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Khalid, Md. Saifuddin; Slættalíð, Tóri; Parveen, Mahmuda; Hossain, Mohammad Shahadat

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A systematic review and meta-analysis of teachers' development of digital literacy

Md. Saifuddin Khalid and Tóri Slættalíð

Aalborg University, Denmark

Mahmuda Parveen

University College Nordjylland, Denmark

Mohammad Shahadat Hossain

University of Chittagong, Bangladesh

Teachers' development of digital literacy (DL) is gaining importance with the increase in the integration and adoption of information and communication technologies in educational contexts. The focus has been predominantly on students and not much on teachers, who require greater attention due to rapid transformation of both school systems and digital systems' applications. The goal of this systematic literature review is to draw attention of researchers, policy-makers, and practitioners associated with education systems for considering 'digital literacy for the professional development of teachers' as an agenda for the transformation at both individual level and organizational level. Applying the methodology elaborated by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, 16 peer-reviewed articles were selected. Constant-comparative method was used for the qualitative analysis. This paper reports on three main categories: (a) definition of digital literacy, (b) development of digital literacy of pre-service and in-service teachers and (c) models for the development and evaluation of digital literacy. The general definitions of DL include the elements of technical, cognitive, and social aspects. The circumstances and conditions in relation to both pre-service and in-service teachers can help to create a culture that develops DL. Existing DL models can be adopted in teacher education programs and schools and can thus be verified.

Introduction

In this digital age, digital literacy (DL) is described as a 'survival skill' (Eshet-Alkalai, 2004), without which citizens cannot acquire knowledge and skills necessary for life in the 21st century (Martin & Grudziecki, 2006). With the increased integration and adoption of digital technologies in the contexts of both formal and informal learning environments, teachers' development process in relation to the concept of DL requires greater attention. The discussion on DL concept might be claimed to have taken off with the publication of Paul Gilster's 'Digital Literacy' book (Gilster, 1997). Some scholars have indicated that the concept of DL has been coined at different times or context, discontinued, and diffused through different networks' paths (Almås & Krumsvik, 2007; Bawden, 2008). Therefore, the concept of DL is broad and understanding the DL development process of teachers is a challenge. It is substantiated by significant number of scholars that DL competence has a significant impact on teachers' and students' development in the society that is increasingly adopting digital technologies (Almås & Krumsvik, 2007; Bawden, 2008).

An overview on the discussion of the DL gives the impression that most of the existing literature mainly focuses on students' development of this skill and that teachers' DL is a peripheral issue (Hall, Atkins, & Fraser, 2014; p. 5). This imbalance must be taken into consideration. Almås and Krumsvik identify DL as the major challenge in Norwegian primary schools as there is '[...] highly digitally confident students [...] and [there is] a lack of digitally literate teachers' (Almås & Krumsvik, 2007). In this situation, Almås and Krumsvik (2007, p. 173) recommended that teachers must have DL to handle their teaching, instruction, and assessment. It is also believed that the security of teachers' proficiency in DL will provide more opportunities for pupils to develop their DL (Pianfetti, 2001). From a globalization perspective, Spring (2008, p. 338) argued that it is in public schools that students are prepared for lifelong learning, as required by the rapidly changing technology in a global economy. DL should be seen as a part or even as a prerequisite for lifelong learning. Due to the lack of focus on the DL of the teachers in educational contexts, this paper aims to contribute to a state-of-the-art study on teachers' development of DL. This

study conducts a systematic literature review and a meta-analysis of the relevant literature dealing with teachers' development of DL.

The goal of this study is to draw attention of researchers, policy-makers, and practitioners associated with education systems, and to consider 'digital literacy for the professional development of teachers' as an agenda for the transformation at both individual level and organizational level. This paper explores and introduces the themes and topics emphasized in the existing literature dealing with teachers' DL. The educational institutions and teachers are expected to gain understanding about the definition of DL, barriers to the development of DL, and how to evaluate their own DL.

The paper contains three main sections. The Methodology section discusses the process of identification, inclusion, and analyses of articles. Then, their main categories of themes are reported as part of qualitative analysis and synthesis, followed by a meta-analysis. Finally, the Discussion section includes reflection and identification of the scope of future work.

