UPPER SECONDARY SCHOOL TEACHERS' DIGITAL COMPETENCE: ANALYSED BY DEMOGRAPHIC, PERSONAL AND PROFESSIONAL CHARACTERISTICS

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Abstract

Educational technology provides an opportunity to improve the quality of education. There is however a lack of uptake in utilizing the equipment provided, as well as a lack of well-established methods for monitoring the use of educational technology. In this paper, which is based on one of the largest ICT studies in secondary schools in Norway, we explore the relationship between upper secondary school teachers' digital competence analysed by demographic, personal and professional characteristics. The implications of this study are that demographic, personal and professional characteristics, such as a teacher's age, work experience, gender, screen time and ICT education, predict teachers' high or low digital competence in upper secondary school to a certain degree. Further research is recommended in order to validate these preliminary findings.

Key words: Digital competence; upper secondary school; teachers; professional characteristics

Introduction

Advancements in computer technology have provided great opportunities to improve the quality of education. However, despite great investments by national and local authorities to make the latest educational technologies available within education facilities internationally and in Norway, there has been a lack of uptake in teachers' utilisation of such technologies (Cuban, Kirkpatrick & Peck, 2001). This apparent reluctance to make use of educational technology might be due to technophobia, scepticism or other reasons (Somekh, 2008). Recently, Howard (2013) found that teachers' scepticism to integrate educational technology in classroom teaching is influenced by negative affective responses to technology, general risk-aversion in teaching and the perceived value of technology in teaching. At the same time, experiences from the practice field show that there are also teachers who are 'frontrunners' in the use of educational technology that seem to possess a high level of digital competence. However, anecdotal evidence is not enough—we need more research-based knowledge on what kind of demographic, personal and professional characteristics constitute such digital competence among teachers. In order to achieve this, it is important to use well-established methods to monitor the professional development of teachers' digital competence and their use of educational technology and examine whether, for example, information and communications technologies (ICT) education has any significant benefit in relation to digital competence.

Following a request from the Norwegian Association of Local and Regional Authorities (KS) and the Eastern Norway County Network, the research group Digital Learning Communities (DLC) accepted the assignment to carry out a comprehensive research study (SMIL[1]) exploring the connection between ICT use and learning outcomes in upper secondary schools. In particular, this study focused on teachers' digital competence. Earlier research dealing with teachers' adoption of ICT (e.g., Mumtaz, 2000; Erstad, 2005; Somekh, 2008; Sefton-Green, Nixon, & Erstad, 2009; Erstad, 2010; Ferrari, 2012) shows that there are different perceptions concerning how to describe this kind of competence and different strategies regarding how to improve teachers' ICT skills and digital competence. Earlier studies also indicated that there have been gender differences among teachers' ICT use (Yuen & Ma, 2002), and thus it seems to be important to examine whether there are gender differences among teachers' ICT use in the context of Norwegian secondary schools. A common recommendation found in these studies is that there seems to be a need for continuous ICT education for teachers, and several Norwegian policy documents and national reports have stated the same (KD, 2009, 2014; Norgesuniversitetet, 2014). However, there is a need to examine this area more in depth within the Norwegian context among teachers in upper secondary school. This paper will therefore present the findings from the SMIL study concerning this issue and will revolve around how demographic, personal and professional characteristics such as ICT education influence teachers' digital competence in upper secondary school.

The SMIL study, which is the largest ICT study carried out in upper secondary schools in Norway, involved 17, 529 students and 2, 477 teachers as well as school owners, school leaders and representatives from student councils and the Norwegian Student Organization. The study was conducted from 2012 to 2013 in seven counties in Norway and relates to how school owners and school leaders exercise leadership, how teachers teach and how students learn in the technology-dense classrooms in these counties. Moreover, we explored whether the national curriculum (LK06) has changed any of the underlying premises of school leadership, teaching and learning in upper secondary schools. All these issues have been important to investigate due to the increased technology density in Norwegian classrooms (1:1)[2] resulting from digital teaching aids, students' digital lifestyle and the focus in the national curriculum on pupils' digital competence (digital competence is currently the fifth basic skill in all subjects throughout their education). For teachers to handle this complexity, it goes without saying that teachers need to have professional digital competence in today's digitised schools. However, what constitutes teachers' individual digital competence? The main objective of this paper is thus to examine how demographic, personal and professional characteristics influence teachers' individual digital competence. In this paper we will present the quantitative part of a mixed method design. The research question is as follows: How is upper secondary school teachers' digital competence predicted by their demographic, personal and professional characteristics (i.e., a teacher's age, work experience, gender, screen time and ICT education)?

