What Affects Students’ Computer and Information Literacy around the World? – An Analysis of School and Teacher Factors in High Performing Countries

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Abstract: This paper presents findings based on the IEA-study ICILS 2013 (International Computer and Information Literacy Study, 2010-2014) which investigates the computer and information literacy (CIL) of secondary school students in 21 countries. Students’ CIL is measured by computer-based tests in live-software environments. In addition, representative data of contexts in which students develop CIL are gathered by student, teacher and school questionnaires. By means of multilevel path analyses, this contribution focuses on teacher- and school-related factors contributing to students’ acquisition of CIL. For a selection of high performing countries findings reveal differences and similarities in supporting and hindering factors such as school leadership, teachers’ professional development and appropriateness of IT-equipment. Finally, data about the national contexts are applied to frame the findings and to discuss how schools can support students’ skills to participate in the 21st century.

Introduction

Due to the increasing use of information and communication technologies (ICT) and the society’s transition towards an information or knowledge society new challenges for schools have emerged (Anderson, 2008). Thus, the need for students to develop relevant skills in order to participate effectively in the digital age is constantly gaining importance. Knowing about, understanding, and using information technologies has become important for the life in a modern society and is defined as a key competence for lifelong learning (European Commission, 2008). Furthermore, the relevance of the exchange and transformation of knowledge through ICT is increasing which emphasizes that digital literacy such as computer and information literacy (CIL) are one of the core competencies in the 21st century (Fraillon, Schulz, & Ainley, 2013; Voogt, Erstad, Dede & Mishra, 2013). In this understanding, information technologies provide the tools for creating, collecting, storing, and using knowledge as well as for communication and collaboration (Kozma, 2003). The ongoing development of new technologies has affected every part of 21st century professional and private life. Accordingly, to promote students’ skills and prepare them for life through computer-assisted teaching and learning in schools still presents an ambitious task (Eickelmann, 2011; Voogt & Knezek, 2008). Thus, there seems to be a certain necessity to gain a better understanding of the contexts in which students develop their skills and which factors support or hinder the acquisition of such-like competencies. In this context, the study ICILS 2013 (International Computer and Information Literacy Study, 2010-2014) which is conducted by the IEA (Fraillon et al., 2013) investigates the computer- and information literacy of secondary school students (Grade 8) in 21 educational systems around the world for the first time by means of an international comparison and by applying computer-based test environments. In addition, representative student, teacher and school data related to the contexts in which students develop these competencies are gathered in all participating countries. With an in-depth analysis this contribution not only compares competency levels between the countries but investigates the supporting and hindering factors for the development of students’ CIL on the school and teacher level in the most successful participating educational systems.

Theoretical framework of students’ computer and information literacy acquisition

When studying student outcomes related to digital literacy it is important to consider these in light of the different factors influencing them. The learning of individual students is set in the overlapping contexts of school learning and out-of-school learning, both of which are embedded in the context of the wider community.

The theoretical framework of contexts for CIL learning and learning outcomes distinguishes between individual student factors, the home environment, schools and classrooms as well as the wider community where antecedents and processes of CIL learning can be located (Fraillon et al., 2013). In this framework, antecedents are exogenous, contextual factors that determine the ways in which CIL learning takes place. Variables such as the
socioeconomic status (SES) of the students’ families fall into this category. Processes are those factors that directly influence CIL learning. They are constrained by antecedent factors and contain variables such as opportunities for CIL learning during instruction. Therefore, the development of computer-related skills has to be analyzed with simultaneous consideration of the different levels on which student learning with and about ICT takes place. In this paper the focus will be on the effects on the school level, which can affect students’ skills, while controlling for aspects such as gender and SES on the individual student level. As an assignment of aspects to antecedents or processes of CIL is not always conclusively possible – some factors may be mandatory but can be organized differently within schools (cf. Eickelmann, 2010) – these two dimensions will not be separately attended to within the specified model of this contribution.

