In total, nine models were tested in this study. First, a null model without any explanatory variables was estimated, in order to check whether multilevel modeling was required over a single level analysis. In the subsequent eight models, the ICT related pupil characteristics (Model 1), ICT related home situation characteristics (Model 2), cognitive and motivational characteristics (Models 3 and 4), socioeconomic and cultural pupil characteristics (Model 5), class level factors (Models 6 and 7), and school level factors (Model 8) were integrated as explanatory variables respectively. In order to facilitate the comparison of the effects of the different explanatory variables, the standardized regression coefficients (β) were also reported for the final model. The change in deviance between models was used to investigate model improvement. This difference in deviance is a test statistic with a chi-squared distribution that is used to test whether a model significantly fits the data better than another model.

Variable	*Description (source)*	*Sample*	*Nr items*
Pupil level			
ICT related characteristics			
ICT experience	Hours a week spent on a computer at home	pupil	/
ICT attitude	Computer interest, confidence, and perceived usefulness; Aesaert et al., 2015)	pupil	5
ICT related home situation			
ICT support	Parental assistance at home by:		
- Active support	- doing ICT activities together (adapted from Valcke, Bonte, De Wever, & Rots, 2010; Aesaert et al., 2015)	parent	13
- Rules	- imposing computer rules (adapted from Valcke et al., 2010; Aesaert et al., 2015)	parent	5
ICT attitude	Parents' perceived usefulness of ICT (Aesaert et al., 2015)	parent	5
ICT availability	Availability of private/shared computer and Internet access at home	parent	/
Sociocultural and economic factors			
Sex		pupil	/
Socioeconomic status	Highest educational level of mother	pupil	/
Age		pupil	/
Cognitive and motivational characteristics			
Learning style	Learning by:		
- Memorization	- repeating strategies (adapted from OECD, 2009; Aesaert et al., 2015)	pupil	3
- Control	- monitoring and regulating (adapted from OECD, 2009; Aesaert et al., 2015)	pupil	3
- Elaboration	- connecting to other learning areas (adapted from OECD, 2009; Aesaert et al., 2015)	pupil	3
Analytic intelligence	Nonverbal ability to deal with novelty and solve problems (Raven Progressive Matrices Test: Raven, Raven, & Court, 2003)	pupil	60 (binary)
Learning motivation	Pupils learn (adapted Self-Determination Theory and Academic Motivation Scales):		
- Extrinsic regulation	- to get rewards, avoid punishment, meet external expectations (Vandevelde et al., 2013)	pupil	3
- Introjected regulation	- to avoid guilt, shame, fear; to feel proud (Vandevelde et al., 2013)	pupil	4
- Identified regulation	- because they find it personally useful and valuable (Vandevelde et al., 2013)	pupil	4
- Intrinsic regulation	- because they find it interesting and fun (Vandevelde et al., 2013)	pupil	4
- Amotivation	- pupils have no sense of purpose or no expectation of reward of learning (Vallerand et al., 1992; Aesaert et al., 2015)	pupil	4

Table 1. Scale information of the independent factors

Variable	*Description (source)*	*Sample*	*Nr items*
Classroom level			
ICT experience	Number of lessons in which the computer is used	teacher	/
Logistic appropriateness	Satisfaction with available ICT equipment (Vanderlinde & van Braak, 2010)	teacher	4
ICT use	Specific types of ICT use in the class (Vanderlinde & van Braak, 2010)		
- for basic skills		teacher	4
- as information tool		teacher	5
- as a learning tool		teacher	5
ICT competences	Competence in ICT integration (Vanderlinde & van Braak, 2010)	teacher	5
ICT attitudes	Teachers' perceived usefulness of ICT (Aesaert et al., 2015)	teacher	5
ICT professional development	Initiatives to improve ICT competences and integration (Vanderlinde & van Braak, 2010)	teacher	4
School level			
ICT support			
Roles of the ICT coordinator	Organisation of ICT support and coordination (Vanderlinde & van Braak, 2010)	teacher	7
- planner	The ICT coordinator fulfils tasks related to (Devolder et al., 2010)):		
- technician	- planning, development, facilitation and monitoring of an ICT vision and policy	ICT-coord.	5
- budgeter	- the management of the ICT infrastructure and communication concerning technical issues	ICT-coord.	3
- educationalist	- the administration of the ICT budget of the school	ICT-coord.	4
Vision and policy on ICT	- support and training of teachers in their implementation and use of ICT in the classroom	ICT-coord.	7
ICT infrastructure	Clear vision and policy plan on ICT integration (Vanderlinde & van Braak, 2010)	ICT-coord.	7
	Ratio computers/pupils at the school	ICT-coord.	/

Table 1 (continued)

5. Results

5.1. Descriptive statistics and reliability

With regard to the dependent variable, ICT self-efficacy, the results in Table 2 indicate that primary school pupils judge themselves as highly competent in communicating, and locating and processing information with a computer and the internet (M = 80.30, SD = 13.50). The ICT self-efficacy scale showed a good internal consistency (α = .93). All other instruments have an acceptable to good internal consistency, with Ordinal alpha's varying between .61 and .96. Ordinal alpha's were used as these estimate reliability more accurately than Cronbach's alpha for ordinal response scales such as Likert-type scales (Gadermann, Guhn, & Zumbo, 2012). In order to measure analytic intelligence, the Raven Progressive Matrices Test was used. As this test is build out of 60 binary items, BILOG-MG was used to calibrate the empirical reliability of this scale, producing good results (r = .82, comparable to Cronbach's alpha). Table 2 shows that the values of the correlates between the explanatory variables were rather low. As such, the assumption of no perfect multicollinearity was not violated and thus no variables had to be removed.

5.2. Multilevel model

Although nine models were tested for this study, only the results for the null model and the final model are presented here (see Table 3). A detailed overview of all the estimated models can be found in Appendix B.

5.2.1. Null model

The first step in the analysis was to explore whether multilevel modeling was required over a single level analysis to explain differences in primary school pupils' ICT self-efficacy. For this purpose, a fully unconditional two-level random intercepts model was estimated. This model is also referred to as a null or empty model, as it contains not one explanatory variable. The estimates of the null model support the use of multilevel modeling, as both the between-class variance (class-level: σ^2_{u0}=8.99, χ^2=14.02, p<.001) and the within-class variance (pupil level: σ^2_{e0}=172.98, χ^2=1061.14, p<.001) differ significantly from zero. The results indicate that the within–class differences are much larger than the between-class differences. The estimates σ^2_{e0}=172.98 and σ^2_{u0}=8.99 yield an intraclass correlation coefficient (ICC=σ^2_{u0}/ (σ^2_{e0} +σ^2_{u0}) of .951, which indicates that 95.06% of the variance in pupils' judgment of their ICT competence is attributed to

	M (SD)	*α*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pupil level characteristics																	
1. Sex			1.00														
2. Age	12.08 (0.50)		.05*	1.00													
3. ICT experience	7.24 (6.20)		-.05*	.08**	1.00												
4. ICT attitude pupil	68.38 (19.88)	.84	-.26**	.03	.15**	1.00											
5. ICT support active	53.35 (19.01)	.94	.00	-.09**	.04	.04	1.00										
6. ICT support rules	73.78 (22.68)	.88	-.01	-.06**	-.15**	-.01	.52**	1.00									
7. ICT attitude parents	71.81 (17.44)	.87	.04*	-.04	.14**	.08**	.15**	.03	1.00								
8. ICT availability	1.73 (0.99)		-.01	-.00	.43**	.08**	.07**	-.09**	.10**	1.00							
9. Memorization	54.48 (21.71)	.61	.07**	.00	.02	.06**	.02	-.01	-.03	.00	1.00						
10. Control	72.48 (19.35)	.68	.14**	-.06**	-.07**	.04	.04	.05*	.03	-.02	.36**	1.00					
11. Elaboration	36.29 (23.36)	.73	-.10**	.07**	.02	.16**	.08**	.05*	.01	.00	.26**	.24**	1.00				
12. Analytic intelligence	45.48 (5.71)	.82	.07**	-.17**	-.09**	-.04	-.00	.02	.04	-.07**	-.04*	.09**	-.10	1.00			
13. Amotivation	22.93 (18.66)	.82	-.14**	.02	.10**	.02	-.02	-.03	-.02	.04	-.17**	-.32**	-.01	-.1**	1.00		
14. Extrinsic regulation	44.05 (29.50)	.90	-.07**	.05**	.03	.07**	-.05*	-.04*	.01	-.02	-.04	-.12	-.00	-.05*	.36**	1.00	
15. Introjected regulation	44.09 (21.02)	.71	-.06**	.06**	-.02	.15**	.01	.03	.01	-.00	.09**	.01	.17**	-.08**	.22**	.32**	1.00
16. identified regulation	83.32 (16.19)	.88	.13**	.02	-.05*	.10**	.04	.02	.03	-.03	.28**	.36**	.19**	.03	-.55**	-.28**	.04
17. Intrinsic regulation	63.25 (22.49)	.90	.14**	.01	-.06**	.11**	.01	.00	.01	-.02	.23**	-29**	.20**	.07**	-.46**	-.31**	.05*
Class level characteristics																	
18. ICT experience	3.32 (3.95)		-.04	-.04*	-.01	.04	-.01	.02	-.02	.02	-.03	-.02	.02	.04*	.03	.02	-.00
19. Logistic appropriateness	63.15 (22.37)	.87	.02	-.12**	-.05*	-.03	-.01	.01.	.04	-.00	-.01	.04*	-.08**	.08**	-.03	.00	-.04*
20. ICT use basic skills	45.80 (19.36)	.71	.01	-.04	-.01	.07**	-.03	-.01	.03	.02	.04*	.03	.02	.05*	-.02	-.02	-.01
21. ICT use information tool	43.32 (14.74)	.75	.03	-.04	-.03	.05*	.00	.03	.02	.01	.04*	.03	.01	.05*	-.01	-.02	-.01
22. ICT use learning tool	49.96 (20.95)	.84	.01	-.03	-.02	.00	-.02	.03	.03	.03	.03	.04	.01	-.01	-.02	.02	.00
23. ICT competences	66.75 (16.81)	.90	.00	-.09**	-.01	.01	-.02	.01	.01	.03	.02	.04	-.04*	.07**	-.01	-.02	-.00
24. ICT attitudes	65.26 (14.23)	.84	.01	-.01	.01	.04*	-.02	.02	-.00	-.01	.03	.04	.02	-.00	-.03	-.04	.02
25. ICT professional development	56.02 (20.24)	.86	.04	-.05*	-.04	.03	-.01	-.00	.03	.04	.05*	.03	-.02	.06**	-.03	-.06**	.01
School level characteristics																	
26. ICT support	70.04 (18.71)	.91	.03	-.12**	-.01	-.07**	-.01	-.02	.00	.05*	-.01	.00	-.03	.04*	-.00	-.02	-.01
27. ICT coordinator: planner	60.82 (19.55)	.93	.01	-.06*	-.04	.03	.03	.00	.03	-.01	-.06**	.01	-.03	.02	.04	.00	-.02
28. ICT coordinator: technician	82.25 (22.56)	.96	.02	-.00	-.01	-.01	.01	-.01	.03	.06*	.01	-.03	.00	-.02	-.01	-.02	-.03
29. ICT coordinator: budgeter	48.46 (21.84)	.85	.01	-.02	-.05*	-.01	.03	-.01	.02	.04	-.07**	-.02	-.02	-.02	-.02	-.04*	-.04
30. ICT coordinator: educationalist	61.97 (19.35)	.93	.01	-.05*	-.02	.05*	.01	-.01	-.02	-.01	-.07**	.01	-.01	.06**	.01	-.04	-.03
31. Vision and policy on ICT	61.47 (17.04)	.91	.01	-.02	-.01	.04	.00	-.01	.00	.00	-.06**	.03	-.05*	.05*	-.04	-.03	-.03
32. ICT infrastructure	0.23 (0.09)		.04	.06**	.01	.00	.04	.07**	.03	.01	-.07**	-.07**	-.01	-.04*	.01	.00	-.02
33. ICT self-efficacy	80.30 (13.50)	.93	-.10**	-.03	.15**	.43**	.02	-.02	.10**	.10**	.13**	.15**	.14**	.04	-.12**	-.05*	-.01

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Pupil level characteristics																		
16. identified regulation	1.00																	
17. Intrinsic regulation	.67**	1.00																
Class level characteristics																		
18. ICT experience	-.02	-.01	1.00															
19. Logistic appropriateness	-.02	-.00	.06**	1.00														
20. ICT use basic skills	.01	.05*	.20**	.16**	1.00													
21. ICT use information tool	.01	.05*	.20**	.36**	.46**	1.00												
22. ICT use learning tool	.05*	.07**	.27**	.27**	.34**	.40**	1.00											
23. ICT competences	-.01	.02	.17**	.38**	.27**	.37**	.33**	1.00										
24. ICT attitudes	.05*	.05*	-.08**	.16**	.20**	.25**	.19**	.09**	1.00									
25. ICT professional development	.04*	.06**	.17**	.33**	.31**	.41**	.24**	.54**	.18**	1.00								
School level characteristics																		
26. ICT support	-.02	-.01	.14**	.47**	.11**	.21**	.14**	.31**	.00	.35**	1.00							
27. ICT coordinator: planner	-.04	-.05*	.23**	.30**	.22**	.28**	.07**	.26**	-.02	.24**	.38**	1.00						
28. ICT coordinator: technician	.01	.03	-.06**	-.13**	.02	-.10**	-.04	-.02	-.09**	.03	-.16**	-.00	1.00					
29. ICT coordinator: budgeter	.01	-.01	.07**	.15**	-.02	.12**	-.05*	.02	-.15**	.16**	.08**	.46**	.37**	1.00				
30. ICT coordinator: educationalist	-.03	-.04	.24**	.15**	.11**	.15**	.00	.20**	-.04	.17**	.30**	.61**	-.13**	.38**	1.00			
31. Vision and policy on ICT	-.01	.00	.08**	.10**	.06**	.12**	-.14**	.21**	-.00	.222**	.22**	.46**	-.08**	.33**	.49**	1.00		
32. ICT infrastructure	-.03	-.05*	-.04	.15**	-.04	-.02	.02	.08**	-.01	.09**	.05*	.10**	.07**	.17**	.06*	.13**	1.00	
33. ICT self-efficacy	.16**	.12**	-.01	.02	.05*	.04	-.01	-.00	.03	.01	-.03	-.02	-.02	-.00	.01	-.01	-.01	1.00

Table 2. Descriptives and correlates *p<.05 ** p<.01

differences at the pupil level, whereas only 4.94% of the variance is due to differences between classes. The intercept of 80.27 should be interpreted as the overall mean of the score on the ICT self-efficacy scale of all pupils in all of the classes.

5.2.2. Model 4b (final model)

In the next step, the ICT related pupil characteristics (Model 1), ICT related home situation characteristics (Model 2), cognitive and motivational characteristics (Models 3 and 4), and socioeconomic and cultural pupil characteristics (Model 5) were added to the consecutive models. Only Model 4b is presented, which is a parsimonious model, in which all of the non-significant pupil level characteristics were removed. In this model, the intercept of 80.09 represents the overall mean of ICT self-efficacy across pupils with an average score on computer experience, ICT attitude, controlling learning strategy, analytic intelligence, amotivation and of which their parents also had an average score on the ICT attitude scale.

Taking a closer look at the *ICT related pupil characteristics*, the estimates reveal that both pupils' ICT experience ($\chi^2 = 20.92$, d$f = 1$, $p < .001$) and their ICT attitude ($\chi^2 = 381.69$, d$f = 1$, $p < .001$) significantly contribute to the model. The positive slopes indicate that for every increase with one unit, the score on the ICT self-efficacy scale increases by 0.21 and 0.28 respectively. In other words, pupils who spend more hours a week on a computer and who perceive computers as useful and interesting, consider themselves better in digital communication and information processing than those who spend less time on a computer and have less positive attitudes toward ICT.

Taking the *ICT related home situation characteristics* into account, pupils' ICT self-efficacy does not seem to be related to ICT availability at home or the support that parents provide to their children in terms of working together with them at a computer or imposing rules upon their computer use. However, parental ICT attitude made a significant contribution to the model. Pupils for whom the parents believe that learning to use ICT is useful for their child, have a slightly – but significantly – higher mean level of ICT self-efficacy (mean = 80.09 + 0.04 = 80.13, $\chi^2 = 4.46$, d$f = 1$, $p < .05$).

The effects of *cognitive and motivational pupil characteristics* on primary school pupils' ICT self-efficacy were also considered. With regard to learning styles, the mean level of ICT self-efficacy of pupils who use repeating strategies (memorization) and pupils who connect content to other learning areas, does not significantly differ from the intercept of 80.09. However, the learning style 'control' makes a significant contribution to the model. Pupils who report that they study more by monitoring and regulating their learning process have a higher mean level of ICT self-efficacy ($80.09 + 0.08 = 80.17$, $\chi^2 = 28.10$, $df = 1$, $p < .001$). Furthermore, analytic intelligence leads to a significantly higher mean level of ICT self-efficacy $\chi^2 = 3.94$, $df = 1$, $p < .05$. The positive slope indicates that for every increase with one unit on the Raven Progressive Matrices Test, the score on the ICT self-efficacy scale increases by .10. In other words, pupils with a higher nonverbal ability to deal with novelty and solve problems, judge themselves as more competent in digital information processing and communication. With regard to the different types of *learning motivation*, only amotivation made a significant contribution to the model. The negative regression coefficient indicates that the more pupils are amotivated for learning and studying, the lower they rate their own level of ICT competence ($80.09–0.06 = 80.03$, $\chi^2 = 14.55$, $df = 1$, $p < .001$). Of the three *socioeconomic and cultural pupil characteristics* neither sex, age nor SES made significant contributions to the model. As such, all socioeconomic and cultural pupil characteristics were removed for further analysis.

