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A framework of pre-service teachers' conceptions about digital literacy: Comparing the United States and Sweden

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ABSTRACT

We examine the conceptions of digital literacy of pre-service teachers in the United States (n = 188) and Sweden (n = 121). Pre-service teachers were asked to define digital literacy in an open-ended fashion and to select those skills that they considered to be essential for digital literacy from a list of 24 skills provided. Based on pre-service teachers' open-ended responses, four profiles of digital literacy conceptions, progressing in sophistication, were identified (i.e., technology focused, digital reading focused, goal directed, reflecting critical use). Moreover, pre-service teachers' selections of skills or competencies essential for digital literacy were used in cluster analysis. Profiles of digital literacy conceptions were consistent across open-ended and selected-response forms of assessment. Important similarities and differences in conceptions of digital literacy across the United States and Sweden are discussed, as are implications for improving teacher education.

1. Theoretical frame

The Programme for International Student Assessment (PISA) defines digital literacy as students' ability to: "evaluate information from several sources, assessing the credibility and utility of what is written using self-established criteria as well as the ability to solve tasks that require the reader to locate information, related to an unfamiliar context, in the presence of ambiguity and without explicit directions" (OECD, 2015, p. 50). In 2006, the European Union launched an initiative emphasizing digital competence, based on OECD's identified competence areas. The definition of digital competence that emerged, referred to as DigComp 2.0 (European Commission, 2017) has developed, from a definition that mainly focused on operational and technical "know-how" towards one that included more knowledge-oriented cognitive, critical, and socially responsible perspectives. Many similar definitions abound (Buckingham, 2010; Fraillon, Ainley, Schultz, Friedman, & Gebhardt, 2014; Hobbs & Coiro, 2019; Spante, Hashemi, Lundin, & Algers, 2018).

Across these definitions there has been the shared recognition that digital literacy stands as a critical competency for today's learners, challenged by the technological, informational, cognitive, and socio-emotional demands of the digital age. Despite the emphasis that has been placed on digital literacy throughout the literature, less is known about how individuals themselves may define digital literacy and the competencies that it requires. The focus of this study is to understand how pre-service teachers, in particular, soon to be tasked with instructing their own students in digital literacy, define or conceptualize this construct. We examine definitions

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of digital literacy among pre-service teachers in two national and educational contexts, the United States and Sweden, and propose a framework for the progressive development of pre-service teachers' conceptions of digital literacy.

We consider the examination of conceptions of digital literacy across national, cultural, and educational settings to be essential, as preparedness in digital literacy has been considered necessary for students' economic participation across developed nations, including the United States and Europe, and a point of international cooperation across governments (Chetti, Qigui, Gcora, Josie, Wenwei, & Fang, 2018; Van Dijk, 2009). The United States and Sweden were selected as national settings because of important commonalities and differences in these nations' approaches to digital literacy. On the one hand, these both reflect developed countries, wherein access to technology is plentiful; on the other hand, while Sweden has demonstrated a commitment to digital literacy (i.e., referred to as digital competence) in its national curriculum (Swedish Ministry of Education, 2018), no similarly broad and centralized commitment in the United States has been forthcoming for reasons of both curriculum and policy (Davis, South, & Stevens, 2018). In this study, we examine the extent to which such commonalities and differences contribute to conceptions of digital literacy among pre-service teachers in the United States and Sweden.

1.1. Defining digital literacy

A variety of frameworks defining digital literacy and associated constructs [e.g., information literacy, Internet and communications technology (ICT) literacy, multimedia literacy, 21st century skills] populate the literature (Alexander, *The Disciplined Reading, & Learning Research*, 2012; Bawden, 2008; Spante et al., 2018; Stordy, 2015). Ng (2012), drawing together various definitions, suggests that digital literacy arises at the intersection of students' technical, cognitive, and socio-emotional competencies. The technical dimension of digital literacy includes students' "technical and operational skills to use ICT for learning and in every-day activities" (Ng, 2012, p. 1067). The cognitive dimension encompasses the skills students need to search for, evaluate, and create digital information as well as students' abilities to critically analyze this information. Finally, the socio-emotional dimension of digital literacy requires that students be able to use ICTs for responsible communication, collaboration, and other social goals related to learning.