State of the art: Factors contributing to the use of ICT in schools and the acquisition of computer and information literacy

In the context of integrating new technologies in schools, factors contributing on either the teacher level or the school level are known to contribute to the use of ICT. So far, there is a considerable amount of literature investigating the successful implementation of ICT in schools which focuses to a substantial extent on factors regarding different school levels that support the use of ICT in classrooms. As previous research reveals, there seems to be a range of supporting and hindering factors on the school level related to school leadership, attitudes and competencies of teachers as well as the ICT infrastructure in schools (Eickelmann, 2010; ISTE 2009).

As to the teacher level, findings showed that the perceived impact of ICT use on students demonstrated a high correlation to the pedagogical approaches adopted by teachers using ICT (Law, Pelgrum, & Plomp, 2008). In an attempt to capture essential qualities of teacher knowledge for technology integration in teaching, while addressing the complex, multifaceted, and situated nature of this knowledge, Mishra and Koehler (2006) created the framework of Technological Pedagogical Content Knowledge (TPCK). They argue that thoughtful pedagogical uses of technology require the development of a complex, situated form of knowledge. Within this framework the intricate roles of teachers in enhancing students’ competencies are pointed out. From this perspective, research shows that teachers in a variety of roles are crucial factors for the digital education in the 21st century (Davis, Eickelmann, & Zaka, 2013). Further research has confirmed the relevance of teacher cooperation for professional development while highlighting the importance of support on all levels within a school (Dexter, Seashore, & Anderson, 2002; Law & Chow, 2008; Schulz-Zander & Eickelmann, 2010).

On the school level research has revealed that one of the most important factors in schools seems to be the role and engagement of school principals (e.g. Dexter, 2008). They ought to create environments on the school level to facilitate the teachers’ integration of ICT by creating school visions and sharing goals (e.g. Ottestad, 2013). Besides, the most relevant obstacle to ICT use on the school level identified by teachers was a lack of support, especially pedagogical support (Law, Pelgrum, & Plomp, 2008).

Moreover the IT infrastructure in schools is a relevant factor regarding the use of ICT for learning purposes. On the one hand, most of the studies point out that a modern and adequate ICT infrastructure and equipment at school is needed to incorporate computers and new technologies in instructional settings (European Commission, 2013). On the other hand, it seems to be well-accepted that ICT as such does not support learning itself but needs to be properly integrated into relevant learning scenarios (Lai, 2008; Law et al., 2008). All in all, there is an extensive body of research documenting the importance of the various factors for using ICT at schools.

These factors on the school and on the teacher level as well as factors on the students’ individual level, such as gender and SES, are also regarded as contributing to the acquisition of students’ computer- and information literacy (Fraillon et al., 2013). Furthermore, research aims at the potential of ICT to enhance learning while focusing on the supporting function for learning processes in single subjects such as mathematics or the enhancement of domain-specific competences such as reading literacy (e.g. Lee & Wu, 2012; Wittwer & Senkbeil 2008). What is more, further research exists towards the effects of ICT use on students’ cross-curricular competencies such as digital literacy and the competent and reflective use of computer-based information (Fraillon, Schulz, & Ainley, 2013; Schulz, Fraillon, Ainley, Losito, & Kerr, 2008). Research results indicate that factors both on the student level as well as on the school level affect student achievement in this field. Concerning students’ individual level, studies reveal the relevance of factors such as gender or the parental occupation and parental education which contribute to considerable differences in digital competencies (ACARA 2012; Hohlfeld, Ritzhaupt, & Barron, 2013). Results from a multi-level analysis have shown that higher levels of mastery orientation and self-efficacy and the students’ family background were predictors of students’ levels of digital competence (Hatlevik, Ottestad, & Thronsen, 2014). Furthermore, it could be shown that students’ ICT competency was affected by the level of ICT competency among the teachers and their willingness to use ICT in their lessons (Aoki, Kim, & Lee, 2013). This study found that...
the ICT infrastructure of schools on its own is not enough to enhance the ICT competency but the efforts of the teachers and administration were more important than any other factor. Further research indicates that teaching strategies for digital competencies are often not well implemented in the educational practice (Voogt et al., 2013). The reasons for this include a lack of integration of these competencies in curricula and assessment, insufficient preparation of teachers and the lack of systematic attention for strategies to adopt innovative teaching and learning practices. Additionally, when school leaders reported higher participation rates of teachers in professional development courses, increased levels of digital competence were found among students (Hatlevik, Ottestad & Thronsen, 2014).