The parsimonious Model 4b (in which all non-significant pupil level factors were no longer retained) has a better fit than the two level null model, as the difference in deviance between the two models is highly significant ($\chi^2 = 4530.07$, $df = 6$, $p < .001$). More detailed information on model comparison and model fit measures for all the consecutive models can be found in Appendix B.

In the next step, the classroom level factors (Models 6 and 7) and the school level factors (Model 8) were added to the model. However, none of these factors made a significant contribution to the model (see Appendix B). As such, all classroom and school level characteristics were removed from the model and Model 4b was considered as the final model with regard to factors related to differences in primary school pupils' ICT self-efficacy. In the end, the final Model 4b explains 24.39% of the variance at the pupil level and 27.08% of the variance at the teacher level. This was not entirely expected, as Model 4b only contains pupil level characteristics. Taking a closer look at the standardized regression coefficients (β) makes it possible to compare the relative strength of the coefficients. In Model 4b, the pupils' attitude toward ICT seems to have the strongest association with ICT self-efficacy ($\beta = .412$), whereas the association with analytic intelligence seems to be significant, but small ($\beta = .042$). Similarly, parents' ICT attitude is significantly related to their children's ICT self-efficacy, but only in a limited way ($\beta = .052$). The degree to which pupils spend time on a computer at home ($\beta = .098$), are less motivated to learn ($\beta = -.083$) and the degree to which they use a controlling learning style ($\beta = .115$) seems to have a discrete association with their ICT self-efficacy.

	Null model	Model 4b	*β*
Fixed			
Intercept (cons)	80.27 (0.38)***	80.09 (0.35)***	
Pupil level characteristics			
ICT experience		0.21 (0.05)***	*.098*
ICT attitude pupil		0.28 (0.01)***	*.412*
ICT support active			
ICT support rules			
ICT attitude parents		0.04 (0.02)*	*.052*
ICT availability			
Memorization			
Control		0.08 (0.02)***	*.115*
Elaboration			
Analytic intelligence		0.10 (0.05)*	*.042*
Amotivation		-0.06 (0.02)***	*-.083*
Extrinsic regulation			
Introjected regulation			
Identified regulation			
Intrinsic regulation			
Sex			
Age			
SES education mother: primary			
lower secondary			
higher secondary			
higher education			
Class level characteristics			
Computer experience			
Logistic appropriateness			
ICT use basic skills			
ICT use information tool			
ICT use learning tool			
ICT competences			
ICT attitudes			
ICT professional development			
School level characteristics			
ICT coordinator: planner			
ICT coordinator: technician			
ICT coordinator: budgeter			
ICT coordinator: educationalist			
Vision and policy on ICT			
ICT infrastructure			
Random			
Class level σ^2_{u0} (between)	8.99(2.40)*** 4.94%	6.26 (2.04)**	
Pupil level σ^2_{e0} (within)	172.98(5.31)*** 95.06%	131.33 (4.61)***	
Model Fit			
(Deviance (2-log)	18119.43	13589.36	
X^2		4530.07	
D*f*		6	
P		<.001	
Reference		Null model	

Table 3. Model estimates for the two-level analyses of pupils' ICT self-efficacy

6. Discussion and conclusion

Until now, research into factors related to students' ICT self-efficacy has almost exclusively focused on samples in post-primary education and, methodologically, from a single level perspective. The aim of this study was to evaluate the degree to which certain pupil, classroom and school level factors are related to primary school pupils' ICT self-efficacy. For this purpose, factors were drawn from the EDC model, which categorizes these factors into ICT-related pupil characteristics, such as sociocultural and economic characteristics, ICT oriented home situation, cognitive and motivational characteristics (pupil level); ICT-related classroom factors (classroom level); and ICT-related school level factors (school level). In order to allow the nested structure of pupils within classrooms, multilevel analysis was used. For the data to be representative of the factors at each specific level, different stakeholders took part in this study i.e. pupils, their parents, their teacher, and the ICT coordinator of the school.

The descriptive statistics indicate that primary school pupils generally consider themselves to have a high ability in retrieving and processing digital information, and a high ability in communication through computers and the internet. However, the ICT self-efficacy scale used in this study contains items measuring higher-order learning-processing skills as well as basic ICT skills with regard to digital information processing and communication. This combination of items possibly reduces the difficulty of the scale. Nevertheless, our findings are in line with the work of Kim and Glassman (2013). During the development of the Internet Self-efficacy Scale (ISS), these authors found that undergraduate students score highly on the subscales internet communication self-efficacy and internet search self-efficacy. Similarly, the results of Torkzadeh and van Dyke (2002) indicate that university students have relatively high levels of internet self-efficacy and feel comfortable browsing the internet. To our knowledge, almost no research has examined ICT self-efficacy in primary education. As such, this study builds upon previous studies by confirming that primary school pupils also consider themselves competent in digital information processing and communication. Consequently, this study adds to the research on ICT self-efficacy by mapping young pupils' judgment of their own ICT competences. However, this study is based on a one-time measurement and self-efficacy measures often have the problem of self-reported bias. Moreover, the accuracy of self-perceived measures increases with age (Bouffard, Markovits, Vezeau, Boisvert, & Dumas, 1998). As such, future research should explore the stability of the construct of ICT self-efficacy for young pupils of primary education by comparing measurement outcomes at different times.

The results of the multilevel analysis indicate that primary school pupils' ICT self-efficacy should be considered as a pupil-level phenomenon. The unconditional random intercepts model show that approximately 95% of the variance in primary school pupils' ICT self-efficacy can be attributed to differences between pupils, whereas only 5% is due to differences between classes. Although the between-class variance is small, the results of this study support the use of multilevel analysis when studying ICT self-efficacy in order to obtain accurate coefficients. Furthermore, our final model provides empirical evidence for the factors of the EDC-model that are significantly related to differences in pupils' ICT self-efficacy. More specifically, the model shows that the variables ICT experience (pupil), ICT attitude (pupil), ICT attitude (parents), controlling learning style, analytic intelligence and amotivation are associated with primary school pupils' ICT self-efficacy. It is a remarkable finding that all of these factors are located at the pupil level of the EDC-model and that no classroom and school level factors seem to be related to the differences in pupils' ICT self-efficacy. These results indicate that, in times in which educational policies are focusing on ICT integration and developing ICT frameworks and ICT curricula, pupils' perceptions and judgment of their ICT competences are still developing outside of the school setting, rather than inside the classroom. In this regard, this study confirms Zhong's (2011) statement that the family – which is an out of school setting in which children use ICT – works as a more powerful predictor of ICT self-efficacy than the school. For example, the present study shows that the teacher's ICT attitude and experience in the classroom does not contribute to ICT self-efficacy, whereas parents' ICT attitude and experience at home does. Although ICT experience at home (number of hours/week) and ICT experience at school (number of lessons/week) were operationalized in a different way, the results indicate that pupils use ICT far more intensively at home than in class. In this regard, Claro et al. (2012) state that the frequency of ICT use is much lower at school than at home. This low frequency of ICT use at school could imply that the ICT activities at school have a low impact on pupils' actual ICT competences, which in turn could lead to lower levels of ICT self-efficacy, as these are mediated through positive experiences. This low frequency of ICT experience at school also can be considered as a possible explanation for the non-significant effects of the classroom and school level variables. For example, it can be expected that the influence of specific types of ICT use, the teacher's ICT attitude or a school's vision on ICT on pupils ICT self-efficacy is limited if pupils are not given sufficient opportunities to experience these conditions. As such, future research could investigate how these classroom and school level factors have an effect in classrooms with many ICT opportunities and in those with almost none.

The effect sizes (standardized coefficients) indicate that especially pupils' ICT attitudes seem to be related to their ICT self-efficacy. However, the small effect sizes of the other significant variables (ICT experience, parental ICT attitude, controlling learning style, analytic intelligence and amotivation) should not imply that these factors are not important. In educational research small, replicable effects are noteworthy if they produce important outcomes, whereas large effects may not be relevant if they involve trivial outcomes (Thompson, 2002). As such, an effect size of even 0.1 can be a very significant improvement, considering the benefits they can lead to (Ellis, 2010 and Glass, McGaw, & Smith, 1981). With regard to pupils' ICT attitude, this study indicates that primary school pupils that are interested in using computers and find it useful to learn computer skills, consider themselves competent ICT users. These results corroborate the findings of Pamuk and Peker (2009). Investigating the relationship between university students' computer self-efficacy and the different dimensions of the Computer Attitude Scale, these authors found a negative relationship between computer anxiety and computer self-efficacy, and a positive relationship between computer self-efficacy and computer confidence, computer liking and computer usefulness. With regard to self-efficacy in general, emotional states such as attitude and anxiety are postulated as possible sources of self-efficacy (Pajares, 2008). As such, negative feelings toward ICT use and ICT activities can inhibit ICT task performance. Low performance in ICT tasks may be experienced as negative, which in turn may contribute to low self-efficacy. Similarly, positive ICT attitudes can lead to higher self-efficacy. Teachers could attempt to improve pupils' ICT self-efficacy by helping them to read, understand and interpret their ICT attitudes. They should help pupils to understand that negative feelings toward ICT activities are not always congruent with the pupil's actual performance. Such insight will likely lead to higher ICT self-efficacy, which may in turn stimulate the development of positive feelings toward ICT. Furthermore, teachers should provide their pupils with increasingly challenging ICT activities. The mastery of simple ICT-tasks will likely result in more positive ICT attitudes and higher ICT self-efficacy (Johnson, 2005). Only when pupils' confidence increases, they should be presented with more complex and difficult tasks.

However, helping pupils to reflect on their own ICT attitudes and offering them more challenging ICT activities requires much effort and know-how on the part of the teacher. Professional development offered by schools could be a possible way to help teachers to acquire the necessary knowledge and skills for both initiatives. Jones (2004) states that professional development should not only focus on improving teachers' ICT skills and attitudes, but also on pedagogical aspects. Teaching pupils to reflect on their own ICT attitudes and helping teachers to choose and develop ICT activities that are appropriate in terms of difficulty and ease can be considered as pedagogical aspects that ICT professional development should focus on. As pupils advance through primary education, the selection of ICT activities should be considered at both the teacher and school level. For example, integrating ICT activities that increase in difficulty should be part of the educational policy of a school. Indeed, schools often possess an ICT policy plan or an ICT teaching-learning trajectory. Vanderlinde et al. (2010) describe an ICT policy plan as a comprehensive document that acts as a blueprint for the sequence of events a school hopes to achieve for ICT integration. As such, ICT policy plans contain expectations, goals, content and actions with regard to the use of ICT in schools (van Braak, 2003). Vanderlinde et al. (2010) have operationalized the content aspect of the ICT policy plan as educational ICT activities linked to ICT attainment targets. In order to support teachers in helping pupils to develop ICT self-efficacy and ICT competences, a systematic classification of such ICT activities according to their level of difficulty could be integrated into such a policy plan.

Future research could investigate whether the results of this study could be replicated with an actual measure of ICT competence, based on the analysis of performance-based items or observed real-life actions. Although ICT self-efficacy is an important research topic, a final objective of ICT competence research remains the identification of factors that are related to pupils' actual ICT competences. It is well-known that measures of ICT self-efficacy cope with validity problems as pupils' own judgment of their ICT competences can be accurate or inaccurate (Litt, 2013; van Deursen, van Dijk, & Peters, 2012). As such, research that focuses on factors related to actual ICT competences could yield different results. It would be interesting to investigate whether pupils in general over or underestimate their actual ICT competences and if the variance in ICT self-efficacy matches the variance in their actual ICT competences. Further, this study identified ICT self-efficacy as a pupil rather than a class and school phenomenon. It would be interesting to investigate the degree to which the variance in pupils' actual ICT competences can be attributed to differences at the pupil, class and school level.

The present study has certain limitations. Variance was only measured at the pupil and classroom level. The low number of teachers per school in our sample, and thus the possibility of confounding the classroom and school level, made it impossible to investigate any additional variance at the school level. Future research should investigate a three-level model, or go further by elaborating the EDC-model through an investigation of the international educational context in which the model is embedded. However, it also should be mentioned that the small amount of variance found at the classroom level is a possible indication that little or no variation will be found at higher levels. A second limitation of this study is the exclusion of the pupil level factor 'ICT use at home' in the analysis. Other research indicates that pupils use ICT at home for different purposes than those at school. ICT use at school (e.g. searching for information, word processing and using educational software) is not or less related to pupils' ICT skills than their more intensive and exploratory ICT use at home (e.g. surfing the web, chatting, watching DVD's, …) (van Braak & Kavadias, 2005; Zhong, 2011). Future research should investigate the effect of pupils' ICT use at home when the other factors of the EDC-model are taken into account. The third limitation of this study concerns the fact that the data (with regard to ICT self-efficacy) were based on a one-time measurement. Future research should investigate the stability of ICT self-efficacy over time, especially with young children. Further, future research should investigate whether the relations with small effects sizes are replicable in other samples. Such results could confirm whether these relationships are important or should be ignored. Finally, future research should meaningfully elaborate on the relationships that were found in this study. More specifically, qualitative research is needed to unravel the associations that exist between the factors of the EDC-model and pupils' ICT self-efficacy. For example, in-depth interviews can be used to explore possible interactions between pupils' ICT attitudes and their ICT self-efficacy. Such research is not only needed to understand how certain factors promote or hamper ICT self-efficacy, but also to make substantiated adaptations to these factors. In spite of these limitations, this study adds to the research on ICT competences and ICT self-efficacy, as it explores factors related to primary school pupils' ICT self-efficacy from a multilevel perspective.

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Appendix A

ICT self-efficacy

Item 1	How good can you search for information on the internet?
Item 2	How good can you configure a search engine to search for images?
Item 3	How good can you improve a false search query in order to find the right information?
Item 4	How good can you judge if the information on a website is true or false?
Item 5	How good can you use the information of different websites to make a new product with the computer?
Item 6	How good can you send a polite e-mail?
Item 7	How good can you use e-mail to ask a clear question that is completely understandable for the receiver?
Item 8	How good can you use e-mail to inform a friend about something you have found on the internet?
Item 9	You are sitting at a computer, together with a pupil who has difficulties with reading. How good can you add matching images to a text, in order for the pupil to be able to follow the text?
Item 10	Here you see an image of a website's menu. How good can u use the menu of a website to find something on that website?*
Item 11	Here you see an image of a digital form. How good can you fill in such a digital form?*
Item 12	How good can you save a text on a computer?
Item 13	How good can you find a saved text on a computer?
Item 14	How good can you play a movie on a computer?
Item 15	How good can you open an attachment of an e-mail?
Item 16	How good can you use an USB-stick?
Item 17	How good can you use a cd-rom?
Item 18	How good can you change the background of your desktop?

* items supported by an image in order to make the content more concrete and understandable for pupils.