Methodology

This study applies the methodology elaborated by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher, Liberati, Tetzlaff, & Altman, 2009). A systematic literature review is defined as

A systematic, explicit, [comprehensive] and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners. (Okoli & Schabram, 2010).

The PRISMA statement is an evidence-based minimum set of items, which includes a 27-item checklist and a four-phase flow diagram (Figure 1). This paper strictly adheres to the flow diagram as a methodology but does not rigorously comply with the checklist, primarily due to the space-quality trade-off associated with the page limit of a conference article as opposed to a report.

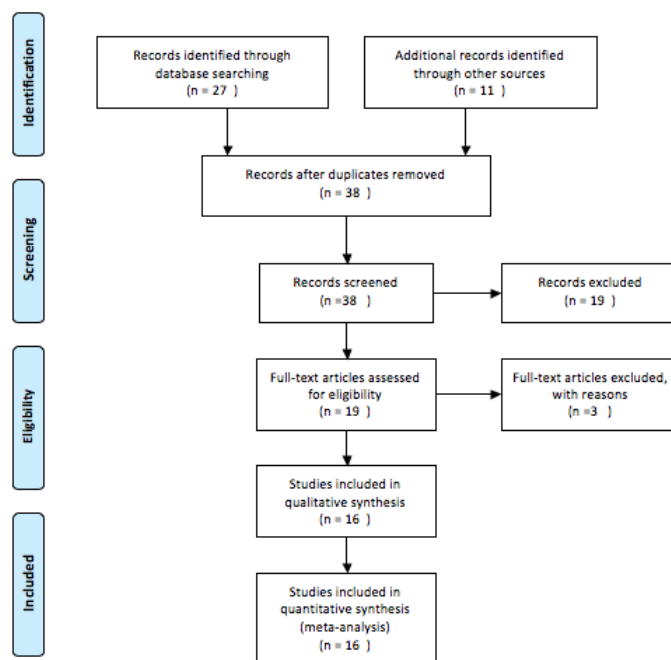


Figure 1 PRISMA Flow Diagram (Moher et al., 2009)

Three databases were selected and searched through EBSCO host. They are as follows: Academic Search Premier, The Education Resources Information Center (ERIC) and Teacher Reference Center. Searches were conducted on the abstracts of peer-reviewed articles, during 19/09/2014 to 23/09/2014, using different combinations of the following keywords and synonyms: develop* digital literacy, teacher*,

instructor*, educator*, tutor*, competence* and skill*. To focus on a context and thereby to reduce the number of papers returned, school* and classrooms* were included. After the removal of duplicates, the abstracts of 27 articles were rigorously assessed and the full-texts of the articles were considered for screening.

The criterion for further exclusion was determined by answering the question, does this study deal with the digital literacy of teachers? With this query, 19 of 27 articles were excluded due to their research focus on children/pupils' development of DL and lack of focus on teachers' DL. At this stage, seven articles were included for the qualitative analysis and meta-analysis. It is worthwhile to reflect on two points on the search and selection/rejection phases on this topic. First, at the search phase, it was difficult to separate the literature that deal with teachers only. Second, publications emphasizing teachers' DL constitute less than 26% (7 of 27) of the articles published on the DL of teachers and students.

A forward reference-chain was explored by looking for relevant literature that cited the seven selected articles, and a backward reference-chain was explored by screening the lists of references included in the seven articles. First, searching the titles in Google Scholar, the articles that cited the selected articles were identified and screened. The search, selection, and exclusion process was done using the same focus questions that were used in the previous stage. Second, by searching titles occurring in the lists of the seven selected papers' references and by considering articles that occurred during database searches, more articles were screened, and 11 additional unique articles were considered. Later, 2 of these full-text articles were excluded.

Constant-comparative method (Hewitt-Taylor, 2001) is used for the qualitative analysis and synthesis, which includes 14 peer-reviewed journal articles and 2 project reports. Based on the meta-data of source databases, it was not possible to verify whether the two reports are peer-reviewed.

Qualitative Synthesis and Meta-Analysis

This section is divided into three sub-sections: (a) an overview of the articles, (b) a qualitative synthesis, and (c) a quantitative analysis or meta-analysis.

