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Direct measures of digital information processing and communication skills in primary education: Using item response theory for the development and validation of an ICT competence scale

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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

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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 digital 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