Conceptual Framework

Throughout the last two decades, several researchers and academics have been grappling with the definition of digital literacy in a digitised society and what it means for everyday people, pupils, teachers, teacher educators, etc. Buckingham (2003, 2006), Gilster (1997), Knobel (1999), Lanham (1995), Lankshear and Knobel (2003), Erstad (2005) and Tyner (1998) have made important contributions to the concepts of computer literacy, media literacy, digital literacy and digital competence. Studies conducted by Dwyer, Ringstaff and Sandholtz (1991) and Hooper and Rieber (1995) have focused more directly on teachers' digital literacy, and Christensen and Knezek's (2008) Will, Skill, Tool (WST) model is one of the most promising attempts to determine the degree to which a teacher's will (attitude), skill level (technology competency) and access to technology tools are vital elements when integrating ICT into teaching. However, in the review article "Factors Affecting Teachers' Use of Information and Communications Technology: A Review of the Literature," Mumtaz (2000) found a number of challenges related to teachers' use of technology, which are related to demographic, personal and professional characteristics. Cox, Preston and Cox (1999) and Cuban et al. (2001) found the same tendencies as well as challenges related to the school management level. Recent studies conducted by Sipilä (2014), Howard (2013), Loveless (2011) and Underwood and Dillon (2011) show that teachers' use of ICT in teaching can represent a number of new possibilities as well as a number of challenges (which are also related to a lack of digital competence[3]). One assumption that is shared by several different positions and studies dealing with digital literacy and ICT in teaching is that teachers' digital competence is more complex than digital literacy in other occupations and among average citizens. It is therefore important to be aware of the complexity of digital competence and also that the way in which teachers carry out and experience the pedagogical use of ICT will very often depend on their high or low digital competence. Studies conducted by Sefton-Green et al. (2009), Erstad (2010) and Ferrari (2012) confirm this and have contributed to developing a better understanding of what digital literacy and digital competence mean in and out of school settings as well as what constitutes the digital competence of today.

However, recent studies still indicate some confusion regarding what digital competence actually means for teachers, pupils, teacher students, teacher educators and school leaders. Is it the same across these groups or is it different? Even if there are several common traits across these groups, it is important to underscore that the groups have different roles in our educational system, and thus digital competence has to be seen in relation to what role each group has in school and in teacher education. So then what constitutes teachers' individual digital competence in school contexts? Based on the national curriculum in Norway (LK06) (KD), we can generally say that teachers need a *generic digital competence* where they are mastering general skills and knowledge about educational technology in the digital learning environment; they need a *subject didactic digital competence* where they apply their digital competence in subjects; and, finally, they need a *professional digital competence* which includes elements that occur outside the teachers' teaching but are simultaneously within the teacher profession. However, these are very general descriptions and there seems to be a gap between the arena of formulation and the arena of realisation when it comes to this issue due to the different interpretations of digital competence. ICT and educational technology are therefore often perceived among teachers in a way other than that intended in the policy documents. This paper attempts to bridge some of this gap through the use of a digital competence model that is attached to the curriculum and is more concrete in order to avoid common misunderstandings and too many different interpretations.

Research shows that ICT is often perceived in teacher education only as a tool that can be handled with elementary ICT skills (Tømte, Hovdhaugen, & Solum, 2009). In both teacher education and in school, there seems to be confusion and a discrepancy between the concepts of *basic ICT skills* (similar to the OECD's term *key competencies*, which is defined as "decisive for learning and development and attached to the national curricula in school") and *elementary ICT skills* (a simple, first step towards ICT skills). Ottesen and Møller (2010) also found that there is frequently a mismatch between *elementary skills* and *basic skills* among teachers in school, especially concerning digital skills. To avoid further confusion around this distinction, Krumsvik (2013) describes *elementary skills in the use of digital tools* as the way teachers manage to use a PC and digital tools (such as turning on a PC or iPad, using a word processor, etc.) effortlessly in school. Furthermore, he describes *basic skills in the use of digital tools* as the way teachers manage to use digital teaching aids (such as digital learning platforms and digital teaching aids attached to the curricula) in the school setting and in teaching in a basic way. The author explains that the main distinction between these two definitions is that one is related to elementary skills (which involve a more generic digital competence), whilst the basic ICT skills are pedagogically related directly to the school context and the national curriculum (i.e., to the competence aims). The two definitions are also dialectically related and are the "starting point" for the teachers' digital competence model presented below.

Considering the implications that this situation and context may have particularly for the teachers' role and digital competence, we have suggested the following definition to describe *digital competence* for teachers: "Digital competence is the individual teacher's proficiency in using ICT in school with good pedagogical judgement, and his/her awareness of its implications for learning strategies and the digital Bildung of pupils" (Krumsvik, 2012, p. 466). This definition is attached to a visual model (Figure 1) of teachers' digital competence. The model was developed on the basis of empirical research carried out in Norway from 2004 to 2012 and the implementation of the Norwegian school reform known as *The Knowledge Promotion* in 2006, where digital competence became the fifth basic skill in the national curriculum (MOK, 2006). The first version of this model had a special focus on pupils, while later versions have also encapsulated teachers and teacher educators. The model presented in this paper is directed only towards teachers' digital competence since the research question focuses on the teacher's role.

The model consists of five parts representing the stages that a teacher goes through during his/her digital competence development. These five parts are also connected to the three sections in the national curriculum (parts I, II & II in LK06, MOK, 2006) which the teachers have to follow. We will elaborate on the theoretical underpinnings of the model in the section below.

Today there is a need to link the macro, meso and micro levels within our understanding of teachers' digital competence. Krumsvik's (2012) digital competence model aims to reduce the complexity in this varied area by focusing on what are considered the most important parameters within digital competence for teachers. Based on previous research and theories, the model attempts to categorise the different characteristics by identifying the typical phenomena traits and theoretical assumptions of the model. With these premises as a backdrop, in the following section we will describe the teachers' digital competence model in depth.