Appendix B

	Null model	Model 1	Model 2	Model 2b	Model 3
	B (S.E.)	*B (S.E.)*	*B (S.E.)*	*B (S.E.)*	*B (S.E.)*
Fixed					
Intercept (cons)	80.27 (0.38)***	80.26 (0.35)***	80.34 (0.37)***	80.16 (0.35)***	80.05 (0.36)***
Pupil level characteristics					
Computer experience		0.18 (0.05)***	0.17 (0.05)***	0.16 (0.05)***	0.18 (0.05)***
ICT attitude pupil		0.28 (0.01)***	0.29 (0.02)***	0.28 (0.01)***	0.27 (0.02)***
ICT support active			-0.02 (0.02)		
ICT support rules			0.01 (0.02)		
ICT attitude parents			0.05 (0.02)**	0.05 (0.02)**	0.04 (0.02)*
ICT availability			0.14 (0.33)		
Memorization					0.03 (0.01)
Control					0.08 (0.02)***
Elaboration					0.02 (0.01)
Analytic intelligence					0.12 (0.05)*
Amotivation					
Extrinsic regulation					
Introjected regulation					
Identified regulation					
Intrinsic regulation					
Sex					
Age					
SES education mother: primary					
lower secondary					
higher secondary					
higher education					
Class level characteristics					
Computer experience					
Logistic appropriateness					
ICT use basic skills					
ICT use information tool					
ICT use learning tool					
ICT competences					
ICT attitudes					
ICT professional development					
School level characteristics					
ICT coordinator: planner					
ICT coordinator: technician					
ICT coordinator: budgeter					
ICT coordinator: educationalist					
Vision and policy on ICT					
ICT infrastructure					
Random					
Class level σ^2_{u0} (between)	8.99(2.40)*** 4.94%	6.15 (1.98)**	6.55 (2.19)**	6.41 (2.04)**	6.63 (2.12)**
Pupil level σ^2_{e0} (within)	172.98(5.31)*** 95.06%	137.25 (4.62)***	134.90 (4.89)***	136.74 (4.68)***	132.30 (4.69)***
Model Fit					
(Deviance (2-log)	18119.43	14761.68	12860.17	14344.54	13364
X^2		3357.75		417.14	
D*f*		2		1	
P		<.001		<.001	
Reference		Null model		Model 1	

	Model 3b	Model 4	Model 4b		Model 5
	B (S.E.)	*B (S.E.)*	*B (S.E.)*	*β*	*B (S.E.)*
Fixed					
Intercept (cons)	80.07 (0.35)***	80.02 (.35)***	80.09 (0.35)***		77.71(2.25)***
Pupil level characteristics					
Computer experience	0.20 (0.05)***	0.21 (0.05)***	0.21 (0.05)***	*0.098*	0.23 (0.05)***
ICT attitude pupil	0.28 (0.01)***	0.28 (0.02)***	0.28 (0.01)***	*0.412*	0.29 (0.02)***
ICT support active					
ICT support rules					
ICT attitude parents	0.04 (0.02)*	0.04 (0.02)*	0.04 (0.02)*	*0.052*	0.03 (0.02)
ICT availability					
Memorization					
Control	0.10 (0.02)***	0.07 (0.02)***	0.08 (0.02)***	*0,115*	0.09 (0.02)***
Elaboration					
Analytic intelligence	0.11 (0.05)*	0.10 (0.05)*	0.10 (0.05)*	*0,042*	0.11 (0.06)
Amotivation		-0.05 (0.02)*	-0.06 (0.02)***	*-0.083*	-0.05 (0.02)**
Extrinsic regulation		-0.00 (0.01)			
Introjected regulation		-0.02 (0.02)			
Identified regulation		0.01 (0.03)			
Intrinsic regulation		0.01 (0.02)			
Sex					0.50 (0.63)
Age					-0.97 (0.67)
SES education mother: primary					2.02 (2.61)
lower secondary					1.67 (2.37)
higher secondary					2.31 (2.27)
higher education					2.22 (2.28)
Class level characteristics					
Computer experience					
Logistic appropriateness					
ICT use basic skills					
ICT use information tool					
ICT use learning tool					
ICT competences					
ICT attitudes					
ICT professional development					
School level characteristics					
ICT coordinator: planner					
ICT coordinator: technician					
ICT coordinator: budgeter					
ICT coordinator: educationalist					
Vision and policy on ICT					
ICT infrastructure					
Random					
Class level σ^2_{u0} (between)	6.28 (2.03)**	5.67 (2.01)**	6.26 (2.04)**		6.10 (2.20)**
Pupil level σ^2_{e0} (within)	132.76 (4.61)***	129.81 (4.68)***	131.33 (4.61)***		129.72 (4.92)***
Model Fit					
(Deviance (2-log)					
X^2	13871.72	12915.17	13589.36		11749.78
D*f*	472.82		282.36		
P	2		1		
Reference	<.001		<.001		
	Model 2b		Model 3b		

	Model 6	Model 7	Model 8
	B (S.E.)	*B (S.E.)*	*B (S.E.)*
Fixed			
Intercept (cons)	80.12 (0.36)***	80.13 (0.36)***	79.95(0.37)***
Pupil level characteristics			
Computer experience	0.22 (0.05)***	0.22 (0.05)***	0.21 (0.05)***
ICT attitude pupil	0.28 (0.02)***	0.28 (0.02)***	0.28 (0.02)***
ICT support active			
ICT support rules			
ICT attitude parents	0.04 (0.02)*	0.04 (0.02)*	0.04 (0.02)*
ICT availability			
Memorization			
Control	0.09 (0.02)***	0.09 (0.02)***	0.09 (0.02)***
Elaboration			
Analytic intelligence	0.10 (0.05)	0.11 (0.05)*	0.10 (0.05)
Amotivation	-0.06 (0.02)***	-0.06 (0.02)***	-0.06 (0.02)***
Extrinsic regulation			
Introjected regulation			
Identified regulation			
Intrinsic regulation			
Sex			
Age			
SES education mother: primary			
lower secondary			
higher secondary			
higher education			
Class level characteristics			
Computer experience	0.03 (0.09)		
Logistic appropriateness	0.01 (0.02)		
ICT use basic skills	0.01 (0.02)		
ICT use information tool	0.00 (0.03)		
ICT use learning tool	-0.02 (0.02)		
ICT competences		-0.02 (0.03)	
ICT attitudes		0.01 (0.03)	
ICT professional development		0.00 (0.02)	
School level characteristics			
ICT coordinator: planner			-0.03 (0.03)
ICT coordinator: technician			-0.01 (0.02)
ICT coordinator: budgeter			0.01 (0.02)
ICT coordinator: educationalist			0.03 (0.03)
Vision and policy on ICT			-0.03 (0.02)
ICT infrastructure			-0.03 (4.38)
Random			
Class level σ^2_{u0} (between)	6.39 (2.10)**	6.34 (2.09)**	6.26 (2.11)**
Pupil level σ^2_{e0} (within)	131.06 (4.70)***	131.12 (4.71)***	131.12 (4.76)***
Model Fit			
(Deviance (2-log)	12997.912	12998.23	12609.95
X^2			
D*f*			
P			
Reference			

8

General conclusion and discussion

"Whatever exists at all, exists in some amount".

- EDWARD L. THORNDIKE (1916) -

Chapter 8

General conclusion and discussion

Abstract

The research presented in this dissertation focuses on the assessment of ICT competences and on factors related to differences in ICT competences. More specifically, the impact of pupil, classroom and school level characteristics on primary school pupils' ICT competences was studied in the context of direct, performance-based assessment and indirect, self-reported assessment. In this final chapter, an integrated overview and discussion of the results of the studies reported in the previous chapters is presented. This chapter starts with a brief refreshment of the research objectives of this dissertation. Next, the main results of the different studies are presented along the three research objectives. In addition, a general discussion of these findings is presented. This chapter ends with limitations of the different studies, directions for future research, and theoretical, policy and practical implications.

1. Research objectives

The main aim of this dissertation was to gain more insight into primary school pupils' ICT competences and more specifically, into the pupil, classroom and school level factors that are related to differences in pupils' ICT competences. To deal with this main research aim and tackle the different research challenges presented in Chapter 1, three general research objectives were addressed:

Research objective 1 (RO1): To develop a conceptual model that can be used to identify pupil level, classroom level and school level conditions that are related to primary school pupils' ICT competences.

Research objective 2 (RO2): To construct a standardized and performance-based assessment instrument that can be used to measure primary school pupils' ICT competences in a direct and valid way.

Research objective 3 (RO3): To identify important pupil, classroom and school level characteristics that are related to primary school pupils' ICT competences.

Throughout the different chapters in this dissertation, these three research objectives were addressed by means of literature reviews, a qualitative study and quantitative studies (see Table 1). Research objective 1 'the development of a conceptual model' was addressed in Chapter 2 and mainly in Chapter 3. In Chapter 2, a comparative document analysis of the content features of national ICT curricula was conducted. As such, this study presents the educational policy context in which pupils' ICT competences and the developed model are embedded. The actual development of the conceptual, multilayered model that integrates factors that are possibly related to pupils' ICT competences was based on the literature review presented in Chapter 3. Further, Chapter 3 also reports on the development and validation of survey instruments that can be used to measure the factors of the developed model. Both Chapter 2 and Chapter 3 provided the contextual-conceptual foundation of this dissertation (see Figure 1).

Research objective 2 'the construction of a standardized and performance-based assessment instrument was dealt with in Chapter 4 and 5. Chapter 4 presents the test framework that operationalizes the construct of ICT competences. Further, this chapter also outlines the design of the performance-based test that was used in the different studies to measure ICT competence in a direct way. Chapter 5 elaborates on Chapter 4, as it focuses on the validity of the developed test. Item response theory was used to develop a standardized, unidimensional ICT competence scale for primary school pupils. Together, Chapter 4 and Chapter 5 give shape to the developmental phase of this dissertation.

Research objective 3 'the identification of pupil, classroom and school level characteristics related to ICT competences' was tackled in Chapter 6 and Chapter 7. Chapter 6 focused on pupils' general level of actual ICT competence and on factors related to differences in actual ICT competences. As such, Chapter 6 is related to Chapter 4, in which pupils' actual ICT competences were treated at the item level. Chapter 7 explored the degree to which pupil, classroom and school level characteristics are related to pupils' ICT self-efficacy. Chapter 6 and 7 constitute the empirical phase.

In this concluding chapter, an overview of the main results of the different studies is presented along the three general research objectives. Further, the main results brought forward in this dissertation are discussed, and the limitations of this dissertation and some possible directions for future research are presented. This chapter ends with some suggestions for theory, policy and practice.

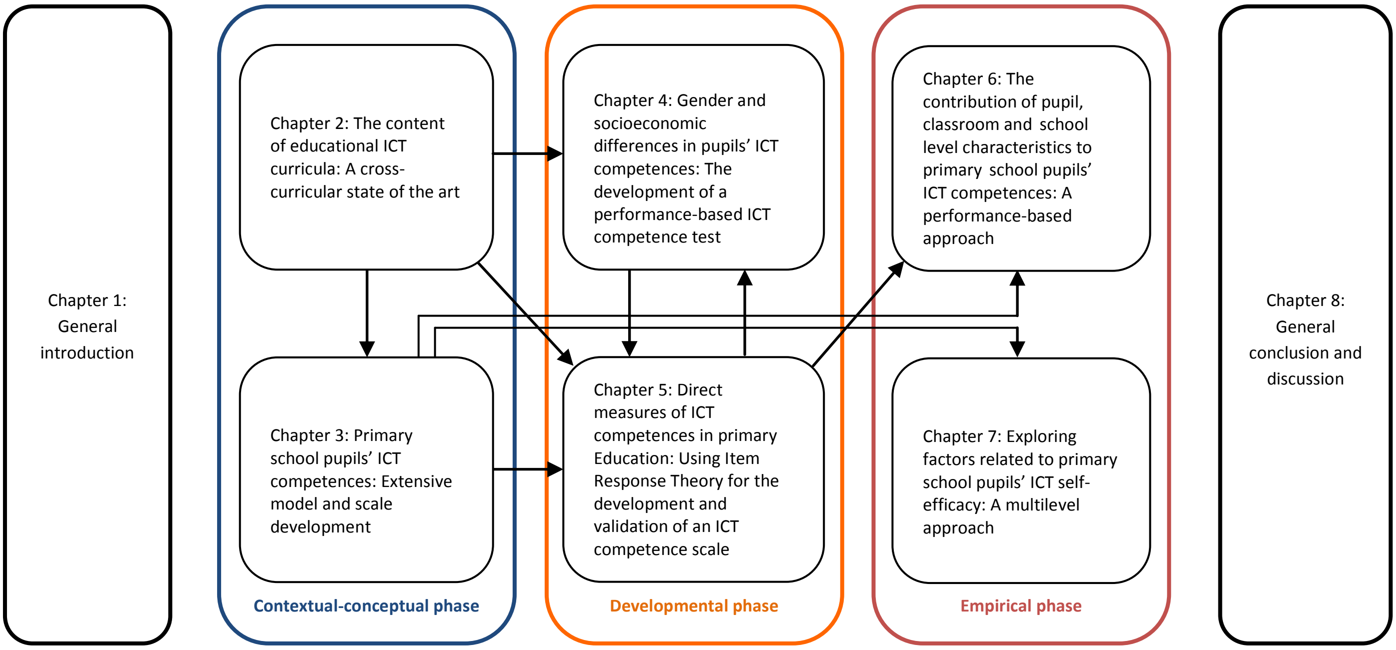

Figure 1. Overview of the dissertation chapters

2. Main results

2.1. Research objective 1: Model development

In the introductory chapter and in Chapter 3 we stated that most research on the identification of factors related to pupils' ICT competences is directed towards characteristics at the pupil level (e.g. age, sex, ICT attitude, ICT experience (Calvani, Fini, Ranieri, & Picci, 2012; Gui & Argentin, 2011; Kuhlemeier & Hemker, 2007; van Deursen & van Dijk, 2011), and less towards classroom and school level factors such as the ICT competences of the teacher or the ICT policy and vision of a school (e.g. Vanderlinde, Aesaert, & van Braak, 2014). For this purpose, a conceptual multilayered ICT competence model – the EDC-model - was developed which takes the educational context in which pupils behave (i.e. pupils into classrooms into schools) into account. The development process of the model as well as the empirical validation of some of its factors (e.g. an ICT self-efficacy scale for use in primary education) are mainly described in Chapter 3. The results of chapter 6 and 7 – which focus on the relationship between the independent factors of the model and primary school pupils' ICT competences – can be considered as the empirical validation of the EDC-model, and are discussed in section 2.3. of this chapter.

Research objective	Research goals	Methodology	Research Design and data collection	Analysis methods	Output
RO1	- To present the educational policy context in which ICT competences are embedded. - To present content features (visions and rationales, ICT competences, instruction related aspects) of ICT curricula.	QL	Document analysis	Cross-case analysis using the constant comparative method	Chapter 2 (study 1)
RO1	- To develop a multilayered, extensive conceptual model that integrates pupil, classroom and school level factors that are likely related to primary school pupils' ICT competences. - To develop and validate a range of quantitative research instruments that can be used to measure the factors integrated in the developed conceptual model.	L QN	Literature review Survey design - pupil survey (*n*=2413) - parent survey (*n*=2267) - teacher survey (*n*=134)	Literature review EFA, CFA, internal replication study (SPSS, AMOS)	Chapter 3 (study 2)
RO2	- To delineate the construct of ICT competence into a test framework - To outline the design of a performance-based test that can be used to measure primary school pupils' ICT competences in a direct and valid way - To identify differences in pupils' ICT competences and how these relate to gender and socioeconomic status.	L QN	Literature review Survey design - pupil performance-based test (*n*= 378)	Literature review Classic item analysis, chi-square tests, nonlinear EFA, ordinal reliability analysis, ANOVA (BILOG-MG, SPSS, NOHARM, R)	Chapter 4 (study 3)
RO2	- To examine the reliability and validity of a new performance-based ICT competence test. - To construct and validate an ICT competence scale that is based on direct or performance-based measurement.	QN	Survey design - pupil performance-based test (*n*= 560)	Item Response Theory (IRT) (BILOG-MG, NOHARM)	Chapter 5 (study 4)
RO3	- To explore primary school pupils' general level of actual ICT competence (cfr. Chapter 4). - To explore which pupil, classroom and school level characteristics are predictors of primary school pupils' actual ICT competences.	QN	Correlational design - pupil performance-based test (*n*= 378) - pupil survey (*n*=378) - parent survey (*n*=378) - teacher survey (*n*=83) - ICT coordinator survey (*n*=56)	Multilevel Analysis (BILOG-MG, MLwiN)	Chapter 6 (study 5)
RO3	- To explore which pupil, classroom and school level characteristics are related to primary school pupils' ICT self-efficacy.	QN	Correlational design - pupil survey (*n*=2421) - parent survey (*n*=2256) - teacher survey (*n*=141) - ICT coordinator survey (*n*=86)	Multilevel Analysis (MLwiN, R)	Chapter 7 (study 6)

Table 1. Research goals, methodology, research design, data collection, analysis methods and output for the different research objectives

RO= Research objective; L=Literature review; QL=Qualitative study; QN=Quantitative study

The developed EDC-model gathers factors that are likely related to primary school pupils' ability to use the computer and the Internet, and complete ICT related problems. Pupils' ICT competences make up the independent variable of the model and refer to hierarchical and integrated units of higher-order learning-process oriented competences and technical and application oriented ICT skills. As such, the model follows a reflective rather than a technical and application oriented approach to ICT competences (Voogt, 2008). This means that technical skills are considered as insufficient to deal with ICT related problems and ICT competences also contain general cognitive abilities (Markauskaite, 2007). In the EDC-model, ICT competence is perceived as a direct measure, as well as a self-perceived measure, i.e., ICT self-efficacy. Moreover, the content covered by the construct of ICT competence is not specifically predefined in the model. As such, the model has the ability to be adapted to suit various research needs. More specifically, the model (or parts of it) can be tested focusing on ICT competences such as accessing digital information (Litt, 2013), as well as on other ICT competences such as creative digital video producing (Ito et al., 2008), technology operations and concepts, collaboration and communication, etcetera (Huggins et al., 2014). The factors that are expected to affect primary school pupils' ICT competences were drawn from the research literature on ICT competences and ICT integration. All factors were presented within six categories of variables that are clustered into three levels, i.e., ICT related school characteristics (school level); ICT related classroom characteristics (classroom level); and socio-economic background characteristics, cognitive and motivational characteristics, ICT related pupil characteristics and ICT supportive home climate (pupil level). The three levels illustrate the multilayered nature of the model and of the characteristics related to pupils' ICT competences.