In summary, it can be concluded that the implementation of ICT in schools as well as its use in classrooms to support teaching and learning has been investigated in depth over the last decades. However, so far only a few studies aim to examine the effect of school- and teacher-related factors on cross-curricular digital competencies of students such as computer and information literacy. In this paper this research gap is addressed by investigating these aspects based on a secondary analysis of ICILS 2013 data using teacher and school data from 21 educational systems. In order to identify the crucial supporting factors, data from the most successful school systems is used for an international comparative approach and focus on supportive factors which enhance students’ CIL on the school and teacher level.

Research Question
Taking into account the perspective of the educational systems and of schools there seems to be the necessity to become acquainted with factors which affect students’ computer and information literacy (CIL) in order to prepare schools and school systems for an active enhancement of these competencies to sufficiently prepare all students for the 21st century. The focus of this paper is to investigate school level factors which support the students’ CIL by comparing relevant factors in high performing ICILS 2013 educational systems. With this paper the following research question will be addressed: What effects do school leadership, teacher factors and IT resources at school have on students’ computer and information literacy in high performing countries?

The Study: Analysis of school- and teacher-related factors for students computer and information literacy

Data collection and instruments
In order to answer the research question data is needed that can provide information about the students’ competencies with regard to CIL in different countries as well as information about the context in which students acquire these competencies. This data is available from the IEA-study ICILS 2013 whose purpose it is to investigate, in 21 participating countries, the ways in which secondary school students develop computer and information literacy (CIL) to support their capacity to participate in the digital age (Fraillon, Ainley, Schulz, Friedman, & Gebhardt, 2014; Fraillon, Schulz, & Ainley, 2013). In order to achieve this aim, the study assesses student achievement by means of an authentic computer-based CIL assessment administered to students in the eighth year of schooling (typically around 14 years of age in most countries).

With ICILS 2013 collected data about students’ use of computers as well as students’ attitudes toward the use of computers and their background to form an understanding of the broader context in which CIL has developed and continues to develop are now available. The population for the ICILS 2013 teacher survey was determined as all teachers teaching regular school subjects to the students in the target grade at each sampled school. The teacher questionnaire comprises questions about the teaching practices with ICT, the attitudes towards the use of ICT in teaching and the participation in professional learning activities related to the use of ICT in teaching. There were also separate questionnaires administered to principals and ICT-coordinators in each school to address questions about the IT infrastructure, school approaches to CIL-related teaching, shared visions about using ICT in classrooms and the monitoring of the teachers’ use of ICT.

Sample
For the secondary analysis presented in this contribution, data is used from IEA-ICILS 2013 with students’ achievement data, data from students’ background questionnaires as well as the teachers’ and principals’ questionnaires considered. To answer the research question, data from the high performing countries of Australia, Canada (Ontario), the Czech Republic, Poland and the Republic of Korea are taken into account serving to identify
determinants that have a significant impact on students’ CIL. With a multi-level path model (e.g. Heck & Thomas, 2009) factors on the individual student level as well as on the school level are considered.

Based on ICILS 2013, data from the five aforementioned high performing countries – in terms of educational systems with high country means regarding students’ computer and information literacy levels – have been chosen to answer the research question and to examine the aspects of schools and teaching practices regarding the use of ICT related to student achievement in computer and information literacy. In order to identify conditions under which students build computer and information literacy in these high performing countries in ICILS 2013, the data of about 150 schools and about 3,000 students for each country will be included.