Particularly important in this model is the intersection of a *mental digital competence journey* (self-awareness, vertical axis) and a *practical competence journey* (proficiency, horizontal axis). The theoretical foundations of this *intersection part* were inspired by Wertsch (1991, 1998), Apple Classroom of Tomorrow (ACOT) (Dwyer et al., 1991), distributed cognition (Hutchins, 1995) and situated learning (Lave & Wenger, 1991). The essence of the model is that cognitive processes are continuously offloaded to digital artefacts when teachers are using computers and that this kind of process is increasingly situated everywhere in teachers' digitised school day. The computer thus becomes an 'intellectual prosthesis' for teachers because in this SMIL study (and in general), they have access to technology anywhere and at any time. An important theoretical underpinning for mastering such processes as part of the model is Wertsch's (1991, 1998) concepts of mastery and appropriation, where the term *appropriation* is the process of mastering and appropriating cultural tools. Wertsch means that in the process of appropriation it is quite common that there will be a kind of contradiction and "friction between mediational means and unique use in mediated action" (Wertsch, 1998, p. 54). The term *mediated action* is linked to the context and refers to how human action is mediated through the use of cultural tools within social practices. One concern that Wertsch discusses is "how the introduction of novel cultural tools transform the action" (Wertsch, 1998, p. 42). ICT is such a cultural tool, and below we will elaborate on how these theoretical underpinnings are made explicit in the teachers' digital competence model.

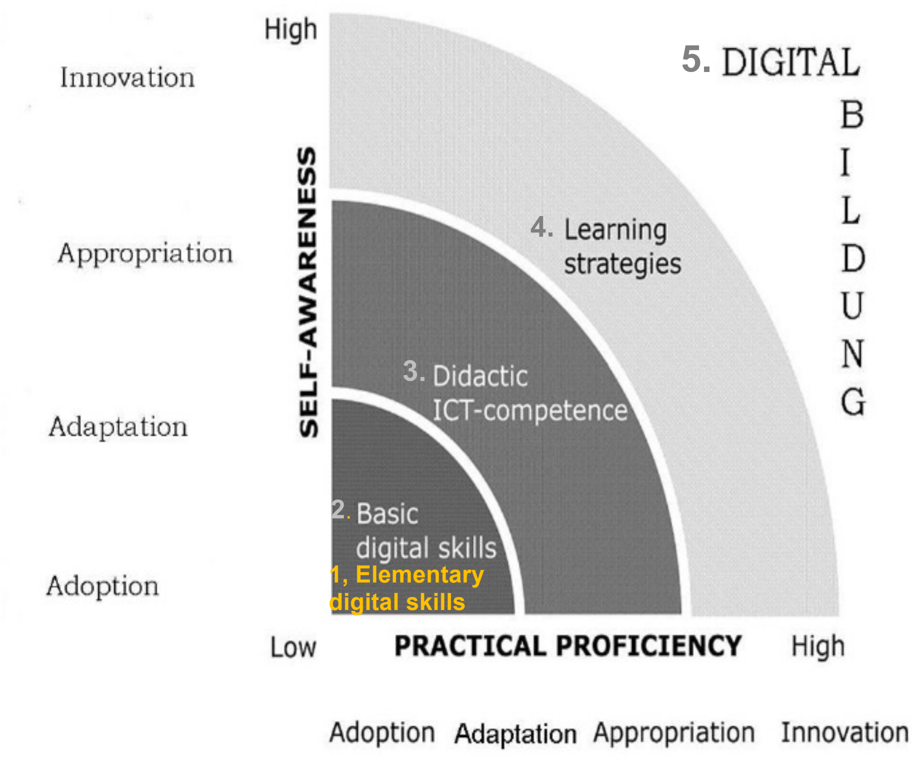

Figure 1. Teachers' digital competence model (Krumsvik, 2007, 2012).

The vertical axes (self-awareness) shows that the *digital competence journey* begins with the teachers being relatively unaware (*adoption*) of what he or she can or cannot do in relation to educational technology and ICT, then gradually becoming more aware and reaching the different stages of *adaptation*, *appropriation* and *innovation* over time (some teachers can, of course, be placed directly into the model at the appropriation stage, for example, because they have already mastered the technology use and are somewhat digitally competent). This journey takes time for novices (several years) and is a great challenge for teachers; they might have never been taught (in their own teacher education) how to achieve such digital competence. Furthermore, they might have no formal ICT education, and it might not have been a natural part of their professional development (continuing ICT education). Additionally, even if psychological obstacles, such as technophobia and scepticism, have decreased among teachers over the last decade, we still find some tendencies of this documented in recent studies conducted by Egeberg, Guðmundsdóttir, Hatlevik, Ottestad, Haug, and Tømte (2012), Howard (2013) and Krumsvik, Ludvigsen, and Urke (2011). However, while this might be gradually fading away as a barrier in both teacher education and in school, we need more updated research knowledge about this in the years to come.