Furthermore, reliable measurement scales were developed and validated that can be used to measure the factors integrated in the EDC-model designed for primary education. More specifically, scales were developed for learning motivation, learning style, parental ICT support, parental ICT attitude, teachers' ICT attitude, pupils' ICT attitude and pupils' ICT self-efficacy. The learning motivation scales are based on the amotivation subscale of Vallerand et al. (1992) and the adapted academic self-regulation scale of Vandevelde, Van Keer and Rosseel (2013). The learning style scales are based on the reading by learning strategies of PISA 2009 (Schleicher, Zimmer, Evans, & Clements, 2009) and refer to the use of controlling strategies, memorization strategies and elaboration strategies for learning. The parental ICT support scales are based on the Internet parenting style scales of Valcke, Bonte, De Wever and Rots (2010) and refer to active parental ICT support and ICT rules that parents impose to their children. The parental and teacher ICT attitude scales were newly constructed and both refer to the belief that the use of computers has economic, educational and social benefits for children. The newly developed pupils' ICT attitude scale measures the degree to which pupils 1) consider themselves as confident and interested computer users; and 2) belief that the use of computers is beneficial for them. Finally, the ICT self-efficacy scale measures pupils' judgment of their own ability in digital communication and digital information processing. The replications of the exploratory and confirmatory factor analyses indicate that the developed scales have an adequate to good internal consistency and good fit estimates that are stable across different samples. In addition to the scales that are already available in the research literature, these new and adapted scales provide validated research instruments for each variable integrated in the EDC-model.

2.2. Research objective 2: Instrument development

The second objective of this dissertation was the development of an assessment instrument for large scale, valid and direct assessment of primary school pupils' actual ICT competences. The complexity of the integrated and hierarchical nature of an ICT competence makes it difficult to measure, and it appears that no instrument is available for primary education that appraises this complexity in a direct and authentic way. However, the development of such an assessment instrument is necessary for several reasons. First, it leads to a more generic understanding of pupils' mastery of specific ICT competences and technical ICT skills. As such, it also delivers information about the difficulty level of specific ICT competences. Second, it enables research into characteristics that contribute to or hamper pupils' ICT competences. Third, using test equation procedures, it enables longitudinal research into the development of ICT competences, as well as research that compares the results of different test administrations.

Chapter 4 outlines the design of a new computer and performance based test for measuring primary school pupils' ability in searching and processing digital information, and in using ICT to communicate in a safe, responsible and effective way. The hierarchical structure of an ICT competence, i.e., higher-order learning-oriented ICT competences underpinned by technical ICT skills, is integrated in the test framework that guided the development of the test. This means that the developed test addresses the reflective perspective on ICT literacy that considers multilayered ICT competences necessary for successful participation in life and society (Claro et al., 2012). The higher-order learning-oriented ICT competences are clustered into six categories that refer to gaining access to digital information, transforming digital information, creating digital information, communicating in a socially acceptable way, communicating in an understandable way and disseminating digital information by using a variety of media.

The higher-order learning-process oriented competences and the technical ICT skills of the test framework are represented by 56 simulation-based items in a walled (closed) computer-based test environment. The use of a walled environment allowed us to anticipate on the actions that the pupils can perform during the simulation-based tasks, and as such improve the standardization of the test. In order to complete the simulation-based tasks, pupils need to interact with six general software applications: a web browser, e-mail software, presentation software, a word processor, a file management system and spreadsheet software. All items were binary scored with 1 = correct, and 0 = incorrect. Whereas the technical ICT skills were scored automatically, the higher-order learning-process oriented ICT competences were manually rated by a panel of test raters.

Chapter 5 focuses on the psychometric exploration and validation of the developed test. More specifically, item response theory was used to explore the person (latent trait) and item characteristics (item difficulty and item discrimination) of a direct measure of ICT competence. To guarantee the quality of the developed instrument, the items were investigated for dimensionality, model-data fit, local item dependence, monotonicity and empirical reliability. This approach allowed us to develop a unidimensional ICT competence scale on which individual pupils can be positioned according to their ability in searching and processing digital information, and communicating using computers and the Internet. With regard to dimensionality, the results of the nonlinear factor analysis indicate that a single latent ability construct – which we labeled pupils' ICT competence – underlies the instrument. This was a rather unexpected result as our theoretical test framework made a distinction between searching and processing digital information, and digital communication as two separate ICT competences, apart from the underlying basic ICT skills. After filtering out the locally dependent items, the 27 remaining items proved to be a reliable instrument with an empirical reliability of the overall test of .89. Further, the standard errors of the ability levels and the test information function at specific ability levels indicate that the developed instrument is most reliable for low and medium ICT competence levels between -2.00 and 0.50. Further, the test allowed us to identify primary school pupils' level of ICT competence, ranging from -2.96 to 1.90 and covered item difficulties ranging from -3.04 to 2.96.

The results in Chapter 5 indicate that the technical ICT skills as well as the higher-order learning-oriented ICT competences are evenly distributed along the ICT competence scale. This result undermines the premise that technical ICT skills are automatically easier to master than higher-order learning-process oriented ICT competences. Using a classic test theory approach and considering mean scores, the results in Chapter 4 indicate that pupils on average score higher on technical ICT skills than on higher-order learning-process oriented ICT competences with regard to digital information searching, processing and communicating.

With regard to using a computer and the Internet for digital communication, it seems that primary school pupils have most difficulties to ask for or deliver content in an understandable and socially acceptable way. Moreover, they experience fewer problems in communicating when using a structured format (e.g. digital form) rather than a non-structured format (e.g. e-mail). With regard to searching digital information, students especially find it difficult to assess and judge the relevance of information that was found on a computer or the Internet. Most students are able to search for information using the menu of a website or a search index. In general, they do not experience problems when they configure a search engine to specify an intended search, nor do they find it difficult to use a search engine to find information. However, the effective use of a search engine seems to decrease as the number of words the search query requires increases. With regard to the technical skills, some skills (e.g. copy-paste) are well mastered by almost every student, whereas other skills (e.g. working with attachments in e-mails) are less developed.

2.3. Research objective 3: Factors related to ICT competences

In Chapter 6 and 7 we argued that few studies are available that attribute differences in pupils' ICT competences to factors at different levels such as a pupil, classroom and school level. Moreover, research should not only elaborate on commonly used pupil level characteristics such as SES, gender and ICT experience, but should also focus on the impact of alternative factors on ICT competences, such as pupils' basic cognitive skills or teachers' particular pedagogical practices (Claro et al., 2012). In order to examine which factors are related to primary school pupils' ICT competences, the EDC-model – presented in Chapter 3 – was empirically tested in Chapter 6 and Chapter 7.

2.3.1. Factors related to actual ICT competences

Chapter 6 investigated how the factors of the EDC-model influence primary school pupils' actual ICT competences. Data on the level of 378 pupils' actual competence in digital information searching, processing and communicating, were obtained with the performance-based ICT competence test presented in Chapter 4 and Chapter 5. Data on the pupil, classroom, and school level factors of the EDC-model were captured by administering survey questionnaires to the same pupil sample that took the performance-based test, their parents, their teacher and the ICT coordinator of the school. The results presented in Chapter 6 show that the majority of primary school pupils has a low to medium score on the performance-based test. Although these results can only be interpreted within the context of the item difficulties of the specific test, they indicate that only a minority of primary school pupils communicate and process digital information on a more advanced level. Further, the results do not support the anticipated multilevel structure of ICT competences. More specifically, 92% of the total variance is attributed to differences between pupils, whereas only 8% of the total variance of pupils' ICT competences is due to differences between classes. The fact that the between-class variance does not significantly differ from zero, indicates that pupils' ICT competences can be considered as a pupil phenomenon. Moreover, the variance of pupils' ICT competences is mainly explained by pupil level characteristics.

In this context, the results indicate that especially non-ICT related pupil level characteristics are related to primary school pupils' ICT competences. More specifically, the motivational and cognitive pupil characteristics analytic intelligence, controlling learning style and introjected regulation seem to explain 24% of the variance of pupils' ICT competences. With regard to analytic intelligence, it seems that the higher a pupil's nonverbal ability to deal with new problems and novelty, the higher their level of ICT competence. With respect to learning styles, the results indicate that the more pupils report to regulate, plan and monitor their learning process, the better they score on the performance-based ICT competence test. With regard to learning motivation, only introjected regulation was related to pupils' ICT competences. This means that pupils whose learning is driven by a need of proof and pride towards others, or feelings of shame and guilt, have less developed ICT competences. Besides these motivational and cognitive characteristics, the sociocultural and economic factors SES and sex are two important non-ICT related pupil level characteristics that explained an additional 6% of the total variance of pupils' ICT competences. With regard to sex, this study tackles the traditional assumption that ICT use is a male activity. More specifically, the results indicate that girls on average are better than boys in digital communication and searching and processing digital information. At the item level, this finding is supported by the results presented in Chapter 4. Girls seem to outperform their male counterparts on technical ICT skills, as well as on higher-order learning-process oriented ICT competences. They seem particularly better at communication oriented ICT competences such as delivering digital information that is understandable for the receiver, delivering information using a non-structured format, delivering digital information in a socially acceptable way, or reacting on a forum. Whereas sex related differences particularly – but not solely – apply to digital communication, the SES related differences apply to almost all aspects of digital information processing and digital communication as operationalized in the test framework. For example, the higher the educational level of a pupil's mother, the better the pupil is at integrating information into existing information products, using the title and textual information found in a conducted search, judging the reliability and relevance of digital information, delivering information using structured and non-structured formats, and at various technical ICT skills, such as adding attachments to e-mails and filling in online forms.

Further, ICT self-efficacy and parental ICT attitude are the only ICT related pupil characteristics that are significantly related to primary school pupils' ICT competences. Pupils' ICT self-efficacy explains about 3 % of the variance in ICT competences. The results indicate that pupils who consider themselves as more competent in digital communication and searching and processing digital information, actually score higher on the performance-based ICT competence test. With regard to the actions that parents take and the environment they create to regulate and support their children's ICT use, only parental ICT attitude explains 1 % additional variance of primary school pupils' ICT competences. Pupils have slightly better developed ICT competences if their parents believe that being able to work with a computer has educational, economic and social benefits for their children.

With regard to the classroom and school level factors of the EDC-model, only educational ICT use as an information tool is related to pupils' ICT competences. Although this factor only explains 2% of the variance, it indicates that pupils who are given more opportunities in the classroom to use ICT for searching and communicating information have better ICT competences concerning these topics. This result illustrates that the way in which ICT is used in the class does matter in the development of ICT competences, and as such, that specific approaches to ICT integration and ICT use in education are needed.

2.3.2. Factors related to ICT self-efficacy

Chapter 7 explored how the factors of the EDC-model are related to a measure of self-perceived ICT competences, i.e. primary school pupils' ICT self-efficacy. Data on 2421 pupils' ICT self-efficacy was captured using the ICT self-efficacy scale presented in Chapter 3. This measure of ICT self-efficacy refers to pupils' belief in their own ability to successfully perform specific digital tasks with regard to retrieving and processing appropriate digital information, and communicating in a safe, sensible and appropriate way. Data on the independent factors of the EDC-model were gathered by administering survey questionnaires to the same pupil sample, their parents, their teacher and the ICT coordinator of their school. The results in Chapter 7 show that primary school pupils judge themselves as highly competent in retrieving and processing digital information, as well as in communicating through computers and the Internet. In this context, it is necessary to stress that the ICT self-efficacy scale contained items that refer to higher-order learning-oriented ICT competences as well as items that refer to basic ICT skills. As the latter category of skills is expected to be easier, this combination of items could have reduced the overall difficulty of the ICT self-efficacy scale. Furthermore, the results indicate that 95 % of the variance in primary school pupils' ICT self-efficacy is due to differences at the pupil level, whereas 5% is attributed to differences between classes. Although both variances at the pupil and classroom level are significant, this illustrates that ICT self-efficacy is mainly a pupil level phenomenon. Moreover, the results indicate that no classroom and school level characteristics of the EDC-model significantly contribute to differences in primary school pupils' ICT self-efficacy. Pupils' ICT attitude seems to have the strongest impact on their ICT self-efficacy (β=.41). This means that pupils who find the use and mastery of computers and the Internet useful and interesting, judge themselves more competent in digital communicating and information processing than those who have less positive attitudes towards ICT use. Further, it seems that pupils who spend more hours a week on a computer and the Internet, consider themselves to have better ICT competences than those with less ICT experience, i.e., those pupils who spend less time on a computer (β=.10). With regard to the ICT related home situation characteristics, only parental ICT attitude makes a limited but positive contribution to primary school pupils' ICT self-efficacy (β=.05) .

Taking the cognitive and motivational characteristics of the EDC-model into account, it seems that analytic intelligence, controlling learning style and amotivation contribute to the variance in pupils' ICT self-efficacy. With regard to analytic intelligence, a small but significant effect seems to exist (β=.04). More specifically, pupils with a higher nonverbal ability to deal with and solve new problems, judge themselves as more competent ICT users. In the context of a controlling learning style, pupils that report that they study by monitoring and regulating their learning process, score higher on the ICT self-efficacy scale (β=.12). With regard to learning motivation, amotivation is negatively related to ICT self-efficacy (β=-.08). In other words, the less motivated pupils are to learn, the lower they judge their own competence to use ICT. Finally, none of the sociocultural and economic characteristics of the EDC-model seems to be related to pupils' ICT self-efficacy. The aforementioned pupil level characteristics that are significantly related to ICT self-efficacy, explain 24% of the pupil level variance and 27% of the classroom level variance.

3. General discussion

In this section, the most important results presented above are discussed around four general themes that reoccurred in this dissertation, i.e. assessment of ICT competences, ICT competences in Flanders, ICT competences: a pupil level phenomenon, and ICT competence: theoretical versus empirical construct.

3.1. Assessment of ICT competences

In Chapter 1, we stated that most studies on ICT competences are directed towards indirect measures of ICT competence, i.e. ICT self-efficacy and self-report measures of ICT competence (Litt, 2013; Meelissen, 2008; van Deursen & van Dijk, 2011). As these indirect measures can suffer from self-report bias, they can insufficiently map pupils' actual or true level of ICT competence. Direct measures based on observation offer a suitable alternative, allowing for more valid measurement (Hargittai, 2002). However, these measures pose practical challenges such as being expensive, time consuming and difficult to replicate, making them difficult to conduct on large samples (Litt, 2013).

In this dissertation, a standardized and performance-based measure of ICT competence was developed and validated that can be used to measure primary school pupils' ICT competences. The performance-based ICT competence test measured two ICT competences, i.e., 1) pupils can use ICT to search for, process and store digital information: and 2) pupils can use ICT to communicate in a safe, responsible and effective way. Both of these ICT competences were chosen because they are integrated in several national and international ICT frameworks as essential ICT competences to be mastered (Aesaert, Vanderlinde, Tondeur, & van Braak, 2013; Voogt & Pareja Roblin, 2012). The two ICT competences were drawn from the eight attainment targets of the Flemish ICT curriculum and the performance-based test was developed in accordance to the conceptualization of ICT competence in the Flemish ICT curriculum. This means that the developed performance-based test addresses two generally important ICT competences while taking the specific context of the Flemish ICT curriculum into account. We believe that the accordance with the Flemish ICT curriculum is an important characteristic of the developed test. In the context of Gee's (2010) situated socio-cultural approach to technology and literacy, ICT competences are not considered as universal but rather as social and cultural value-laden achievements. As the social and cultural experiences through which primary school pupils of the Flemish community develop their ICT competences are incorporated in the Flemish ICT curriculum, the developed test takes this social-cultural approach to ICT competences into account. As such, this test distinguishes itself from international assessment initiatives that use a cross-national and neutral conceptualization of ICT competences. The results presented in Chapter 5 showed that the performance-based test can be considered as a valid and reliable way to measure primary school pupils ICT competences, and more specifically to measure primary school pupils' mastery of the Flemish ICT curriculum. As such, the performance-based test presented in this dissertation should be considered as a first step in providing teachers with a standardized assessment instrument that can be used to capture primary school pupils' ability in using a computer and the Internet.

We believe that the developed test is a step forward to more valid and reliable measurement instruments that teachers can use to assess primary school pupils' ICT competences. First, teachers do not need to rely on pupils' own assessment in order to rate pupils' ICT competences. We think this is especially important in primary education as young pupils experience problems with accurately judging their own competences. In this context, Bouffard, Vezeau, Roy and Lengelé (2011) state that unrealistic optimistic self-perceptions of performance and ability are a normal developmental phenomenon among young children that systematically disappears during primary and secondary education. Using the performance-based test would disable the possible misalignment between young pupils' self-perceived and actual ICT competences, and offer teachers more valid accounts of primary school pupils' ICT competences.

Second, teachers should be able to rely less on their own assessments in order to rate pupils' ICT competences when using the test. If teachers assess pupils' ICT competences by themselves, they mostly rely on observation techniques to capture pupils' ability in using a computer and the Internet. However, observing and evaluating the performances of all pupils of a class on a computer is time-consuming. Moreover, the accuracy of observations is influenced by different factors such as subject performance expectancy, the used observing procedure, sex of the subjects, etcetera (Repp, Nieminen, Olinger, & Brusca, 1988). Elaborating on these factors, we hypothesize that teacher observations are related to teachers' ICT competences. More specifically, it can be assumed that teachers with less developed ICT competences and teachers who consider themselves less ICT competent, also consider themselves less competent in judging the ICT competences of their pupils. Therefore, it can be assumed that less ICT competent teachers will not frequently assess their pupils' ICT competences using observations. We argue that providing teachers with a standardized instrument that automatically scores pupils' ICT competences, will not only stimulate them to assess their pupils' ICT competences more frequently, but also increase their use of ICT in the classroom. In the long run, different equated test batteries could be developed so teachers can eventually use the standardized instrument as a learning tool.