Methods

In order to answer our research question a multi-level path model was conducted with the statistical software Mplus (version 7; Muthén & Muthén, 2012). Within these analyses, weighting variables were included in order to consider the complex structure of the ICILS 2013 data: For the multi-level model a student weight on the individual level (within level) and a school weight on the school level (between level) were included. The Full Information Maximum Likelihood-Method (FIML) was used. Thus, missing values were not imputed but population parameters and standard errors were estimated based on the available data (e.g. Enders, 2006). A robust Maximum Likelihood estimator (MLR) was used to take the complex data structure into account (Muthén, 2004).

Analysis model applied to determine the relevant factors on the school level to enhance students’ CIL

On the individual level, student background variables considering students’ gender and their socioeconomic status are taken into account. On the school level, the ICT equipment at school, the principals’ leadership (e.g. the priority with which ICT use is promoted at the respective schools) as well as teachers’ indications about their ICT use in class and their professional development activities with regard to ICT are focused. The teachers’ indications are aggregated on the school level in order to give information about the teaching practices at their schools. As the sampling design of ICILS 2013 includes a sample of teachers in the 8th grade of a school, no direct link between teachers and students can be assumed and teacher data is treated as a source of information about the school.

With the aspects on these two levels the multi-level path model aims to identify aspects on the school level, which affect the computer and information literacy of students at a school.
Findings

The multi-level path model reveals different results for the selected high performing countries of ICILS 2013. Referring to the research question, it can be pointed out that aspects of school leadership, teacher factors and IT resources differ in their relevance for students’ computer and information literacy in these educational systems. In Australia, for example, the professional development activities of the teaching staff concerning the integration of IT in teaching and learning appears to be a supporting factor for the students’ computer and information literacy in a school (β=.33). In the case of the Republic of Korea, two school level factors show significant effects: the lack of hardware is negatively (β=-.27) and the priorities of the school leader facilitating the use of ICT for the teaching staff (β=.20) is positively related to students’ competencies. Moreover, in Poland, only the school leaders’ priorities appear to be important for the students’ computer and information literacy (β=.26). In addition, in Canada (Ontario), the fact that the principals do not monitor teachers’ ICT use for different purposes is positively correlated to students’ competencies (β=.42). In the Czech Republic, where students have achieved the highest average competence level, none of the selected school and teacher factors show significant effects and therefore do not emerge as relevant to explain students’ CIL in the context of the research focus.
Conclusions

The results can be considered hints to important factors on the school level which contribute to a higher CIL performance of students. They indicate which conditions have to be created on the school level to promote these student competencies which are considered essential 21st century skills in terms of the transition towards an information or knowledge society and as a necessary requirement for the participation in society.

The identified differences between educational systems can presumably be explained through cultural and pedagogical differences as well as different traditions and policies in implementing new technologies in teaching and learning. In Australia, constant professional development activities concerning the use of ICT for teaching is – by tradition – a part of the teachers’ professional development and seems to be an important factor with regard to students’ CIL. The result for Canada (Ontario) might be interpreted against the background of a strong incorporation of using ICT for teaching in the curriculum and in teacher education, which might explain why the principals’ monitoring and controlling of these activities is not relevant. The finding that a lack of hardware is correlated negatively with students’ CIL in the Republic of Korea emphasizes that the appropriateness of the ICT equipment for teaching and learning with new technologies in school and to promote the acquisition of digital literacy at schools continues to present an essential foundation. Furthermore, the principals’ priorities regarding the facilitation of ICT use, as it could be shown for Poland and the Republic of Korea, appear to constitute a relevant factor in the way that teachers’ use of ICT is supported by the setting of priorities and the visions of the school leadership focusing on 21st century skills.

All in all, further research may want to take a closer look at each of the high performing countries analyzed in this paper as this could yield important insights for policymakers and provide knowledge for educational systems to develop a better understanding of the contexts and outcomes of ICT-related educational programs while developing a sound understanding of determinants on the school system and school level to prepare students for the digital age.
References


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