This 'mental' part of the model has to go hand in hand with *the practical competence journey* (proficiency, horizontal axis), which also consists of *adoption*, *adaptation*, *appropriation* and *innovation*. This often becomes the explicit part of the *tacit knowledge*, *know-how* and *awareness* that are acquired throughout the *mental competence journey*. In the first part of this process (adoption and, to a certain extent, adaptation on the horizontal axis), the teachers are mostly occupied with elementary ICT skills (e.g., being able to handle the PC etc.) and basic ICT skills (e.g., using the school's digital learning platform and digital teaching aids in relation to the curriculum, etc.) and overcoming the obstacles that have previously prevented them from handling ICT artefacts. At this stage, ICT artefacts are not immediately comprehensible to the teacher, and the importance of overcoming this stage is obvious. Even if this stage presents a struggle for many teachers, these technological thresholds are considerably lower in comparison to how it was 10 years ago. This is likely a result of more user-friendly technology, decreased technophobia and the more frequent use of ICT among teachers (like other citizens) outside of schools in their spare time. This issue is documented in other parts of the SMIL study, where we found that 32.6% of the teachers had a screen time (use of laptops, iPads, PC, mobile phone, TV etc.) of 4–6 hours per day and 27.2% spent 6–10 hours per day. This indicates that teachers' ICT use is considerably higher than it was a few years ago (see, e.g., Hatlevik, Ottestad, Skaug, Kløvstad, & Berge, et al., 2009) and that they are handling their elementary ICT skills well. Therefore, the first significant obstacle might occur during the appropriation phase (third phase, horizontal axis), and this can be related to the concept of affordance (Gibson, 1977, 1979; Norman 1988, 1990; Kirschner, Martens & Strijbos, 2004). Based on these studies, the SMIL study made a distinction within this concept of affordance: *real affordance*, which means that teachers are able to recognise and utilise the educational technology's potential widely and in an optimal way in teaching, and *perceived affordance*, which is often related to teachers' inability to perceive, recognise and utilise the technology's potential in teaching. In Howard's (2013) study the teachers' perceived value of technology in teaching was a challenge and can be related to this distinction, especially to the perceived affordances.

The pedagogical implications of this are that the teachers who have reached the stage of recognising the *real affordances* are permitted to use his or her professional competence and authority in a way that is not interrupted by technical obstacles, i.e., "form over content." Some case studies have shown that when teachers in school reach the point where educational technology and ICT are perceived as something with educational potential and are clearly understandable to them, they recognise more easily the need to acquire a broader view of knowledge (Krumsvik, 2006a, b, 2008a, b) which influences their way of teaching.

Until now, we have described the two axes of the model—the vertical axis, which is tied to teachers' self-awareness, and the horizontal axis, which relates to teachers' practical proficiency. We will now concentrate on the centre of the model, where we can see that e*lementary digital skills* (1) comprise the first category and are a prerequisite for the other categories. Elementary digital skills refer to the fundamental technical skills, such as being able to use PCs, laptops, iPads and mobile telephones as a teacher. The second category, *basic digital skills* (2), means that the teacher has to be able to handle the administrative and subject tools for teaching in schools, such as e-mail, LMS, interactive whiteboards, digital teaching aids, etc. The third category, *didactic ICT competence* (3), is related to teachers' pedagogical use of digital teaching aids in classroom settings. This also means that the teachers have to possess a double dimension role as an important part of this didactic ICT competence in classrooms. In other words, teachers will, in one way or another, be role models for the pupils with regard to the didactic and pedagogical use of digital teaching aids. Hence, teachers' ability to "teach as they preach" will be an important guiding star for the pupils. At the same time, the teachers must continually make didactic judgements that focus on how digital teaching aids can expand the learning possibilities for pupils. This double dimension involves didactic ICT competence, which is similar to other occupations, but at the same time it is distinctive because teachers are preparing pupils for certification in school (summative assessment, exams), for further higher education and for future practice in society. A typical example of teachers' didactic competence is when a teacher, through his or her wide teaching repertoire in the classroom, is able to blend paper-based and digital teaching aids seamlessly and thus expand the possibilities for the pupil to understand the subject content. This is closely related to the next category of the model which highlights not only the teachers' didactic ICT use in the classroom but also how new *digital learning strategies* (4) used before, within and after classroom teaching can expand teachers' way of teaching and pupils' way of learning.

This next part therefore relates to the digital learning strategies that are required for teachers' own professional development as well as their ability to guide the pupils towards achieving new digital reading and learning strategies through the use of educational technology and ICT. Norwegian educational authorities provided a new definition of reading which included digital reading on screens in 2012. Regarding the PISA 2009 study, Frønes and Narvhus state that it is remarkable that the Norwegian percentage variance for digital reading is 19 percent, whereas for reading on paper about half (10 percent). In other words, the difference between the schools for the same students on the same sample is larger in digital reading than reading on paper, and Frønes & Narvhus state that it is natural to assume that this is due to differing digital practices in schools (Frønes & Narvhus 2012, p 112). Norway is also one of the countries where socio-economic variables mean less in terms of their impact on digital reading (Frønes & Narvhus, 2012, p. 110). Therefore, an important part of digital reading is the teachers' ability to show the pupils how multimodal texts should be used in their digital learning strategies to increase their learning outcome (especially for boys, who perform significantly weaker than girls on digital reading tests like PISA 2009). An example of such new digital learning strategies for the teachers is *flipped classrooms* or *flipped learning* (see Hamdan, McKnight, McKnight, & Arfstrom, 2013), where the pupils learn new subject material by watching 'homework' videos combined with other teaching aids and assignments in class during school hours when the teacher is available to provide guidance and elaborate on certain topics if necessary. The idea is that the teachers have the necessary digital learning strategies to guide both digital reading and these new digital learning strategies and to be a mentor for the pupils in both the physical and the virtual classroom. This implies that the teachers must utilise the pupils' basic digital skills as a starting point but must also maintain a strong focus on the metacognitive aspect, which enables pupils to delve deeper into the pedagogical use of ICT as an entry point for developing new digital learning strategies.