However, in order for the performance-based test to be fully self-reliant and suitable for use in the classroom, adaptations to the test need to be made. More specifically, the automatic scoring procedure should be extended to all items of the test. At this moment, only the items representing technical and application ICT skills are scored automatically as they are directly logged as true or false. The items referring to the higher-order learning-process oriented competences have a content-related aspect that requires more intelligible and therefore human judgment. As such, the human rating of the higher-order ICT competences should be replaced by a system of automatic coding of free text formats. In this context, automatic coding systems based on the interaction between adaptive hypermedia and natural language processing seem promising (see also Zesch & Gurevych, 2009). Further, an automation of the IRT-based calculation of pupils' ability score on the test, would make it possible to offer teachers a visualization of pupils' position on the unidimensional ICT competence scale developed in Chapter 5.

Third, the performance-based test has been developed using IRT. Other performance-based tests that measure ICT competences (e.g. van Deursen & van Dijk, 2009) are often developed using CTT (classical test theory). Using the CTT approach, the ability level of a pupil is often calculated as the number of correct answers on the total test. However, if a test has been developed using IRT, the ability level can be estimated for a pupil completing any subset of ICT competences (Reid, Kolakowsky-Hayner, Lewis, & Armstrong, 2007). In the context of our performance-based ICT competence test, this means that teachers can administer a particular subset of the items in order to estimate the ICT competence level of a pupil. Further, we believe that the use of IRT offers possibilities of adapting the test in order to match the quick changes and evolutions in technology. The ICT competences that pupils should possess, depend heavily on the changing technology they use. In order to assess pupils' ICT competences, these technologies are integrated in the items of our test. As these technologies swiftly change, the usability of our performance-based test is probably limited for an extended time. However, the use of item response theory enables us to create new items equal in content and difficulty, which take these technology changes into account. Integrating new items into the test and replacing old items, test equation procedures (e.g. Kolen & Brennan, 2014) can then be used to make sure that different test forms match in difficulty. Finally, IRT can be used to create easier or more difficult items than the ones integrated in the present test. Adding these items, will provide teachers with a test that covers higher and/or lower levels of ICT competence.

3.2. ICT competence in Flanders

As mentioned in Chapter 1, the Flemish government administered an ICT curriculum to its primary schools in September 2007 (Vanderlinde & van Braak, 2011). In doing so, ICT competences were standardized as official educational outcomes or attainment targets (Vanderlinde et al., 2009). The development of the performance-based test described in this dissertation was the first initiative to measure the degree to which pupils master the Flemish ICT curriculum in a valid way.

On average, most of the primary school pupils have a low to median score on the developed performance-based test. Furthermore, the technical skills are on average better mastered than the higher-order learning-process oriented ICT competences. This result indicates that the attainment targets 'use educational technology to search for, process and store digital information' and ' use educational technology to communicate in a safe, responsible and effective way' of the official Flemish ICT curriculum are only mastered by primary school pupils in a limited way. Although the results provide a first impression about pupils' mastery of the ICT curriculum, they cannot be used to make pass-fail decisions or decisions for placement of pupils in certain educational tracks. As no benchmarks were created in alignment with the two measured attainment targets, teachers can only use the test results to gauge pupils' ICT competences, i.e. the performance-based test should be used for low-stake assessment rather than high-stake testing that focuses on the evaluation of pupils for making selection decisions.

This result is in line with a study of van Deursen and van Diepen (2013) reporting that the levels of information searching and processing Internet competences of secondary school students have much room for improvement. Investigating the Computer and Information Literacy (CIL) of secondary school students from an international perspective, the ICILS-study recently produced similar results. More specifically, the study indicates that on average 78% of 14 to 15 year old students have basic to lower mastery level in collecting, managing, producing and exchanging digital information (Fraillon, Ainley, Schulz, Friedman, & Gebhardt, 2014). Taking a closer look at specific ICT competences, the results in Chapter 4 show that Flemish primary school pupils especially have difficulties assessing and judging the relevance of digital information, with delivering or requesting content in a socially acceptable and understandable way, and with information searches that require more complex search queries. Similarly, the evaluation of the reliability, usefulness and relevance of digital information is situated at the higher levels of the CIL achievement scale of the ICILS-study (Fraillon et al., 2014; Meelissen, Punter, & Drent, 2014). Claro et al. (2012) found that writing e-mails that are adequate in content require a high level of ICT competence. With regard to the complexity of search queries, Kuiper, Volman and Terwel (2005) mentioned that students experience more problems using keywords to find digital Information than browsing the Internet. Van Deursen and van Diepen (2013) elaborate on these results as they state that pupils experience problems formulating search queries. These results indicate that the generation of digital natives is perhaps not as computer and Internet savvy as it is often assumed and that the mastery of some ICT competences, such as judging the reliability of information and searching information, should not be taken for granted. It is possible that the complexity of these ICT competences will even increase in the future and require even more from pupils, as the number of websites and the information available on the Internet is growing at lightning speed and everybody can act as an author. Further, we argued in Chapter 6 that pupils' ICT competences can be considered as a pupil level phenomenon as no significant variance was found at the teacher level. For the Flemish situation, the combination of these results indicate that primary school pupils develop their ICT competences especially in informal, out-of-school settings; that these informal settings on average are insufficient for developing high levels for all attainment targets of the Flemish ICT curriculum; and as such, that formal education in this matter is required. This also indicates that Flemish primary schools probably do not yet live up to the rationale of the Flemish ICT curriculum of providing all pupils with equal and sufficient opportunities for developing ICT competences.

Formal education should especially provide pupils with opportunities to acquire those competences of the ICT curriculum that are less developed. As pupils develop their ICT competences mainly in out-of-school settings, they enter the classroom with different and differently developed ICT competences. Consequently, there exists a need for effective identification of pupils' ICT competences and how these are related to the Flemish ICT curriculum. The identification of these competences is an essential condition for providing all pupils with possibilities to acquire the attainment targets of the Flemish ICT curriculum. However, the identification of pupils' ICT competences and how these are related to the Flemish ICT curriculum is a not an easily performed task for teachers. Within the context of the decentralized educational policy of Flanders, schools and teachers should autonomously translate the broadly formulated ICT attainment targets in specific ICT competences and ICT activities relevant to their own educational context (Vandenbroucke, 2007; Vanderlinde et al., 2009). The test framework developed in this dissertation can act as an example of how teachers and schools can translate the ICT attainment targets of the Flemish ICT curriculum into more specific ICT competences. It would be advisable to integrate the translated specific ICT competences in an ICT policy plan or formal ICT framework at the school level. As such, teachers have an operationalized blueprint of the Flemish ICT curriculum they can use to systematically identify pupils ICT competences.

3.3. ICT competences: a pupil level phenomenon

Pupils develop their ICT competences through a variety of experiences in school and out of school. The in-school experiences and activities are embedded within different educational levels (pupils in classrooms, classrooms in schools, and schools in larger national and international educational contexts) (Fraillon et al., 2014). In Chapter 6 we stated that studies that analyze ICT competences as educational outcomes should take this multilevel level structure into account. For this purpose, the EDC-model was developed as a conceptual framework that maps pupil level factors (i.e. ICT related pupil characteristics, ICT related home situation, sociocultural and economic factors, and cognitive and motivational factors), ICT related classroom level factors and ICT related school level factors that are possibly related to primary school pupils' ICT competences.

In Chapter 6, we empirically validated the EDC-model, i.e. the multilevel structure of primary school pupils' ICT competences was empirically explored and factors related to ICT competences were identified. The results in Chapter 6 indicate that almost all the variance in primary school pupils' ICT competences is situated at the pupil level, i.e., no shared levels of ICT competences exist for particular classes. These results are not in line with the recently published report of the international ICILS study that shows that the proportions of variance between schools vary from 11 to 53% among countries (Fraillon et al., 2014). We believe that theoretically, two possible explanations can be given for this pupil level phenomenon: 1) The fact that no significant variance exists at the classroom/school level could mean that all schools in Flanders organize their educational ICT use in such a way that pupils can develop their ICT competences independently of each other, regardless of whether they are from the same class/school or not. However, from a practical point of view, this explanation sounds unreasonable as there exist large differences between Flemish primary schools in the way they integrate ICT into their teaching and learning activities (Vanderlinde et al., 2009). 2) A second, more plausible explanation reflects a more negative view towards the degree to which Flemish primary schools pay attention to the development of the ICT competences of their pupils. As mentioned, primary schools integrate ICT into their teaching and learning in different ways. As such, it could be expected that there exist differences in ICT competences between schools. However, the results in Chapter 6 indicate that these differences are non-existent. A possible explanation is that the frequency and intensity in which ICT is used in the classroom is too low for these differences in ICT use and ICT integration to have a substantial impact on pupils' ICT competences. This low frequency of ICT use would not only explain why there is no variance at the classroom/school level, it also offers an explanation for the fact that – with exception of the use of ICT as an information tool – none of the classroom and school level characteristics were related to primary school pupils' ICT competences. Frequency of ICT use acts as an indicator for the opportunities that pupils are given in the classroom to acquire ICT competences. In this context, Creemers and Scheerens (1994) state that the time and opportunities that pupils are offered to learn – in this particular case the opportunities they have in the class to develop their ICT competences – can be considered as central mediating factors between classroom/school level factors and pupils' educational outcomes. As such, our results illustrate the need for a severe intensification of educational ICT use in order for teachers and schools to make a difference in the development of primary school pupils' ICT competences and more specifically into mastering the ICT competences of the Flemish ICT curriculum.

In search for antecedents of primary school pupils' ICT competences, the results of this dissertation indicate that especially non-ICT related pupil characteristics are related to ICT competences. With regard to sex, the results presented in Chapter 4 and Chapter 6 show that female primary school pupils on average outperform their male counterparts in digital information processing and communication. These results are in line with the findings of the international ICILS-study that secondary school girls score significantly higher on computer and information literacy than boys in 13 of 18 participating countries (Fraillon et al., 2014). Our study reinforces and elaborates on previous studies that have tackled the traditional assumption that using computers is a male activity (Hohlfeld, Ritzhaupt, & Barron, 2013), by confirming these gender differences in favor of females in primary education. Moreover, we did not find any significant sex difference with regard to ICT self-efficacy.

Educational effectiveness research has repeatedly acknowledged that SES is an important factor in explaining pupils' learning outcomes (Creemers & Kyriakides, 2008). In the particular case of ICT competences, our results show that the higher the educational level of the mother, the higher a pupil's ability to search, process and communicate digital information. Although other performance-based research on ICT competences has delivered similar findings (Claro et al., 2012; Fraillon et al., 2014), our study elaborates on these results in two ways. First, we confirmed this relationship for the specific case of primary school pupils. Second, and more importantly, we believe this is the first time that the relationship between pupils' ICT competences and socioeconomic status has been acknowledged while taking pupils' cognitive ability into account, i.e. socioeconomic status remained significantly related with primary school pupils' ICT competences when cognitive ability was taken into account (Chapter 6). As such, these results not only confirm but also reinforce the notion that SES is related to pupils' ICT competences. We believe this finding is problematic as socioeconomic status is a structural pupil characteristic that cannot easily be altered (Creemers & Kyriakides, 2008). Consequently, the current study emphasizes the need for identifying alterable pupil factors that characterize specific socioeconomic groups.

As mentioned in the introduction, most research into the antecedents of ICT competences has limited its investigation to traditional non-ICT related pupil characteristics such as sex and SES, and ICT related pupil characteristics such as ICT experience and ICT attitudes of pupils (Claro et al., 2012). However, the results in Chapter 6 show that analytic intelligence, controlling learning style and introjected regulation explain more variance in ICT competence than the commonly investigated ICT and non-ICT related pupil characteristics. As such, this dissertation offers a first illustration of the importance of more general cognitive and motivational pupil characteristics in developing pupils' ICT competences. With regard to analytic intelligence, our results show that pupils with a higher non-verbal ability to solve problems and adapt to new situations score higher on the ICT competence test. Although no research has particularly focused on the relationship between ICT competences and general cognitive ability, these results are in line with a study of Deary, Strand, Smith and Fernandes (2007) showing that pupils' scores on cognitive ability tests contribute 22.8% to the variance of their national examination score for information technology. Moreover, there is a broad agreement on the moderate to strong association between pupils' cognitive ability and their educational achievement/outcomes (Bartels, Rietveld, Van Baal, & Boomsma, 2002). In the context of cognitive ability and analytic intelligence, the results presented in this dissertation emphasize the need for integrating more general cognitive and motivational characteristics into studies that focus on differences in ICT competences. This will not only lead to the identification of a possible contribution of these factors, it will also enable researchers to identify more accurate and valid estimates of the contribution of the commonly used ICT and non-ICT related pupil characteristics.

Besides investigating these motivational and cognitive pupil characteristics this dissertation also elaborates on previous research into antecedents of ICT competences by focusing on classroom level and school level factors. However, our results indicate that the use of ICT as an information tool in the classroom was the only classroom/school level characteristic related to pupils' ability in digital information processing. Although this means that the specific ICT activities that teachers organize in their classroom pay off in terms of ICT competence development, the relationships of all other classroom and school level variables of the EDC-model were non-significant. As such, our research delivers limited proof about teachers' and schools' efforts in terms of ICT competence development. For example, research has repeatedly shown that the availability of a clear ICT policy plan that is shared among the teachers or the ICT competences of teachers are factors that strongly influence the degree to which teachers integrate ICT into their educational activities (Vanderlinde et al., 2014; Tondeur, Van Keer, van Braak, & Valcke, 2008). However, our results indicate that the factors that increase ICT integration are not related to pupils' ICT competences. For example, we could not confirm the assumption of Berge, Hatlevik, Kløvstad, Ottestad, and Skaug (2009) that teachers' ICT competences can help narrow the divide in ICT competences among students. These results are rather unexpected, as the development of pupils' ICT competences is one of the general aims of integrating ICT into formal education. Consequently, the results put forward in our study raise a question concerning the educational rationale behind the integration of ICT into the classroom, i.e., is ICT mainly being integrated to support the learning and teaching of traditional subjects such as math, language and science, or is ICT also being integrated to develop ICT competences? Perhaps, the educational rationale behind the integration of ICT is related to the way in which the ICT curriculum is integrated in the total curriculum. For example, in Flanders, the attainment targets are formulated as cross-curricular final objectives. This means that teachers themselves need to decide in which subjects they want to organize learning opportunities for their students to develop the cross-curricular ICT competences. Other educational systems have an ICT curriculum in which ICT is considered as a subject on its own, or in which ICT related attainment targets are formulated for each specific subject curriculum. It is possible, that this direct relationship between ICT and a specific subject makes it easier for schools and teachers to understand how to teach a specific ICT competence in (or as) a specific subject.

3.4. ICT competence: theoretical versus empirical construct

In the research literature, ICT competences are often described as complex and multilayered constructs of basic ICT skills, application ICT skills, and more complex generic and cognitive competences. In this context, the first two dimensions of basic ICT skills and application ICT skills are considered as subordinate layers or dimensions to the more complex, higher-order competences (Martin, 2006). Van Deursen and van Dijk (2011) have elaborated on this matter in the context of Internet skills. The authors divided Internet skills into two types of higher-order content related ICT competences (i.e. strategic Internet competences and information Internet competences) and two types of medium related ICT skills (i.e. operational or navigation Internet skills, and formal or orientation Internet skills). They stress the conditional nature of the medium related ICT skills, indicating that one needs to master the operational and formal Internet skills in order to even come to performing the higher-order strategic and information Internet competences. Similarly, Claro et al. (2012) state in theoretical conceptualization of ICT competences that the mastery of ICT applications (i.e. functional ICT skills) is a condition to solve cognitive tasks in a digital environment. Throughout this dissertation, ICT competences have been perceived as multidimensional and hierarchical constructs. They refer to higher-order, learning-process oriented competences that should be developed in complex and authentic situations, and are underpinned by technical and application ICT skills.

In the theoretical test framework of the developed test, the construct of ICT competence was divided into three dimensions: 1) higher-order information searching and processing competences, 2) higher-order communicating competences and 3) technical-application oriented ICT skills. However, the results of the nonlinear factor analysis reported in Chapter 5 indicate there is little coherence between the theoretical and empirical structure of ICT competences. Instead of confirming the three dimensional theoretical construct of ICT competence, the factor analysis indicated that a single latent trait or dimension – which we labeled ICT competence - underlies all the ICT skills and competences of the developed test. Similarly, Claro et al. (2012) found that the items corresponding to the information and communication dimension of their performance-based test produced only one factor instead of the anticipated two-factorial structure of communication and information processing. A possible explanation is that communication related ICT competences are closely related to the processing of information, and therefore can be considered as one dimension. In this regard, certain ICT competence frameworks have labeled communicating and exchanging information as the productive element of information processing whereas searching and judging information refers to receptive elements of information processing (Fraillon, Schulz, & Ainley, 2013).

These results illustrate that the theoretical assumptions upon which ICT competence frameworks and ICT curricula are based, are not confirmed by empirical results. The difference between the theoretical and empirical dimensionality of ICT competences can be considered as problematic, especially for the assessment of ICT competences. One can question the validity and reliability of assessing pupils' mastery of an ICT curriculum if the structure of the empirical data used to assess specific ICT competences, does not match the structure of the objectives or attainment targets of the ICT curriculum intended to be measured. As such, we believe that the development of ICT curricula and ICT attainment targets should not only be based on theoretical and academic logical arguments, but also on empirically validated data and data structures. In this context, a data-driven approach for curriculum evaluation is essential to develop a high-quality curriculum (Thijs & van den Akker, 2009). More specifically, exploratory and confirmatory analytic techniques can be used to investigate the dimensions that underlie pupils ICT competences. These results in turn could be used to adapt ICT curricula and create more delineated and mutually independent attainment targets that are based on the combination of a theory- and data-driven approach to curriculum development. Although some authors stress a more holistic approach to digital literacy (Martin, 2006), the delineation of ICT competences can be approached as conditional for developing an ICT curriculum that not only reflects the dimensionality of ICT competences but one that is also measurable.