Overview of the articles

The articles that were included in the selection process are shown in Table 1 and Table 2. Table 1 contains the articles that were selected through database screening, and Table 2 presents the articles identified through screening the references of the selected articles. The tables provide an overview of the articles' focus, methods, research goals, and categories.

Table 1

Overview of the seven articles identified through database screening

Author (Year), & Title	Context & Focus	Methods	Research goals	Relevant themes
1. Burnett (2011), Pre-Service teachers' digital literacy practices: Exploring contingency in identity and digital literacy in and out of educational contexts	United Kingdom. Student teachers	Interviews	Digital practices and identity in pre-service teachers' lives.	DL and personal identity. Developing learning communities.
2. Pianfetti (2001), Focus on research: Teachers and technology: digital literacy through professional development	USA. Teachers	Argument with the use of secondary data and literature.	Exploring the relationship between DL and the professional development of teachers in technology	Definitions of DL. The need for teachers' DL. The challenges of preparing educators for teaching in the 21st century.

3. Martin & Grudziecki (2006), DigEuLit: Concepts and tools for digital literacy development	Europe. Teachers and students	Conceptual research	Defining DL, and developing a framework and tools for DL development in European context.	Definition of DL. Framework for developing teacher's DL.
4. Almås & Krumsvik (2007), Digitally literate teachers in leading edge schools in Norway	Norway. Teachers	Case study with interviews	An analysis on how DL is implemented in leading edge schools by digitally literate teachers in the new curriculum.	DL and identity. Definition of DL. DL model. Management's involvement and teachers' DL enhancement.
5. Krumsvik (2009), Situated learning in the network society and the digitised school	Norway. Teachers	Theoretical research – use of relevant theories	Can situated learning and DL create new approaches in educational Practices? Where to reflect in new assessment forms?	Definition of the DL. Developing communities of practice.
6. Wan Ng (2011), Why digital literacy is important for science teaching and learning,	Sydney, Australia. Teachers and students	Conceptual research	Defining DL and discussing why DL is important for science teaching and learning, and the implications for teachers.	Developing DL in teacher education. Definition of DL. DL: a technical, cognitive, and social competence. Implications for teachers.
7. Gruszczynska, Merchant, & Pountney (2013), Digital futures in teacher education: Exploring open approaches towards digital literacy	Sheffield, England. Student teachers	Report of findings from the project	Embedding Open Educational Resources (OER) practice in teacher education for the development of DL	Digital natives – lacking the cognitive and social aspects. Developing DL in the context of school and teacher education. Inadequate views of DL in schools.

Table 2.

Overview of the nine articles identified through forward and backward reference chaining

Author (Year), & Title	Context & Focus	Methodology	Research goals	Relevant themes / categories
1. Ala-Mutka (2011), Mapping Digital Competence: Towards a Conceptual Understanding	Europe. DL as a whole	Presentation of the conceptual discussion in the literature on digital competence.	Reviewing and mapping different concepts and understandings relating to digital competence.	Definition of DL. Components of Digital Competence (DC): knowledge, skills, and attitudes.
2. Collier, Foley, Moguel, & Barnard (2013), Write for your life: Developing digital literacies and writing pedagogy in teacher education	California, United States. Student teachers	Interview and survey	Two courses with 45 teacher students, integrating writing pedagogy and technology in the contents of teacher education courses.	Designing an online community for the development of DL. Developing DL through writing.
3. Erstad (2007), The fifth basic skill	Norway. Primary	Conceptual analysis using	Problematizing – the ability to use digital	Five dimensions of digital