The final category of teachers' digital competence is linked to ethical considerations with regard to *digital Bildung* (5). This means a techno-cultural Bildung (*digital dannelse*) which is based on a more holistic understanding about how children and youth learn and how they grow and develop their identity in a digitised society (Løvlie, 2003). For today's upper secondary students in Norway (the majority being between 16 and 19 years old), the network society, the media and technology are important building blocks in their Bildung journey, where they can be described as *digital inhabitants*. This, of course, has an impact on how schools should utilise this new reality positively, even if many teachers may be *digital immigrants* and have witnessed the difficulties of weaving technology constructively into their teaching.

In summary, these five categories in the digital competence model (as well as the horizontal and vertical axes) are inspired by research and practice and aim to understand teachers' digital competence in school on a general level in research and in school monitoring; however, they are also an attempt to bridge the national curriculum's demands with teachers' competence needs. To incorporate these five categories in this theoretical digital competence model in the study, eight questions were selected in the questionnaire concerning these five categories and were then factor analysed (see Methodology).

School Monitoring and Indicators

Why is there a need to develop monitors for educational technology like the SMIL study? According to Scheuermann and Pedro (2009, p. 5), "Despite the fact that education systems have been heavily investing in technology since the early 1980s, international indicators on technology uptake and use in education are missing." They continue, stating that "… policymakers and researchers cannot be in a position to monitor what is truly going on in schools unless critical indicators about intensity, purpose and context of use of technology in education are available" (Scheuermann & Pedro, 2009, p. 6). School monitoring, therefore, makes it possible for school owners and school management on the regional and local levels to keep track of and monitor their school's development over time based on research (and not anecdotal evidence)—including how teachers' digital competence increases or decreases. For example, Harrison, Comber, Fisher, Haw, Lewin, Lunzer, McFarlane, Mavers, Scrimshaw and Somekh (2002) made an important contribution to this issue in the ImpaCT2 study in Great Britain; however, in order to facilitate accurate monitoring, there is also an increasing need to develop indicators for educational technology and ICT in Norway (see Krumsvik, Egelandsdal, Sarastuen, Jones, & Eikeland, 2013).This type of monitoring can generally be considered as a continuous evaluation that is part of a circular policy process that includes several stages. In this paper the focus is on a typical *secondary indicator*: teachers' digital competence.

Pelgrum (2009) suggests the following five stages when monitoring within the context of education: policy goals, assessment, evaluation and reflection, diagnosis and intervention. Pelgrum further claims that there is an imminent need nationally as well as internationally to develop *indicators* for monitoring within education, suggesting that this will make school leaders better prepared to implement research-based measures to increase pupils' learning outcomes when ICT is used in teaching. Krumsvik et al. (2013) describe an indicator as something one can *navigate* by when monitoring education, which can give us more insight over time with regard to the development within core areas in education. When operationalising the concept and implementing monitoring in education, the term *indicator* is usually seen in relation to concepts such as indicator area,[4] indicator definitions,[5] indicator statistics, primary and secondary indicators and indicator system.[6]

The Norwegian context is examined in this paper, and it is important to bear in mind that different ICT policies in different countries influence our perception of how to define teachers' digital competence based on its attachment to curricula. Thus, "[…] context is not always everything, but it colors everything" (Pajares, 2006, p. 342). In order to be able to compare outcomes internationally, the OECD report *Assessing the Effects of ICT in Education* (OECD, 2009) and its framework were used as a starting point in the SMIL study so that national (and maybe international) indicators for ICT use in school could be developed.

Methodology

In the SMIL study we aimed to explore whether there is a relationship between ICT and learning outcomes. An important part of the study is presented in this paper, where the attention is directed towards the relationship between demographic, personal and professional characteristics and teachers' individual digital competence. In order to be able to measure these relationships, we needed to develop a number of indicator areas and indicator definitions, as Pelgrum (2009) implied above, and teachers' individual digital competence is one such indicator area and indicator definition. Following analyses of relevant policy documents and literature reviews, six indicator areas were considered significant. These were primarily based on recommendations from the framework created by Kikis, Scheuermann and Villalba (2009), which can be found in the abovementioned OECD report. Findings within previous research and suggestions from our employer (KS) were also important when developing the indicator areas.

The six indicator areas consist of implementation strategies, access to PCs, curriculum and competence improvement, infrastructure to support learning, degree of ICT use in teaching and educational ICT activities (pupils). In the SMIL study all six indicators areas were explored with a number of relevant groups; however, in the current paper we concentrate on teachers and their individual digital competence. Indicator definitions were developed based on the indicator areas identified. These were rooted in well-established, distinguished theory, and the mixed methods design that was utilised in the wider study ensured that we also maintained a broad empirical foundation. The indicator definitions were then used when developing the instruments for collecting information. They were divided into operationalised indicator definitions, which means that they could potentially be used again when monitoring similar phenomena in the future.