4. Limitations and directions for future research

The studies reported in this dissertation have resulted in a model that can act as a blueprint in future research on ICT competences, in an instrument that can be used to measure primary school pupils' ICT competences, and in the identification of characteristics related to differences in ICT competences. At the same time, the results and limitations of these studies yielded some new research questions (and did not address others). As each chapter included the limitations of the study in question, the limitations presented in this section deal with the overall picture of this research project. Based on these limitations, we also present some directions for future research.

4.1. Limitations related to the sample

A first limitation with regard to the sample, is that all data to gather information on the classroom related characteristics were collected from sixth grade teachers. From a theoretical point of view this was valid as the attainment targets of the Flemish ICT curriculum are final objectives and therefore their mastery can only be assessed in the final (i.e. sixth) grade of primary education. However, from a methodological point of view, this heavily reduced the average teacher sample size available per school. Because such a small sample size could lead to confounding of levels and increases the risk of less accurate estimates and standard errors (Hox, 2002), we only conducted a two-level analysis in which pupils' ICT competences (Chapter 6) and pupils' ICT self-efficacy (Chapter 7) were allowed to vary at the pupil and classroom level. As such we did not analyze any additional variance at the school level. Although Fraillon et al. (2014) state that given the cross-curricular character of developing ICT competences in school, distinguishing between a classroom and school level is not useful, we believe that future research should use larger teacher samples and investigate a three-level model, or go further by elaborating the EDC-model through an investigation of the international educational context in which the model is embedded as a fourth level. Because of time, money and practical limitations, the incorporation and validation of a fourth level can only be realized through large-scale cross national indicator studies.

Second, a rather small sample was used in the multilevel analysis with regard to primary school pupils' actual ICT competences (Chapter 6, *n*=378) and in the IRT analysis for developing the unidimensional ICT competence scale (Chapter 5, *n*=560). Due to server problems during the administration of the performance-based test, our dataset was incomplete in many cases. As the test measures primary school pupils' mastery of final ICT objectives, the test could only be administered at the end of the school year. Within two weeks, a second test administration was conducted. The data from both test administrations resulted in the 560 pupil sample that was used for developing the ICT competence scale. The representativeness of both samples of test administration was checked at the school level (school size, educational network and province) and at the pupil level (SES, home language, score on the Raven test, and learning problems) (Van Nijlen et al., 2013). However, due to the limited time it was impossible to gather information on all factors of the EDC-model using the pupil, parent, teacher and ICT coordinator survey. As such, the multilevel analysis on pupils' actual ICT competences was conducted on a limited sample of 378 pupils. Although we believe that the use of imputation is useful and could have led to a larger sample, we did not use this approach as imputation masks the uncertainty that results from incompleteness (Verbeke & Molenberghs, 2009). As this small sample size could have led to less accurate estimates and standard errors (Maas & Hox, 2005), future research could use larger samples to elaborate on our results and investigate whether similar estimates can be found.

4.2. Limitations related to the variables

A first limitation in this category is related to the operationalization/selection of ICT competences. Throughout the entire research project we have put performance-based assessment forward as the most valid way to measure pupils' ICT competences. Integral to our choice for computer and performance-based assessment is also the limitation in the maximum number of ICT competences that could be assessed. The scope of ICT competence is broader than the two competences that were assessed in this dissertation, i.e. searching and processing digital information, and communicating using a computer and the Internet. We believe that an elaboration of the developed test with other ICT competences such as collaboration by means of ICT (Huggins et al., 2014), presenting information by means of ICT (Vandenbroucke, 2007) or digital media production (Ito et al., 2008) will deliver a more comprehensive, and construct and content valid picture of primary school pupils' ICT competences. In this context, Litt (2013) also suggests expanding the communication related ICT competences with the socio-emotional skills that pupils need nowadays to use social media. Moreover, an expansion of the scope of ICT competence would be an important step in investigating the dimensionality of ICT competence as a whole.

A second limitation related to the study variables concerns the particular antecedents focused upon when explaining pupils' ICT competences. In order to complete the test, pupils needed to perform some computer simulated activities that required them to search, process and communicate digital information. As the test focuses on information processing, almost all items were characterized by a verbal component that required pupils to read and write continuously to solve the items. In this context, research has already indicated that verbal components, such as language and reading comprehension are related to several academic outcomes (eg. Van Laere, Aesaert, & van Braak, 2014). In the specific case of ICT competences, Fraillon et al. (2014) state that computer and information literacy is heavily reliant on text-based reading skill. Further, the results of their study indicate that students' language background is related to their computer and information literacy. As we recognize that these verbal components can help explain differences in pupils' ICT competences, we plea for the integration of a digital reading test and pupils' home language as antecedents in future research.

The degree to which pupils use ICT for specific activities was not incorporated as an antecedent to explain differences in pupils' ICT competences (Chapter 6) or ICT self-efficacy. Although some research has linked ICT use directly to ICT competences (van Braak & Kavadias, 2005; Zhong, 2011), we would like to stress the mediating role ICT can play between different factors of the EDC-model and pupils' ICT competences. For example, the support that parents offer their children for developing ICT competences will only pay off if this support first results in a higher quality and quantity of specific types of ICT use. As such, we advocate future research to investigate interaction effects between pupils' specific types of ICT use and other factors of the EDC-model.

Further, we did not operationalize the context level integrated in the EDC model. Focusing on differences in ICT competences within an international scope would not only allow us to investigate the contribution of macro education systems on pupils' ICT competences, it would also enable us to explore whether the relationships found in this dissertation can be generalized outside the Flemish context. In this regard, Zhong (2011) found that the educational expenditure of a country is positively related to pupils' ICT competences, whereas the ICT penetration rate is not. Although, we acknowledge the importance of investigating differences in ICT competences from an international perspective, this was not feasible within the scope of the present study. As such, future research should try to operationalize and validate the national and international context level in which the EDC model is embedded.

4.3. Limitations related to the methodology

A first limitation related to the methodology is the cross sectional nature of the data in the different studies. As a consequence, it was not possible to study pupils' achievement gains in ICT competences. Nor was it possible to calculate the added value of schools and teachers to these achievement gains. In order to investigate the added value of the different factors of the EDC-model to the achievement gains of pupils' ICT competences, longitudinal studies need to be conducted in the future.

A second limitation relates to the validation of the ICT competence scale described in Chapter 5. Although the IRT analyses indicate that the developed ICT competence scale showed good internal validity and has a good empirical reliability, further exploration is needed to guarantee test fairness. As such a check-up for differential item functioning (DIF) analysis is required to explore measurement equivalence among subgroups of the test takers. Items display DIF if individuals from different groups (but with the same ability), have a different probability of answering the item correctly (Hambleton, Swaminathan, & Rogers, 1991). For example, future research could investigate whether female pupils have a higher probability of answering items correctly than their male counterparts, while controlling for ability level of ICT competence. The same can be done for pupils belonging to groups with a specific socioeconomic status. Furthermore, future research could integrate this DIF characteristic into generalized linear mixed models and investigate whether this leads to more accurate estimates of the relationships between the factors of the EDC-model and differences in pupils' ICT competences (eg. De Boeck et al., 2011).

Next, throughout this dissertation we heavily criticized the use of self-perceived measures to assess pupils' ICT competences due to validity and social desirability problems. However, in order to gather data on the different factors of the EDC model, many self-reported items were used. We believe that especially young children could experience problems with judging their own capacities and rating personal characteristics (see also Bouffard, Markovits, Vezeau, Boisvert, & Dumas, 1998). For example, the internal consistency of the learning styles was not very high with alphas between .57 and .70. A possible explanation for this is that primary-school pupils are not yet fully aware of their own learning style and cannot yet make a clear distinction between different learning styles. Consequently it is possible that young pupils experience problems expressing themselves in terms of how they learn. As such, we argue that more performance-based measures, e.g. observations, should be used to capture information on the different factors of the EDC model.

A fourth limitation in this category relates to the fact that no interaction effects were included in the multilevel analyses reported in Chapter 6 and Chapter 7. As such we did not investigate whether the effect of certain characteristics of the EDC model depend on the level of other characteristics of the model. For example, it is possible that boys benefit more or less from their previous ICT experience at home than girls in terms of ability in digital information processing and communicating. In the future, we intend to replicate the multilevel analyses, taking interaction effects into account.

A fifth limitation concerns the developed measure of ICT self-efficacy. To our knowledge, our study provides one of the first measures that can be used to measure primary school pupils' ICT self-efficacy, and more specifically pupils' judgment of their own competence in communicating, locating and processing digital information as well as their technical skills. Self-efficacy measures distinguish themselves from other expectancy beliefs as they are more task- and situation-specific and the fact that judgments are made in reference to some type of goal (Bandura, 1986; Pajares, 1997). Taking this view on ICT self-efficacy into account, the developed items reflect a functional rather than a technical perspective, i.e. they describe activities for which pupils must engage in using specific software (e.g. a search engine, a blog). In order to make the items understandable for primary school pupils, some of them were accompanied by a screenshot of the software that the pupils would need in order to solve the task described by the item. Although the content of the items of the ICT self-efficacy scale was based on the test framework of the performance-based test, we did not empirically cross-validate the items of the ICT self-efficacy and ICT competence scale. Future research cross-validating new measures of ICT self-efficacy is necessary to develop valid measures of self-perceived ICT competences that can act as proxies of actual ICT competences, and as such cope with the time-consuming and expensive nature of performance-based assessment (Litt, 2013). Furthermore, we only investigated the relationship between the strength or level of pupils' ICT self-efficacy and their level of actual ICT competence, and did not explore other ICT self-efficacy characteristics such as its calibration. In general, calibration of specific types of self-efficacy refers the degree to which one's judgment of performance matches actual performance (Bol, Hacker, O'Shea, & Allen, 2005). Two commonly used measures of self-efficacy calibration are bias and accuracy (Pajares & Graham, 1999; Pajares & Miller, 1997). Whereas bias indicates whether one is over- or underestimating his ability (direction of judgment error), accuracy refers to the extent to which the over- or underestimation is big or small (magnitude of judgment error). Future research should take the accuracy and bias of ICT self-efficacy measures into account in order to produce more nuanced and valid estimates of the relationship between pupils' ICT self-efficacy and their actual ICT competences.

4.4. Limitations related to the results

A final limitation relates to the results of this dissertation and focuses on the discrepancy between the theoretical dimensionality of ICT competences and the unidimensional structure that was empirically found in this dissertation. In order for future research to develop reliable measurement instruments and identify factors related to pupils' ICT competences, the underlying structure of ICT competences should first be made clear. As such, research should first explore and empirically confirm the dimensionality of ICT competences as grounded in theory.

5. Implications

Drawing on the general results of the conducted studies, this final section presents some theoretical, policy and practical implications of this dissertation.

5.1. Theoretical implications

In the General introduction of this dissertation (Chapter 1) it was stated that research in the field of ICT competences can be categorized into three groups, i.e. 1) a group that is occupied with defining, describing and operationalizing ICT competences, 2) a group that focuses on the assessment of ICT competences, and 3) a group that identifies factors related to differences in ICT competences. From a theoretical point of view, the results of this dissertation have contributed to the research field of all three groups.

With regard to the first research group, this dissertation introduced a test framework of primary school pupils' ICT competences. This test framework described in Chapter 4 is developed from a reflective perspective on ICT competences, i.e. using a computer to search and process digital information and using a computer to communicate are operationalized as higher-order learning process oriented competences, underpinned by their technical ICT skills. Both ICT competences were selected due to their significant presence in international ICT frameworks and their operationalization was grounded in international research literature and in the specific context of the Flemish ICT curriculum. As such, the introduction of the test framework offers a concrete ICT framework that goes beyond the broad formulated aims of most ICT frameworks, has a cross-national foundation, and takes socio-cultural specificity of the Flemish context into account. As the test framework can be easily adapted to suit the specific context of other national ICT curricula, it can be used to guide future studies on the assessment of primary school pupils' digital information processing and communicating competences.

The results of this dissertation have two implications for the research on the assessment of ICT competences. First, two reliable and valid measurement tools were developed to capture primary school pupils' level of ICT competences. The development of the performance- and computer-based test provides researchers with a standardized instrument to measure primary school pupils' actual ICT competences with large samples. As such, our test provides an instrument that goes beyond observational studies and eventually could be deployed in large-scale, longitudinal studies that focus on ICT competence achievement gains and the added value of parents, teachers, schools and the larger educational context to these gains. Besides the performance-based test, a self-perceived measure of ICT competence was developed. Through the development of a task-specific ICT self-efficacy scale, this dissertation provides the research community with one of the first instruments to measure primary school pupils' judgment of their own competence in communicating, locating and processing digital information.

Besides the development of both these instruments, this study also provides insight into pupils' ability in digital information searching, processing and communicating. The results in this dissertation confirm previous findings that pupils' average ICT competence is not highly developed and that they especially have difficulties with judging the relevance of digital information, with delivering content in an understandable and socially acceptable way, and with information searches that require more complex search queries (Claro et al., 2012; Kuiper et al., 2005; van Deursen & van Diepen, 2013). Because the findings in this dissertation are standardized and not based on self-reported measures, they are therefore probably more valid.

Finally, the results of this dissertation also add to the research literature on the identification of factors related to pupils' ICT competences. The development of the EDC-model introduced a theoretical multilayered extensive model that can act as a blueprint when studying pupils' learning and achievement of different ICT competences and ICT skills, other than digital information processing and communicating. Further, the validation of the EDC model in Chapter 6 and 7 resulted in the identification of factors that help to explain differences in primary school pupils' competence in digital information processing and communicating and in their ICT self-efficacy. The results of this dissertation add to the research literature by illustrating that pupils' ICT competences can be considered as a pupil level phenomenon that is mainly developed in an out-of-school context and is explained by non-ICT related pupil level factors. For example, our results confirm previous findings (Fraillon et al., 2014) that SES and gender are related to ICT competences. Further, the findings elaborate on previous research by identifying cognitive and motivational pupil factors such as learning motivation and analytic intelligence as important factors explaining ICT competences.

5.2. Policy implications

In 2007, the department of education of the Flemish government administered a formal ICT curriculum to its schools. In doing so, eight ICT competences were introduced as official educational outcomes, feasible to be mastered by the end of primary education (Vandenbroucke, 2007). The assessment reported in this dissertation was the first initiative to evaluate the degree to which primary school pupils master the Flemish ICT curriculum. We believe that some elements of our assessment program as well as some reported results provide policy makers with some ideas to consider in their process of policy making.

In the context of the Flemish ICT curriculum, ICT competences focus on higher-order learning-process oriented competences that are underpinned by instrumental technical and application oriented ICT skills. Although pupils need the learning-process oriented ICT competences as well as their underlying technical and application oriented ICT skills in order to solve computer related tasks and problems, only the learning-process oriented ICT competences are integrated as separate attainment targets in the curriculum. The results of our study indicate that pupils on average master the technical skills better than the more complex higher-order ICT competences with regard to digital information searching, processing and communicating. Although no benchmarks were used, these results indicate that primary school pupils only master the higher-order competences in a limited way. We advocate the policy makers to actualize the broadly formulated ICT competences of the Flemish ICT curriculum and create a clear and univocal description of a basic level that pupils are expected to master. We believe that the developed test framework can guide such an actualization of the attainment targets.

Another policy implication relates to the instruments that were developed during this dissertation. The development of the test framework has provided policy makers with a concrete and common discourse that can be used to discuss future directions of the Flemish ICT curriculum and the position of ICT in education. Moreover, the development of the performance-based test provides policy makers with an instrument to gain information about the degree to which pupils master the Flemish ICT curriculum and if necessary, to create benchmarks for the attainment targets of the ICT curriculum. In this context, we also refer to the ICT competence scale that was developed and how this can be used in follow-up initiatives of the policy makers. This means that policy makers can use the ICT competence scale as a reference point of educational effectiveness, i.e., they can use the ICT competence scale on different times to see whether policy decisions and adaptations with regard to educational ICT use are paying off in terms of ICT competence development.

Our results also indicate that ICT is still used and integrated in a limited way in the classroom. As the 'classroom use of ICT as an information tool' was significantly related to pupils' ICT competences, policy makers should encourage teachers and schools to think about ways to successfully and increasingly integrate specific types of ICT use in the classroom according to the ICT competences to be acquired. Research indicates that ICT policy planning and teachers' ICT competence development are two important factors to improve ICT integration in the classroom. However, we believe that professional development with regard to these factors will only be successful (i.e. pupils gain achievement in specific ICT competences) if specific types of ICT competences of pupils and ICT use are addressed.

A final suggestion to the policy makers concerns the way in which the ICT curriculum is constructed. Our results illustrate that the theoretical dimensionality that underlies the ICT competences of the Flemish ICT curriculum could not be empirically validated. As such, we would advise the policy makers to further investigate the dimensionality of ICT competences. Results of such an investigation could not only help to empirically unravel the complexity of the construct of ICT competence, but also deliver input for creating an ICT curriculum that is based on academic logical reasoning as well as on a data-driven approach.