(translated from Norwegian)	school (Nursery or class 0-10)	empirical research results	tools is considered as a basic skill, and the role of school education.	competence (DL)
4. Eshet-Alkalai (2004), Digital literacy: A conceptual framework for survival skills in the digital era	Israel. Adult students and pupils	Interviews	Proposing a holistic refined conceptual framework for DL.	Conceptual framework of DL. Framework for the development and evaluation of DL.
5. Hall, Atkins, & Fraser (2014), Defining a self-evaluation DL framework for secondary educators: the DigiLit Leicester project	Leicester, United Kingdom. Teachers	Review of the existing frameworks of DL.	Demonstrate how the critique of existing digital literacy frameworks enabled a self-evaluation framework for practitioners to be developed.	Definition of DL. Analysis of existing DL frameworks. Devise and implement DigiLit Leicester framework.
6. Jimoyiannis & Gravani (2011), Exploring adult digital literacy using learners' and educators' perceptions and experiences: The case of the second chance schools in Greece	Greece. Generally focus on adults	Case study using Interviews	To shed light on adult DL using learners' and educators' experiences and perceptions at Second Chance Schools, a project in Greece aiming to combat social exclusion through education.	Framework for understanding DL. Barriers to DL. Attitudes towards the enhancement of DL.
7. Jordan (2012), Bringing video into the mainstream: Recommendations for enhancing peer feedback and reflection.	University of the Arts London, England. In-service student teachers (2-20 years' experience)	Video recordings of peer-feedback, presentations, personal experience, and feedback interviews	Discusses the benefits and challenges of video as a tool for supporting and enhancing peer feedback and reflection.	The embedded use of video in professional development courses can help to develop the digital literacy of teaching staff.
8. Merchant (2009), Literacy in virtual worlds	Sheffield, England. Teachers and primary school students	Case study of a 3D virtual world: Field notes, in-world interviews and observations	An analysis of pupil and teacher perspectives on the use of DL and its relationship to conventional classroom literacy routines, and use these to trace the potential and inherently disruptive nature of such work.	Teachers need of time for experimentation and professional development; Development of DL through technology-rich environments
9. (Wan Ng, 2012), Can we teach digital natives digital literacy?	Sydney, Australia. Student teachers or pre-service teachers	Mixed method	<i>Digital nativeness</i> of undergraduate students of by investigating their knowledge about educational technologies and the ease with which they learn to make use of unfamiliar technologies.	Conceptual framework of DL Dimensions of DL: Cognitive, technical, and social-emotional.

Qualitative synthesis

This section presents the main themes that were collected from the selected articles focusing on the issue of teachers and the development of their DL.

Definition of digital literacy

DL is a relatively new concept, and most of the articles do attempt to define it. There is not so much disagreement about how DL is defined, but there are differences in how the term is adopted as part of the work of various articles. Most of these definitions are general, but a few researchers are trying to narrow down the definition to emphasize on teachers (Almås & Krumsvik, 2007; Hall et al., 2014; Krumsvik, 2009). The general definitions contain elements of technical, cognitive, and social aspects of the DL, while the narrow definitions focus on the pedagogical knowledge. Almås & Krumsvik's definition is an example of this:

'Digital literacy for in-service teachers is the ability to use digital artefacts as an integrated part of their pedagogical content knowledge and be aware of what implications this has for teaching, learning strategies and building aspects' (Almås & Krumsvik, 2007; p. 487).

This definition focuses on the technical (*ability to use*) and cognitive (Pedagogic knowledge and awareness) aspects. Such definitions lack focus on the social aspect of DL. In addition to the above definition, Hall and Atkins et al. (2014, p. 4) point to the teachers' *attitude* (position), which is part of the learning aspect, and argues that it is a fundamental prerequisite for other aspects. They also emphasize the teacher's critical thinking – why, how, and when technology contributes to student learning. Krumsvik (2009) emphasized critical thinking when he, two years after the above definition, changed it from 'pedagogical content knowledge' to 'pedagogic-didactic judgment', taking into account the teacher's assessment of digital tools for teaching. This change may be due to the large number of digital tools that teachers have to decide from. Therefore, teachers need a better understanding of tools to evaluate these tools. This concept will evolve with new challenges.