In the wider SMIL study both qualitative and quantitative data were utilised as the basis for the data collection and analyses. The data were collected in sequences, and one of the important goals of the SMIL study was to give equal emphasis to both types of data and combine them in the analyses. In this paper we present only the quantitative data (survey) since the focus and the research question are directed towards the relationship between demographic, personal and professional characteristics and teachers' individual digital competence. The survey consisted of four parts, including demographic data, digital competence, approaches to digital educational resources and compliance between classroom management and digital competence. The teachers' digital competence part was further sectioned into five categories:

1. Elementary ICT
2. Basic ICT skills
3. Didactic ICT competence
4. Digital learning strategies
5. Digital Bildung

In the questions concerning teachers' attitudes, opinions and views about digital competence, adjectival Likert scales were used, offering seven response options ranging from "to no extent" (1) to "to a very large extent" (7). This prevented having a mixture of different types of scales and provided more stability and validity within the analyses. It also facilitated a more straightforward construction of indexes. The scales were rooted in theoretical models and were tested empirically to measure their robustness.

An online questionnaire was developed based on the goals of the education monitor, tentative findings in the qualitative interviews in the SMIL study, findings from previous research, the framework for the SMIL project and indicator areas and definitions. The questionnaire was piloted by two researchers in four schools in the Eastern Norway County Network using *live surveys* (Student Response System). Information was gathered from 153 teachers and 921 students in this pilot. KS's project group and the SMIL project's scientific advisor also examined the questionnaire during the pilot phase. When the pilot phase was completed, an electronic survey[7] developed in the online questionnaire system SurveyExact was completed by teachers and students in the Eastern Norway County Network.

The study sample was drawn using *purposeful selection* (Maxwell, 2005) and was comprised of 2, 477 teachers from all public upper secondary schools in the seven counties in the Eastern Norway County Network.

Statistical Analyses

The research questions explore whether there is a relationship between demographic, personal and professional characteristics and teachers' individual digital competence. The survey questionnaire was imported directly from the electronic database into Excel and then into SPSS for statistical analyses. Demographic data were explored using descriptive analyses calculating average scores, standard errors and minimum and maximum values. The data material was thoroughly examined and was presented as frequencies.

In order to explore the relationship between the variables, correlation analyses were used—Pearson's product moment correlations were used for variables at the interval level and cross tabulations were used for variables at lower levels.

To measure the relationship between demographic, personal and professional characteristics and teachers' individual digital competence, it was necessary to convert the digital competence model into a measurable quantity, or an *index*. The teachers were asked to estimate their digital competence in areas such as elementary and basic ICT skills, didactic ICT competence and learning skills related to directing pupils when using ICT and digital judgement (i.e., digital use, digital learning strategies and digital sophistication). Eight of the questions measuring how teachers perceive their own digital competence were considered to be most relevant based on face value. These were then factor analysed in order to reveal possible factors that could be used to develop the digital competence index. The questions that were chosen had the same scale designs and were therefore directly comparable. An exploratory factor analysis was chosen since the scale used in the survey was newly developed. The questions were analysed for their internal consistency by means of Cronbach's alpha. Cohen's guidelines were used, where a correlation coefficient of .10 is considered to represent a small correlation, a correlation of .30 is considered medium and correlations above .50 are considered large (Cohen, 1969). The sample consists of 2,477 teachers, so due to the high N, the significance level is 0.001 in all analyses. The factor analysis was conducted using an oblimin rotation, which allows the factors to be correlated (Russell, 2002). The factor loadings are outlined in Table 1 below.

Table 1

Factor Loadings (Oblique Rotated) from the Principal Axis Factor Analysis (N = 2477)

Questions	**Factor 1**	**Factor 2**	**Communalities**
"How would you rate your *basic skills* when using digital tools in school?"	**.86**	.01	.76
"Based on the previous questions, how would you estimate your overall digital competence in relation to teaching?"	**.84**	.51	.78
"How would you rate your *elementary skills* when using digital tools in your leisure time?"	**.81**	-.02	.72
"How would you rate your skills within didactic ICT use?"	**.77**	.38	.63
"How would you estimate your competence to guide students' digital judgement related to their digital lifestyle within and outside of school?"	**.66**	.56	.58
"How would you rate your skills in guiding students in the use of digital learning strategies?"	**.62**	.57	.55
"Based on the previous questions, how would you estimate the students' overall digital competence within school subjects?"	.27	.75	.57
"To what extent do you believe the teachers at your school are good role models for the students' curricular ICT use in education?"	.13	.74	.56
Eigenvalue:	3.9	1.3	

Question 8 and question 10 load on both factors produced from the analysis (see Table 1). Hence, they must be interpreted according to the other variables loading on the two factors. Factor 1, as we see it, is the (an) indicator of teachers' individual digital competence; factor 2 indicates a contextually related competence scale that also included teachers' understanding of their own competence and skills.

Factor 1 statistically explains 48.5% of the variation. Six out of the eight variables analysed show loadings above the guidelines for identifying significant factors (Hair, Anderson, Tatham, & Black, 1998), and these were used to create an index representing the teachers' digital competency. Questions 12 and 13 were not included in the index due to their low factor loadings. Compared to the other questions, questions 12 and 13 are more related to how the teacher perceived others' (pupils' and colleagues') competence rather than their own digital competence.