5.3. Practical implications

In the last decennia, computers and the Internet have permeated nearly every aspect of our daily lives. ICT has transformed the way in which people create, use and share information, and revolutionized the way in which people participate in the society and economy. In this context, educational ICT curricula have been developed, ICT competences are formalized as official educational outcomes, and teachers and schools are expected to deliver ICT competent pupils. However, we believe that the development of learning environments in the classroom in which pupils can develop ICT competences is not an easy process for teachers and schools.

We believe that the frequency in which ICT is used for specific activities in the classroom is a first topic to address for educational practice. Our results indicate that primary school pupils' on average do not develop very high levels of ICT competence. Furthermore, one of the studies in this dissertation did not show any variance between schools with regard to pupils' ICT competences and revealed that most factors at the classroom or school level did not explain any differences in the mastery of ICT competences. The results also showed that the degree to which pupils are given the opportunity to work with computers and the Internet in the classroom is very low. Based on these results, we believe that schools at this particular moment do not substantially affect the development of pupils' ICT competences. We believe that the degree to which pupils are given the opportunity to work with ICT in the classroom should be intensified. In this context, Creemers and Kyriakides (2008) state that the opportunities that pupils are given in the classroom to practice and learn specific knowledge and skills is one of the most important characteristics affecting pupils' educational outcomes. Further, our results also demonstrate the importance of providing pupils with specific types of ICT activities, i.e., the more learning activities that focus on the use of ICT as an information tool, the better pupils' mastery of digital information processing and communicating. This means that the intensification of educational ICT use should focus on specific types of ICT activities and use. This intensification on specific types of ICT use implies that teachers also know which specific technical skills and higher-order competences to focus on when teaching the broadly formulated ICT competences incorporated in ICT curricula. With regard to the ICT competences of digital information searching, processing and communicating, teachers can use the test framework developed in this study as an operationalized ICT framework to focus on specific ICT related activities. Furthermore, teachers must be supported and encouraged to learn about the benefits of specific types of ICT use in order for them to integrate them in the classroom (Tondeur, 2007). Teacher training that helps teachers translate ICT competences into specific technical ICT skills and sub competences, focuses on the educational, social and economic benefits of mastering these specific types of ICT competences, and builds on good practices of teacher colleagues might be a way to encourage teachers to pay more attention to specific ICT competences in the classroom.

A second topic addresses the need for a step-by-step didactic approach to the teaching of ICT competences. Our results indicate that pupils' mastery of ICT competences depend on the characteristics of the application that is used, the complexity of the task related to the competence, and of the complexity of the competence being measured. For example, our results indicate that it is easier for pupils to communicate using highly structured digital formats such as a digital form than using less structured digital formats such as a an e-mail program. Another example concerns pupils' ability to use a search engine to find digital information. The ability to use a search engine seems to be related to the number of keywords required to obtain a correct search result. More specifically, children experience fewer problems conducting a search with one keyword than with more than one. Furthermore, the results in Chapter 4 indicate that pupils have less difficulties with browsing the menu of a website to find information than with using a search engine in its most basic way. These results indicate that pupils' competence in online searching behavior is related to the freedom that comes with a search engine in terms of being a less structured application compared to a search index or the menu of a website, and also with the complexity of the required search query. At present, ICT competences are often integrated in ICT frameworks or ICT curricula as final objectives. No assumptions are made about the different steps that pupils need to master in order to gradually acquire an ICT competence. We believe that a step-by-step didactic should be developed that demonstrates how teachers can gradually teach these ICT competences to their pupils. For example, with regard to searching digital information, pupils should first learn to use applications with a specifically designed interface that guides and structures their searching behavior and use of keywords. Afterwards, they can use the acquired searching strategies in other applications where they are free to roam and were the complexity of their search queries is increased. Schools can support their teachers in this matter, by integrating such a step-by-step didactic into their ICT policy plan. Furthermore, helping teachers to choose and develop ICT activities that are appropriate in terms of difficulty and ease can be considered as pedagogical aspects that ICT professional development should focus on.

Moreover, we consider this step-by-step didactic and use of ICT activities that are appropriate in terms of difficulty and competence complexity very important in the context of the relationship between ICT self-efficacy and pupils' ICT competences. The mastery of easier and more appropriate ICT-tasks will likely result in more positive ICT attitudes and higher ICT self-efficacy (Johnson, 2005). In turn, this higher ICT self-efficacy is likely to result in pupils taking up more ICT activities, i.e. more opportunities to learn, which in turn could lead to a better mastery of ICT competences. Only when pupils' ICT self-efficacy and confidence increases should teachers proceed with more complex and difficult tasks. Furthermore, our results indicate that pupils' ICT attitude is strongly related to their ICT self-efficacy. Teachers could try to increase pupils' ICT self-efficacy by helping them to read, understand and interpret their ICT attitudes. They should help pupils to understand that negative feelings toward ICT use and activities are not always congruent with the pupil's actual performance. Such insight will likely lead to higher ICT self-efficacy, which may in turn result in better ICT competences.

Finally, we want to stress the importance of involving parents into schools' educational ICT use in order to improve pupils' ICT competences. Research has indicated that parental involvement has a big impact on pupils' educational achievements (Jeynes, 2007). Our results illustrate that pupils' with parents who belief that mastering ICT competences is useful for their children, score higher on the ICT competence test. As such, we believe that teachers and schools play an important role in 'teaching' parents about the benefits and importance of ICT competences for their children, i.e., teachers should help parents to develop a positive ICT attitude. Schools should focus on building strong relationships with parents and encourage parents to participate in courses and assignments that focus on the importance of ICT competences. We believe that hands-on experiences that focus on parent-child co-learning of ICT competences create opportunities for parents to engage in educational ICT use and foster positive attitudes towards the use of ICT and development of ICT competences. As such, parents can play a more pro-active role in educational ICT use and the acquisition of ICT competences of their children.

To conclude

The concept of ICT competence represents an interesting but complex construct. This complexity in which a hierarchical knot of technical ICT skills and higher-order learning-process oriented competences are embedded makes its assessment very difficult. Although the research presented in this dissertation covers only a tip of the iceberg concerning the assessment of ICT competences, it provides a starting point for the standardized and large-scale performance-based assessment of primary school pupils' ICT competences. Primary school pupils' digital information searching, processing and communication competences appeared not to be as well developed as it is often presumed. ICT competences are especially a pupil level phenomenon, influenced by socioeconomic and cognitive and motivational pupil level characteristics. At this moment, the impact of the school is limited to the use of ICT as an information tool in classroom.

In the future, ICT competences should receive continuing and increasing attention of researchers, educational practitioners and policy makers. They offer children the possibility of engaging in a world immersed in information and applications.

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Nederlandstalige samenvatting

Summary in Dutch

Nederlandstalige samenvatting

Identificatie en assessment van digitale competenties in het lager onderwijs

1. Context

In de context van de 21st century skills-beweging en vaardigheden voor levenslang leren, vormen ICT-competenties of digitale competenties een set van essentiële vaardigheden waarover leerlingen dienen te beschikken om succesvol te kunnen participeren aan de huidige informatiemaatschappij. Een ICT-competentie wordt dikwijls omschreven als het toepassen van generieke cognitieve capaciteiten en technische vaardigheden om ICT- en informatie gerelateerde taken op te lossen. In dit proefschrift voegen we een hiërarchische component toe aan deze interactie en verwijzen ICT-competenties naar gelaagde en complexe constructen van leerprocesgeoriënteerde denkvaardigheden van hogere orde die onderbouwd worden door technische en toepassingsgeoriënteerde ICT-kennis en –vaardigheden. De laatste decennia komt het belang van ICT-competenties steeds hoger op de agenda te staan van het nationale en internationale onderwijsbeleid, wat tot tal van referentiekaders voor ICT-competenties heeft geleid. In deze context, introduceerden bepaalde overheden zoals die van Vlaanderen en Noorwegen recent ICT-competenties in hun nationaal curriculum.

De introductie van een officieel ICT-curriculum in het leerplichtonderwijs heeft twee grote gevolgen. Enerzijds formaliseert een ICT-curriculum de finaliteit van ICT competenties als officiële, op zichzelf staande leerdoelen die onderwijs dient na te streven en die leerlingen dienen te beheersen. Anderzijds verandert de introductie van een officieel ICT-curriculum de status van het didactisch ICT-gebruik in de klas en op school. ICT-gebruik is bijgevolg niet langer louter afhankelijk van de interesse en het initiatief van de individuele leraar. Alle leraren krijgen de verantwoordelijkheid onderwijsleersituaties te creëren om al hun leerlingen gelijke leerkansen te bieden om ICT-competenties te ontwikkelen.

Deze ontwikkelingen hebben twee belangrijke gevolgen voor het onderzoek naar ICT-competenties. Ten eerste vereist de formalisering van ICT-competenties als officiële leerdoelen de ontwikkeling van valide meetinstrumenten om de ICT-competenties van leerlingen of de mate waarin ze het ICT-curriculum beheersen te meten. Ten tweede vereist de aanname dat leraren en scholen de ICT-competenties van hun leerlingen dienen te ontwikkelen, dat onderzoek nagaat welke implementatievoorwaarden hiermee samenhangen, en meer concreet welke leerling-, klas- en schoolfactoren gerelateerd zijn aan de ICT-competenties van leerlingen.

Voor het meten van ICT-competenties maakt het meeste onderzoek gebruik van indirecte meting of meetinstrumenten die vertrekken vanuit zelfperceptie, met name de mate waarin leerlingen van zichzelf denken dat ze ICT-competent zijn of bepaalde ICT-gerelateerde taken succesvol kunnen oplossen. Hoewel deze instrumenten kunnen ingezet worden bij grote steekproeven, zijn er vragen bij de validiteit. Leerlingen kunnen hun eigen competenties immers over-of onderschatten. Directe metingen of metingen waarbij de ICT-competenties van leerlingen worden bepaald op basis van de analyse van direct waargenomen acties worden gebruikt om tegemoet te komen aan dit validiteitsprobleem. Tot op heden blijft het onderzoek dat vertrekt vanuit een directe meting hoofdzakelijk beperkt tot observatiestudies. Hoewel deze studies een hoge validiteit garanderen, zijn ze moeilijker uit te voeren bij grote steekproeven, nemen ze veel tijd in beslag, dragen ze hoge kosten met zich mee, en zijn ze moeilijk op een betrouwbare manier te herhalen. In dit proefschrift proberen we deze tekorten op te vangen door een gestandaardiseerde en performance-based ICT-toets te ontwikkelen die kan ingezet worden in grote steekproeven.

Onderzoek dat nagaat welke factoren gerelateerd zijn aan de ICT-competenties van leerlingen focust hoofdzakelijk op traditionele leerlingfactoren zoals sekse, socio-economische status (SES), ICT-ervaring en ICT-gebruik. Bovendien zijn de meeste studies uitgevoerd in het secundair en hoger onderwijs en vanuit een single-level perspectief. Dit laatste betekent dat ze geen rekening houden met de genestheid van de data, i.e., leerlingen in klassen in scholen. In dit proefschrift proberen we in te spelen op deze tekorten door het ontwikkelen en het empirisch valideren van een multi-level model dat leerling-, klas-, en schoolfactoren omvat die mogelijk samenhangen met ICT-competenties van leerlingen van het lager onderwijs.

2. Onderzoeksdoelen en -design

Het hoofddoel van dit proefschrift is het meten van ICT-competenties van leerlingen van de lagere school en meer in het bijzonder het nagaan van relaties tussen ICT-competenties van leerlingen en factoren op leerling-, klas- en schoolniveau. Dit hoofddoel wordt opgesplitst in drie onderzoeksdoelen:

1) De ontwikkeling van een conceptueel model voor de identificatie van leerling-, klas- en schoolfactoren die gerelateerd zijn aan ICT-competenties van leerlingen van het lager onderwijs.

2) De ontwikkeling van een gestandaardiseerd en performance-based toetsinstrument voor het direct en valide meten van de ICT-competenties van leerlingen van het lager onderwijs.

3) Het identificeren van leerling-, klas- en schoolfactoren die gerelateerd zijn aan de ICT-competenties van leerlingen van het lager onderwijs.

De resultaten van dit proefschrift worden gepresenteerd via zes studies: één kwalitatieve studie, twee studies waarin een literatuurstudie werd gecombineerd met een kwantitatieve analyse en drie kwantitatieve studies. Voorafgaand aan het kwantitatieve luik van dit proefschrift werd een documentanalyse uitgevoerd om de educatieve beleidscontext waarin ICT-competenties zijn ingebed beter te begrijpen. De vijf kwantitatieve studies zijn gebaseerd op data die werden verzameld met een performance-based ICT-toets, aangevuld met vragenlijsten voor leerlingen, ouders, leraren en ICT-coördinatoren.

Het eerste onderzoeksdoel wordt behandeld in studie 1 (hoofdstuk 2) en studie 2 (hoofdstuk 3). Om de onderwijsbeleidscontext te schetsen waarin de ICT-competenties van leerlingen zijn ingebed, werd een documentanalyse van drie nationale ICT-curricula uitgevoerd. De data-analyse is gebaseerd op de methode van constante vergelijking. De resultaten van studie 1 leverden de input voor de selectie van de te meten ICT-competenties in de daaropvolgende studies. In studie 2 worden een literatuurstudie en een vragenlijstonderzoek gecombineerd. Het hoofddoel van de literatuurstudie is het ontwikkelen van een uitgebreid en gelaagd conceptueel model waarin de leerling-, klas- en schoolfactoren zijn opgenomen die mogelijks gerelateerd zijn aan de ICT-competenties van leerlingen. Het doel van het vragenlijstonderzoek is de ontwikkeling en validering van betrouwbare schalen voor de verschillende factoren van het conceptueel model. Hiervoor werden 2413 leerlingen, 2267 ouders en 134 leraren bevraagd. Exploratieve (EFA) en confirmatorische (CFA) factoranalyses werden gebruikt om de schalen te ontwikkelen. Verschillende replicatie-analyses werden uitgevoerd om de gevonden structuren tijdens de EFA te bevestigen.

Het tweede onderzoeksdoel wordt behandeld in studie 3 (hoofdstuk 4) studie 4 (hoofdstuk 5). Studie 3 bevat de combinatie van een literatuurstudie en een kwantitatieve analyse van de resultaten van de performance-based test. Het hoofddoel van de literatuurstudie is de ontwikkeling van een theoretisch test raamwerk ter ontwikkeling van de performance-based toets. Dit raamwerk operationaliseert de ICT-competenties die in dit proefschrift werden gemeten. De kwantitatieve analyse van studie 3 heeft als doel te exploreren hoe verschillen in ICT-competenties zijn gerelateerd aan sekse en socio-economische status. Hiervoor werden de data van 378 leerlingen op de performance-based test geanalyseerd aan de hand van klassieke item analyses, chi-square toetsen, non-lineaire factoranalyses, ordinale betrouwbaarheidsanalyses en ANOVA. Studie 4 heeft als hoofddoel het ontwikkelen en valideren van een ICT-competentieschaal op basis van directe meting. Hiervoor werden de antwoorden van 560 leerlingen geanalyseerd aan de hand van item response theory.

Aan het derde onderzoeksdoel komen we tegemoet in studie 5 (hoofdstuk 6) en studie 6 (hoofdstuk 7). Studie 5 heeft als doel het nagaan van de mate waarin leerlingen de gemeten ICT-competenties daadwerkelijk beheersen. Daarnaast staat ook de identificatie van leerling-, klas- en schoolfactoren die gerelateerd zijn aan de gemeten ICT-competenties van leerlingen centraal. Hiervoor werden via de performance-based test data verzameld van 378 leerlingen, alsook via vragenlijsten van deze leerlingen, hun ouders (n=378), hun leraren (n=83) en ICT-coördinatoren (n=56). In studie 6 wordt nagegaan welke leerling-, klas- en schoolfactoren samenhangen met leerlingen hun zelfwaargenomen ICT-competentie. Hiervoor werden vragenlijsten afgenomen van 2421 leerlingen, 2256 ouders, 141 leraren en 86 ICT-coördinatoren. Omwille van de geneste structuur van de data werden zowel in studie 5 als in studie 6 via multilevel modeling regressie-analyses uitgevoerd op de data.

3. Overzicht van de resultaten

3.1. Onderzoeksdoel 1: Ontwikkeling van het conceptueel model

De literatuur die zich bezighoudt met de identificatie van factoren gerelateerd aan ICT-competenties richt zich hoofdzakelijk op het leerlingniveau en minder op factoren op klas- en schoolniveau, zoals de ICT-competenties van de leraar zelf of het ICT-beleid van een school. Om deze factoren in kaart te brengen en rekening te houden met de educatieve context waarin leerlingen zich bevinden (leerlingen in klassen in scholen), werd het Extensive Digital Competence (EDC)-model ontwikkeld. Dit conceptueel model geeft de factoren weer die mogelijks gerelateerd zijn aan leerlingen hun ICT-competentie. De ICT-competenties van leerlingen vormen de afhankelijke variabele van het model en worden in deze studie omschreven als een hiërarchische en geïntegreerde eenheid van leerproces georiënteerde ICT-competenties van hogere orde, onderbouwd door technische en toepassingsgeoriënteerde ICT-kennis en –vaardigheden. In het EDC-model worden ICT-competenties zowel als effectieve als zelfwaargenomen competenties geoperationaliseerd.