Development of teachers' digital literacy

Trained teachers begin their profession with a desired level of knowledge on content and pedagogy, but lack the DL because of a lack of dedicated time to develop such competence through education and training (Ng, 2011; p. 30). For an effective development of DL to take place, the pre-requisites include some social and spatial conditions (Ng, 2011). In addition to time, there must be a culture of recognition and mutual respect from both the management and employees (Jimoyiannis & Gravani, 2011, p. 225; Pianfetti, 2001, p. 258). Support from management in the form of technical support and access to resources is also required to create good conditions for DL development (Almås & Krumsvik, 2007, p. 491; Wang & Ng, 2011, p. 21). The strengthening of technology-rich events provides good conditions for natural integration of technology into the everyday life of teachers. This natural integration also allows teachers to experiment and create opportunity for reflection on how digital technologies can be incorporated into the classroom (Merchant, 2009; p. 54). Furthermore, by creating practice environments or *collective scaffolding* (Krumsvik, 2009; p. 175). 175) DL can also be developed through shared activities that are closely related to everyday life, and provide the possibility of carrying out the concept of *learning by doing* and *learning through interaction* (Almås & Krumsvik, 2007, p. 482; Burnett, 2011, p. 447; Collier et al., 2013, p. 265).

There is strong emphasis on student teacher's (or pre-service) development of digital literacy. Based on the focus on the reviewed literature, there is slightly higher focus on student teachers (31%) compared to DL of practicing teachers (25%). This trend appears desirable as Haugerud suggests, '[...] there is an explicit need to investigate how student teachers develop their understanding of teaching in a technology-saturated environment' (2011, p. 227).

Broadly, it can be stated that the literature on the development of teachers of the DL is written in the very circumstances (i.e. in-service, pre-service, school, early childhood, etc.) that make the DL development a more natural process for the teachers.

Models for the development and evaluation of digital literacy

Martin and Grudziecki (2006, p. 255) present a model that can be used for self-reflection on and evaluation of DL of individuals by looking at the DL in three levels, where the bottom layer includes the most basic elements and involves higher complexities at the higher levels. The model can be used as self-reflection and assessment of individuals' DL.

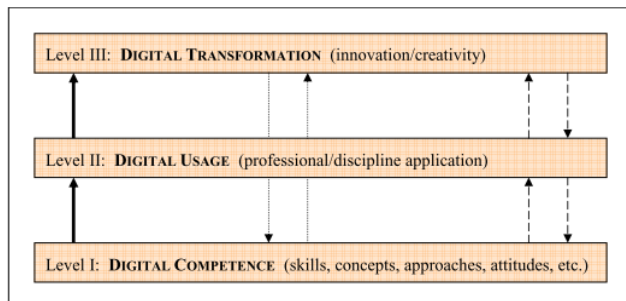


Figure 1 Model for self-reflection on and evaluation of DL of individuals (Martin & Grudziecki, 2006; p. 255)

Erstad (2007, p. 48) presents five dimensions of DL and shows the practices of DL that take place in a school context. These are (a) proficiency in use, (b) ICT as a private field of knowledge, (c) ICT in subjects, (d) ICT and learning strategies, and (e) cultural competence or perception towards the digital. These dimensions can also be put into Ng's (2012) dimensions to see DL as a balance across the three dimensions: technical, cognitive and socioemotional. These two models can be used for implementing an education that develops DL and for the evaluation and development of teachers' own DL skills.

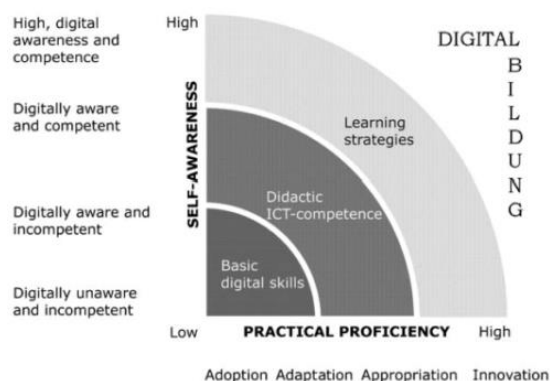


Figure 2 Five dimensions of digital literacy (Almås & Krumsvik, 2007; p. 485)

Alma & Krumsvik (2007; p. 485) developed a detailed model aimed directly at the development of teachers' DL (see Figure 2). The model is based on what they see as the four levels of DL, develops in proportion to the development of teachers' practical IT skills and self-awareness in the practical situation: (a) basic digital skills, (b) didactic ICT-competence, (c) learning strategies, and (d) digital formation. It is also an attempt to sensitize teachers' 'tacit knowledge' (p. 486).