Technically, the index is the arithmetical mean of the answers to the six questions included. A Cronbach's alpha value of .86 indicates that the internal consistency of the digital competence index was high.

Having identified the teachers' digital competence index, a regression analysis was completed in order to analyse whether the demographic, personal and professional characteristics, such as the teacher's age, work experience, screen time or ICT education, could predict their individual digital competence. All statistical analyses were conducted in SPSS version 22.

Results

The teacher survey consisted of four parts, including demographic data, digital competence, approaches to digital educational resources and compliance between classroom management and digital competence. Some of the demographics as well as the main findings related to digital competence are reported here as these are most relevant for the research questions and discussion in this paper. For a full description of all the results, see Krumsvik et al. (2013).

The demographic data show that 53.5% of the teachers were female and 46.5% were male. Most age groups were represented. Twenty-one percent of the teachers stated that they had worked 15 years or more in upper secondary education, 29.8% had worked 7–15 years, 11.1% had worked 3–7 years and 13.6% had worked 3 years or less. Other significant information relates to teachers' opinions about whether the good access that pupils have to PCs in schools is important when it comes to learning outcomes: 49.4% of the teachers answered that they thought it was very important. However, from these teachers, 27.3% answered "5," which is the next scale number above the middle; 27.8% of the teachers considered the access to PCs to be of medium importance and 22.8% of the teachers thought that good access to PCs had little significance.

The teachers' self-reported data concerning the five elements of the digital competence model revealed that on a adjectival Likert scale offering seven response options ranging from "no skills" (1) to '"very good skills" (7), they answered in the following way: 21.4 % answered "5," 34.5 % answered "6" and 38.4 % answered "7" on *elementary ICT skills*; 25. 6% answered "5," 40.6 % answered "6" and 24.0% answered "7" on *basic ICT skills*; 20.5 % answered "4," 36.7 % answered "5" and 25.3 % answered "6" on *didactic ICT competence*; 15.4 % answered "3," 32.9 % answered "4" and 27.6 %

answered "5" on *digital learning strategies* and 22.8 % answered "4," 32.7 % answered "5" and 23.0 % answered "6" on *digital Bildung*. When teachers considered their overall digital competence (with all the five elements included), 21.8 % answered "4," 40.9 % answered "5" and 23.3 % answered "6."

A digital index covering six questions based on the theoretical model was developed. In order to explore whether there was a relationship between demographic, personal and professional characteristics and teachers' digital competence, the index was statistically analysed and compared to a number of factors.

Table 2 presents an overview of mean scores and standard deviation for digital competence in relation to the *gender*, *work experience* and *age of the teachers*. Women have a higher mean score of digital competence than men; teachers with over 15 years of work experience have the lowest mean score of digital competence and digital competence decreases for teachers aged 50 years and older.

Table 2

Teachers' Digital Competence in Relation to Gender, Work Experience and Age

Measure	Mean	Standard deviation	(N)
Gender*			
Men	5.0	0.93	(1143)
Women	5.2	0.83	(1334)
Work experience*			
3 years or shorter	5.1	0.77	(342)
3–7 years	5.2	0.82	(567)
7–15 years	5.3	0.87	(571)
15 years or more	5.0	0.93	(998)
Age*			
20–31 years	5.3	0.79	(30)
32–37 years	5.3	0.76	(170)
38–43 years	5.3	0.79	(268)
44–49 years	5.3	0.82	(443)
50–55 years	5.2	0.86	(466)
56–61 years	5.0	0.88	(399)
Over 61 years	4.8	0.91	(298)

Note.* $p < .00$.

Table 3 shows how teachers' formal ICT education has an impact on their level of digital competence. Teachers with the longest formal ICT education are those with the highest level of digital competence. Teachers with continuing ICT education have higher digital competence than teachers with no continuing education.

Table 3

Teachers' Digital Competence in Relation to Type of ICT Education

Type of ICT education	**Mean**	**Standard deviation**	**(N)**
Formal ICT education*			
No formal ICT education	5.0	0.85	(1 645)
15 credits or less	5.3	0.81	(247)
15–30 credits	5.4	0.84	(187)
30–60 credits	5.7	0.79	(273)
Continuing ICT education *			
Yes	5.4	0.85	(573)
No	5.0	0.86	(1 776)

Note.* p < .00.

Table 4 shows how the digital competence varies with teachers' screen time. Teachers with low screen time are those with the lowest digital competence and digital competence increases with an increase in screen time. The digital competence evens out when it reaches a screen time between 10–12 hours per day. As Table 4 shows, few teachers report their screen time to be above 12 hours a day (2.6 %).

Table 4

Teachers' Digital Competence in Relation to Screen Time

Screen time*	**Mean**	**Standard deviation**	**(N)**
0–2 hours	4.6	1.09	(205)
2–4 hours	4.9	0.86	(641)
4–6 hours	5.1	0.78	(815)
6–8 hours	5.3	0.80	(459)
8–10 hours	5.5	0.82	(215)
10–12 hours	5.7	0.81	(79)
12–14 hours	5.6	0.77	(35)
14–16 hours	5.3	1.30	(11)
Over 16 hours	5.5	1.09	(17)

Note.* p < .00.