De factoren waarvan wordt verwacht dat ze gerelateerd zijn aan de ICT-competenties van leerlingen worden weergegeven in zes clusters van variabelen die werden gecategoriseerd in drie niveaus: ICT-gerelateerde school factoren (schoolniveau); ICT gerelateerde klasfactoren (klasniveau); en socio-economische en culturele factoren, cognitieve en motivationele factoren, ICT-gerelateerde leerlingfactoren en een ICT-ondersteunend thuisklimaat (leerlingniveau). De drie niveaus illustreren de gelaagdheid van het model.

Naast de modelontwikkeling werden ook een aantal schalen ontwikkeld opdat voor elke variabele van het EDC-model een betrouwbaar meetinstrument beschikbaar zou zijn dat kan ingezet worden in het lager onderwijs. Meer specifiek werden er meetinstrumenten gehanteerd en verder gevalideerd voor leermotivatie, leerstijl, ICT-ondersteuning door ouders, ICT-attitude van ouders, ICT-attitude van leraren, ICT-attitude van leerlingen en ICT self-efficacy van leerlingen. De replicatie-studies van de EFA en CFA tonen aan dat alle gehanteerde schalen over de verschillende samples heen beantwoorden aan de kwaliteitscriteria voor betrouwbaarheid en fit.

3.2. Onderzoeksdoel 2: Toetsontwikkeling

Bij de start van dit onderzoek waren in de literatuur geen instrumenten beschreven om ICT-competenties van leerlingen van de lagere school op een directe en valide manier te meten bij grote steekproeven. Het tweede onderzoeksdoel richt zich dan ook op de ontwikkeling van zo een meetinstrument, rekening houdend met de complexiteit en hiërarchische structuur van ICT-competenties. De ontwikkeling van een dergelijk instrument levert niet enkel informatie op over de mate waarin leerlingen specifieke ICT-competenties beheersen, maar maakt ook longitudinaal onderzoek mogelijk naar factoren die de ontwikkeling van ICT-competenties bevorderen of verhinderen.

De eerste stap in de ontwikkeling van de performance-based ICT-toets was het operationaliseren en het afbakenen van het begrip ICT-competentie in een test raamwerk. Dit test raamwerk diende nadien als een blauwdruk voor de verdere ontwikkeling van de ICT-toets. De resultaten van studie 1 tonen aan dat “het opzoeken, verwerven en verwerken van digitale informatie” alsook “het gebruik van ICT om op een doelmatige, verantwoorde en veilige manier te communiceren” als centrale thema’s terugkeren in nationale ICT-curricula. Bijgevolg werden beide thema’s gekozen als concretisering van ICT-competenties voor de toets. Rekening houdend met de hiërarchische structuur van een ICT-competentie werden zowel leerproces-georiënteerde competenties van hogere orde als technische ICT-kennis en -vaardigheden in het test raamwerk geïntegreerd. De leerprocesgeoriënteerde competenties werden hierbij geclusterd in zes categorieën, i.e., toegang krijgen tot digitale informatie, transformeren van digitale informatie, creëren van digitale informatie, communiceren van digitale informatie op een inhoudelijk begrijpbare manier, communiceren van digitale informatie op een sociaal aanvaardbare manier en het verspreiden van informatie door middel van verschillende digitale media.

Alle leerprocesgeoriënteerde competenties en technische ICT-vaardigheden werden ingebouwd in 56 simulatie gebaseerde items in een gesloten toetsomgeving. Het gebruik van een gesloten omgeving liet ons toe te anticiperen op de mogelijke antwoorden van de leerlingen en verbetert bijgevolg de standaardisatie van de toets. Om de items te beantwoorden dienden de leerlingen in interactie te gaan met zes gesimuleerde generieke software applicaties, i.e., een web browser, een e-mailprogramma, een tekstverwerkingsprogramma, presentatiesoftware, een rekenvel en een programma voor bestandsbeheer. Alle items werden binair gescoord (1=correct; 0= incorrect). Terwijl de technische ICT-vaardigheden automatisch werden gescoord, werden de leerprocesgeoriënteerde competenties omwille van hun inhoudelijke component manueel gescoord door een team van test raters.

De item response theory analyses toonden aan dat een unidimensioneel construct onderliggend is aan de items van de toets. Deze empirisch gevonden unidimensionaliteit is tegenstrijdig met de multidimensionaliteit van het theoretische test raamwerk i.e. digitale communicatie en informatieverwerving als twee aparte leerprocesgeoriënteerde competenties met daarnaast de technische ICT-vaardigheden als een derde dimensie. Na het uitfilteren van de 'local dependent' items, vormden de 27 overblijvende items een betrouwbare schaal van ICT-competentie met een empirische betrouwbaarheid van .89.

De resultaten tonen aan dat de technische ICT-vaardigheden en leerprocesgeoriënteerde ICT-competenties evenredig verdeeld zijn over de ICT-competentieschaal. De resultaten van studie 3 tonen aan dat leerlingen gemiddeld beter scoren voor technische vaardigheden dan voor de leerprocesgeoriënteerde competenties met betrekking tot het communiceren, verwerven en verwerken van digitale informatie. Maar dit betekent niet dat alle technische ICT-vaardigheden automatisch als makkelijker beschouwd kunnen worden dan de leerprocesgeoriënteerde ICT-competenties.

Verder tonen de resultaten aan dat leerlingen de meeste problemen hebben met het communiceren van digitale informatie op een begrijpbare en sociaal aanvaardbare manier. Daarnaast is het makkelijker om te communiceren via een gestructureerd format zoals een digitaal formulier dan via een ongestructureerd format zoals e-mail. Met betrekking tot het zoeken van informatie blijken leerlingen de meeste moeilijkheden te hebben met het beoordelen van de relevantie van informatie die ze vinden op het internet. De meeste leerlingen beheersen de competentie om via een zoekindex, zoekmachine of het menu van een website informatie te vinden. Dit beheersingsniveau daalt echter wanneer de complexiteit en het vereiste aantal woorden van een zoekopdracht in te geven in een zoekrobot stijgt. Verder hebben leerlingen ook weinig problemen met het configureren van een zoekmachine om een zoekopdracht te specificeren.

3.3. Factoren gerelateerd aan ICT-competenties

Om het laatste onderzoeksdoel te beantwoorden werd nagegaan welke leerling-, klas- en schoolfactoren gerelateerd zijn aan de ICT-competenties van leerlingen. Hierbij wordt een onderscheid gemaakt tussen de effectieve ICT-competenties van leerlingen en zelfwaargenomen ICT-competenties van leerlingen.

3.3.1. Factoren gerelateerd aan daadwerkelijke ICT-competenties

De resultaten van studie 5 tonen aan dat de meerderheid van de leerlingen laag tot gemiddeld scoort op de performance-based ICT-toets. Hoewel deze resultaten enkel kunnen geïnterpreteerd worden in de context van de moeilijkheidsgraad van de items van deze specifieke toets, indiceren ze dat slechts een minderheid van de leerlingen op een geavanceerd niveau digitale informatie kan verwerven, verwerken en communiceren. Daarnaast duiden de resultaten ook aan dat er op het gebied van ICT-competenties van leerlingen geen verschillen zijn tussen scholen. Ondanks het feit dat deze resultaten onvoldoende generaliseerbaar zijn (n=378) vormen ze een indicatie dat verschillen in ICT-competenties van leerlingen hoofdzakelijk kunnen toegeschreven worden aan factoren op leerling- en niet op klas- en schoolniveau.

Verder blijkt dat de ICT-competenties van leerlingen hoofdzakelijk samenhangen met niet-ICT gerelateerde factoren. Terwijl analytische intelligentie en controlerende leerstijl positief gerelateerd zijn met de ICT-competenties van leerlingen, correleert geïntrojecteerde regulatie van de motivatie negatief met ICT-competenties. Dit betekent dat hoe meer de motivatie tot leren gestuurd wordt door een behoefte aan trots en bewijs ten opzicht van anderen, of om gevoelens van schaamte en schuld te ontwijken, hoe lager de score op de ICT-competentieschaal. Daarnaast blijken ook sekse en socio-economische status te correleren met de ICT-competenties van leerlingen. Met betrekking tot sekse doorbreekt studie 5 de traditionele aanname dat ICT-gebruik vooral een mannelijke activiteit is. Meer in het bijzonder tonen de resultaten aan dat meisjes in het algemeen beter zijn in het communiceren van digitale informatie. Terwijl sekse hoofdzakelijk kan gelinkt worden aan het communicatieve aspect van ICT-competenties, blijkt SES gerelateerd aan bijna alle aspecten van ICT-competenties die via de performance-based toets zijn gemeten. Dit betekent dat hoe hoger het diploma van de moeder, hoe hoger de leerling scoort op het communiceren, verwerven en verwerken van digitale informatie. Daarnaast blijken ook ICT self-efficacy en de ICT-attitude van ouders positief gerelateerd te zijn aan de ICT-competenties van leerlingen. Leerlingen die zichzelf als meer competent inschatten op het gebied van het communiceren, verwerven en verwerken van digitale informatie, scoren ook daadwerkelijk hoger op de performance-based ICT-toets. Daarnaast blijken de ICT-competenties iets beter te zijn van leerlingen waarvan de ouders overtuigd zijn dat het leren werken met de computer educatieve, sociale en economische voordelen heeft voor hun kind.

Met betrekking tot de klas- en schoolfactoren van het EDC-model, blijkt enkel het gebruik van ICT als informatietool in de klas gerelateerd te zijn aan de ICT-competenties van leerlingen. Leerlingen die meer kansen krijgen in de klas om ICT te gebruiken voor het opzoeken, verwerken en communiceren van digitale informatie, beheersen deze competenties ook beter. Dit resultaat toont aan dat de manier waarop ICT in de klas wordt gebruikt, en de kansen die leerlingen op school krijgen om specifieke ICT-competenties in te oefenen, een rol spelen in het verwerven van die competenties.

3.3.2. Factoren gerelateerd aan ICT self-efficacy.

De resultaten in studie 6 tonen aan dat leerlingen van zichzelf vinden dat ze competent zijn in het verwerven en verwerken van digitale informatie en het communiceren via de computer en het internet. Aansluitend bij de resultaten van de directe meting (studie 5) zijn slechts zeer kleine verschillen te vinden tussen klassen op het gebied van ICT self-efficacy. Dit betekent dat ICT self-efficacy kan beschouwd worden als een fenomeen op leerlingniveau. Bovendien blijken geen klas- en schoolfactoren van het EDC-model gerelateerd te zijn aan de ICT self-efficacy van leerlingen. De ICT-attitude van leerlingen, hun ervaring met computers en het internet buiten de school alsook de ICT-attitude van de ouders zijn positief gerelateerd aan de zelfwaargenomen ICT-competenties van leerlingen.

Daarnaast zijn analytische intelligentie en een controlerende leerstijl positief gerelateerd aan ICT self-efficacy. Amotivatie correleert daarentegen negatief met ICT self-efficacy. Dit betekent dat leerlingen die minder gemotiveerd zijn om te leren hun ICT-competenties ook lager inschatten. Verder tonen de resultaten dat de socio-culturele en –economische factoren sekse, leeftijd en SES niet gerelateerd aan de zelfwaargenomen ICT-competenties van leerlingen.

4. Algemene conclusie

Dit proefschrift geeft een aanzet tot het valide meten van ICT-competenties van leerlingen van de lagere school en tot het identificeren van factoren op leerling-, klas- en schoolniveau die samenhangen met ICT-competenties van leerlingen.

Hiervoor werd eerst een conceptueel model ontwikkeld dat verschillende leerling-, klas- en schoolfactoren omvat die mogelijks verband houden met de ICT-competenties van leerlingen. Deze factoren omvatten ICT-gerelateerde school-, klas- en leerlingfactoren, socio-culturele en –economische factoren, cognitieve en motivationele factoren, en factoren gerelateerd tot een ICT-ondersteunend thuisklimaat. Voor verschillende factoren van het model werden valide en betrouwbare meetschalen ontwikkeld om over een instrumentarium te beschikken om deze factoren kwantitatief in kaart te brengen.

Vervolgens werd via item response theory een performance-based ICT-toets ontwikkeld die in het lager onderwijs kan gebruikt worden om de ICT-competenties van leerlingen te meten en die aansluit bij het Vlaamse ICT-curriculum. De resultaten in studie 4 illustreren dat dit nieuwe meetinstrument psychometrisch goed onderbouwd is. Hoewel het ontwikkelde meetinstrument enkel de top van de ijsberg belicht betreffende het meten van ICT-competenties, biedt het een startpunt voor gestandaardiseerde, grootschalige en performance-based metingen van ICT-competenties van leerlingen van de lagere school.

Terwijl leerlingen hun eigen ICT-competentie in het algemeen hoog inschatten, scoren ze laag tot gemiddeld op de performance-based ICT-toets. Leerlingen scoren hierbij in het algemeen beter op technische ICT-vaardigheden dan op leerproces-georiënteerde ICT-competenties van hogere orde. Tot slot tonen de resultaten van dit onderzoek aan dat er weinig verschillen zijn tussen scholen wat betreft de ICT-competentie van leerlingen aan het eind van het lager onderwijs en dat verschillen in zowel effectieve als zelfwaargenomen ICT-competenties van leerlingen vooral toegeschreven worden aan factoren op leerlingniveau. Bovendien blijken de cognitieve en motivationele factoren alsook de socio-economische factoren op leerlingniveau het grootste aandeel van de variantie te verklaren.

Dit proefschrift heeft implicaties voor theorie, praktijk en beleid. Op theoretisch niveau werd bijvoorbeeld het EDC-model ontwikkeld. Dit model biedt een referentiekader dat gebruikt kan worden in toekomstige studies voor het meten van ICT-competenties. Daarnaast werd een gestandaardiseerde performance-based ICT-toets ontwikkeld. De ICT-toets kan in grootschalige, longitudinale studies worden ingezet om de leerwinst in ICT-competentie van leerlingen op een valide manier te meten. Naast de ontwikkeling van de ICT-toets illustreren de resultaten van dit proefschrift ook dat de algemene ICT-competentie van leerlingen niet zeer hoog is en dat leerlingen vooral moeilijkheden hebben met het beoordelen van relevante digitale informatie en het begrijpbaar en sociaal aanvaardbaar communiceren via de computer en het internet. Tot slot toont dit proefschrift aan dat vooral de leerlingfactoren een rol spelen in het verklaren van verschillen in de beheersing van ICT-competenties.

Studie 5 toont aan dat het specifieke gebruik van ICT als een informatietool in de klas een bijdrage levert aan de ICT-competenties van leerlingen. Een praktische implicatie van deze studie is bijgevolg dat professionele ontwikkeling van leraren kan versterkt worden om in te zetten op specifieke soorten ICT –gebruik overeenkomstig de doelen of ICT-competenties die van de leerlingen verwacht worden. Verder roepen de onderzoeksresultaten op tot een intensiveren van specifiek ICT-gebruik in de klas, het introduceren van een stap-voor-stap-didactiek en het verhogen van leerlingen hun ICT-attitude en ICT self-efficacy indien het versterken van ICT-competenties van leerlingen wenselijk wordt geacht.

Dit proefschrift is niet zonder beperkingen. Een eerste beperking is de betrekkelijk kleine steekproef waarop de multilevel-analyses in studie 5 werden uitgevoerd. Een uitbreiding van de steekproef is aan te raden om na te gaan of gelijkaardige resultaten en meer accurate schattingen en standaardfouten worden gevonden. Daarnaast is het ook zinvol om de variabelen die werden opgenomen in het EDC-model en de verschillende studies uit te breiden. Aangezien heel wat items van de performance-based test een verbale component omvatten, kan toekomstig onderzoek bijvoorbeeld rekening houden met de thuistaal van de leerling of zijn/haar leesvaardigheid. Het belangrijkste methodologisch tekort van dit proefschrift is de cross-sectionele aard van data waardoor het onmogelijk was om leerwinst in ICT-competentie vast te stellen. Om de leerwinst van leerlingen alsook de toegevoegde waarde van leraren en scholen na te gaan, kunnen er in de toekomst longitudinale studies worden opgezet.

Tot slot maken we nog een terugkoppeling naar het algemene doel van dit proefschrift: het meten van ICT-competenties van leerlingen van de lagere school en meer specifiek het nagaan van relaties tussen ICT-competenties van leerlingen en factoren op leerling-, klas- en schoolniveau. Door de ontwikkeling van een nieuw, performance-based meetinstrument hebben we zicht gekregen op de mate waarin leerlingen van de lagere school belangrijke ICT-competenties beheersen. Terwijl onderwijsoverheden van scholen verwachten dat ze onderwijsleersituaties creëren om de ICT-competenties van alle leerlingen te ontwikkelen, tonen de resultaten in dit proefschrift aan dat verschillen in ICT-competentie hoofdzakelijk gerelateerd zijn aan leerlingkenmerken. We willen via dit proefschrift nog eens het belang van leraren en scholen in de ontwikkeling van ICT-competenties benadrukken en hopen dat onze resultaten van belang kunnen zijn voor de verschillende actoren die betrokken zijn bij de ontwikkeling van ICT-competenties van jongeren.

Academic output

Academic output

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