Meta-Analysis

The geographical distribution of the articles shows that there is a clear tendency to focus on the DL in Europe than elsewhere. 69 per cent of the articles (11 of 16) deal with a European context. One possible reason can be EU's agenda, set forth in the year 2000, on the globalization discourse by drawing attention to the DL related term *lifelong learning*, which was regarded as necessary for citizens to keep up with changing work demands and technologies (Spring, 2008; p. 339). Of these 11 articles, 5 (45%) are from the UK, 3 (27%) from Norway and 2 (18%) focused on a general European context. Among the rest, there are two articles from Australia, both of which have the same author, and two from the United States.

An overview of the articles shows that 31 per cent focus on student teachers, 25 per cent on practicing or in-service teachers, and 18 per cent on in-service teachers and students simultaneously. Altogether, in-

service teachers' DL is considered in 43 per cent of the articles. The remaining 26 per cent has a more general focus. There is a clear tendency to focus on student teachers in the newer articles. In Table 2, the five articles that focus on student teachers are all from 2011–2014.

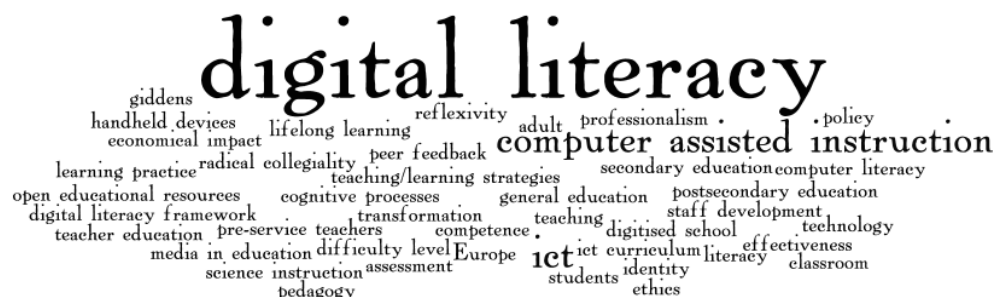


Figure 3 Word cloud using keywords of articles

12 of the 16 selected articles specified keywords, the word cloud (generated using wordle.net) in Figure 3 shows that the most frequent keywords are *digital literacy*, *computer assisted learning*, and *ICT*. With the few key words, it is not possible to look at a specific trend. However, it is interpreted that the keywords emphasize on the macro level, for example, *economic impact*, *policy*, and *Europe*.

Discussion and scope of future work

In this review, three main themes of digital literacy of schoolteachers were chosen to for qualitative synthesis.

First, the general definitions of DL include the elements of technical, cognitive, and social aspects. However, the social aspect is not sufficiently present in the definitions dealing with teachers. Considering how social media and Web 2.0 technologies have transformed schools in the recent years, there is a need for re-defining the term with the social networking aspects. Hall et al. (2014), however, has included the social aspect of the definition.

Second, regarding the findings on teachers' development of DL, we expected explicit guidelines on how teachers should develop their DL. The articles discussed the circumstances and conditions that can help to create a culture that develops DL. This may allude to a social-constructivist understanding of the evolution of DL, where learning and development takes place in a social context through interactions. 'Cultural conditioning in school develops DL of teachers' is a hypothesis that should be researched further. Furthermore, the development of teachers' DL is constrained due to the following barriers: lack of dedicated training time for DL, lack of a culture of recognition for IT-pedagogy integration competence, lack of support from management for both access to resources and technical support. In situ technology-rich events for *collective scaffolding*, *learning by doing*, and *learning through interaction* are expected to solve these barriers.

Third, the DL models (Almås & Krumsvik, 2007; Erstad, 2007; Martin & Grudziecki, 2006) show that DL development and evaluation process involves complex combinations of competence dimensions and stages. There is ample scope for empirical testing and validation of these models in situated context, and long-term diffusion of innovations study might be required for sufficient understanding and improvement of these models (Khalid, 2014).

The meta-analysis part on only 16 articles possibly shows hypothetical trends. However, these hypotheses can be considered in other studies for testing. Therefore, meta-analysis is seen as a prelude to further investigations of these generating trends. A review on teachers' digital *competence* is a related concept that should also be reviewed to contribute to the scope of this paper.

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