Digital competence is correlated with the independent variables as follows (Pearson's bivariate correlation): gender (-.08), age (-.18), work experience (-.10), screen time (.28), formal ICT education (.28) and continuing ICT education (.19).

Table 5

Hierarchical Regression Analysis for Variables Predicting Teachers' Digital Competence (N=2477)

	Model 1			Model 2			Model 3			Model 4		
	B	SE B	Beta	B	SE B	Beta	B	SE B	Beta	B	SE B	Beta
Gender #	-.12*	.05	-.07	-.19*	.03	-.10	-.14*	.03	-.08	-.15*	.03	-.09
Age	-.09*	.01	-.018	-.09*	.01	-.18	-.07*	.01	-.14	-.08*	.01	-.16
Formal ICT edu.				.25*	.02	.30	.23*	.02	.27	.18*	.02	.22
Screen time							.13*	.01	.22	.13*	.01	.21
Work experience							-.01	.02	-.01	-.02	.02	-.02
Cont. ICT edu.										.28*	.04	.14
R2		.038			.122			.166			.182	
F/sign.		42.6/.00			236.7/.00			62.0/.00			39.7/.00	

Note. * p < .00. # Gender (0=W; 1=M). Abbreviations: Formal ICT education (Formal ICT edu.) Continuing ICT education (Con. ICT education)

Table 5 shows that formal education contributes mostly to the determination coefficient in Model 2, where age and gender from Model 1 are included as well. The significant negative effects of age and gender indicate that male teachers and older teachers show slightly less digital competence compared to females and younger teachers. In Model 4, teachers' screen time and work experience are included. Only the amount of screen time contributes significantly to digital competence. In the last Model, teachers with continuing ICT education have significantly more digital competence than those without such education. However, the beta coefficient shows that the effect of formal (and prior to this) ICT education is higher (0.22 vs. 0.16), but teachers' self-reported screen time use is close to formal education in terms of the effect (0.21).

Discussion and Implications

The main objective in this paper was to describe the part of the SMIL study related to teachers' individual digital competence. More specifically, we wanted to examine whether demographic, personal and professional characteristics influence teachers' individual digital competence with the following research question: What is the relationship between teachers' individual digital competence and demographic, personal and professional characteristics (teacher's age, work experience, gender, screen time and ICT education) in upper secondary school?

The study shows that when examining the SMIL teachers' individual digital competence, there is a clear tendency indicating that they have quite good elementary and basic ICT skills, but their didactic ICT competence, digital learning strategies, digital Bildung and overall digital competence are more blended.

As demonstrated above, we found that it is statistically possible to draw on a theoretical model in order to explore the relationship between teachers' individual digital competence and demographic, personal and professional characteristics. Through the regression analysis we found that the variables formal education and teachers' self-reported screen time contribute mostly to explaining the highest individual digital competence among teachers. We also found that those teachers with continuing ICT education have significantly more digital competence than those without such education. These results mean that these variables can predict some of the complexity of what constitutes teachers' individual digital competence in upper secondary school, but at the same time we need more research on other factors and characteristics that can provide a complimentary picture of what constitutes teachers' individual digital competence. The internal consistency of the digital competence index was measured to be high, which indicates that the theoretical model has certain potential within this area and can be followed up with by, for example, confirmatory factor analysis to examine the model's further potential.

The implications of this part of the SMIL study are that demographic, personal and professional characteristics, such as a teacher's age, work experience, gender, screen time and ICT education, predict teachers' high or low digital competence in upper secondary school to a certain degree. Our findings are related more generally to those of Christensen and Knezek (2008), Yuen and Ma (2002), Mumtaz (2000), Sipilä (2014), Howard (2013), Loveless (2011) and Underwood and Dillon (2011), which shows that it is often a combination of demographic, personal and professional characteristics that affect teachers' use of ICT in teaching and digital literacy. Our findings complement Ferrari's (2012) analysis of the framework of digital competence in practice.

On a more general level, our study contributes to monitoring what is going on in schools when it comes to teachers' individual digital competence. The theoretical digital competence model with high internal consistency revealed in the digital competence index can be seen as an indicator developed in this study (at the theoretical and methodological levels). This can be used by other researchers and school owners in future studies to examine and monitor teachers' individual digital competence over time in school settings. On a more practical level, we found that formal ICT education, continuing ICT education and teachers' self-reported screen time can be seen as indicators of teachers' individual digital competence. The implication of these findings is that school owners have to monitor such indicators in the years to come and implement strategies that support vulnerable teacher groups in order to increase their individual digital competence (e.g. though continuing ICT education).

Limitation

The digital competence index in this study is based on teachers' self-ratings, and this might be a limitation of the study.

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Notes

1. Sammenhengen Mellom IKT-bruk og Læringsutbytte (the relationship between ICT use and learning outcomes).
2. Pupils in all Norwegian upper secondary schools are provided with one laptop each.
3. In this paper digital literacy and digital competence are similar concepts, but in our SMIL study we used digital competence, which is the most commonly used concept in the Scandinavian countries.
4. Indicator areas are general areas one wishes to explore (such as infrastructure).
5. Indicator definition means the indicator's exact formulation for what one wishes to study (such as PC density per student).
6. In the SMIL study a set of primary and secondary indicators were developed in order to answer the main research question. Collectively, they represent an indicator system that school owners can use when monitoring education in the future.
7. Available from the first author upon request.

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