In a more expansive framework, Eshet-Alkalai (2004) considers students' digital literacy to include a set of five, interrelated literacies. These are photo-visual literacy, reproduction literacy, branching literacy, information literacy, and socio-emotional literacy. Photo-visual literacy refers to students' skills in "reading" or comprehending the graphic and other multimedia information that characterizes content on the Internet. Reproduction literacy, or synthesis, refers to students' skills in combining disparate pieces of information to create a novel product. Branching literacy refers to students' skills in navigating the range of information available online and is particularly engaged when learners try to traverse hypertexts, characterized by their hierarchical or lateral linking to one-another. Information literacy refers to the skills involved in analyzing and evaluating the variety of information available online and is necessary for students to be critical consumers of said information. Finally, socio-emotional literacy refers to students' adherence to online norms for collaboration and communication, and the social sharing of information on the Internet. In an updating of this framework, Eshet-Alkalai (2012) added real-time thinking as a sixth literacy, corresponding to students' competencies in simultaneously processing a large volume of stimuli, as is done during online learning or video game play.

1.2. Students' conceptions of digital literacy

Beyond these efforts to define digital literacy, limited work has examined students' own definitions of digital literacy, referred to as *conceptions* in this study, due to their often componential nature, including the skills and competencies that students consider to be essential for digital literacy. Although students' conceptions of digital literacy have yet to be directly examined, at least three related literatures may have a bearing on these. These are literatures on students' attitudes toward technology adoption, beliefs regarding their own digital literacy skills, and investigations of professional competence, within pre-service teacher populations, more specifically.

1.2.1. Students' attitudes toward technology adoption

Among the most robust literatures on students' digital-literacy-related perceptions and beliefs, has been the literature on students' attitudes toward technology (Garcia-Martin & Garcia-Sanchez, 2017; Lai, 2017; Lee, Yeung, & Cheung, 2019; Lu, Yu, Liu, & Yao, 2003; Marangunic & Granic, 2015). This has included general considerations of students' positive and negative attitudes toward various technological tools as well as more specific attitudes about the usefulness and usability of various technologies, both contributing to students' likelihood of technology adoption. At the same time, such attitudes toward and readiness for technology use can be viewed as only a part of the competencies that students need for digital literacy.

1.2.2. Students' beliefs about their own digital literacy

Beyond examining learners' attitudes toward technology, their self-beliefs regarding digital literacy have been examined, as well. In particular, such investigations have often focused on students' self-efficacy for various facets of technology use and found these to be quite high (Albion, 2001; Bates & Khasawneh, 2007; Hatlevik, Throndsen, Loi, & Gudmundsdottir, 2018). In addition to examining self-efficacy for digital literacy and its constituent skills, generally, some studies have specifically asked students to report on their own skills with regard to digital literacy (Hatlevik, Gudmundsdottir, & Loi, 2015; Schmid & Petko, 2019). However, studies of both self-efficacy and self-reports of skills related to digital literacy have been found to be discrepant with the actual degree of digital literacy-related competency that learners evidence (Haltevik et al., 2018; Porat, Blau, & Barak, 2018). Such discrepancies, in our mind, point to the importance of examining not only students' self-efficacy for digital literacy, but more fundamentally students' conceptions

of what digital literacy entails – as we seek to do in this study.

1.2.3. Professional competence as a facet of digital literacy

In work on both attitudes toward technology adoption and self-efficacy beliefs about digital literacy, in addition to examining undergraduate samples generally, specific attention has been paid to the beliefs and attitudes of pre-service teachers, in particular (e.g., Burnett, 2011; Güneş & Bahçivan, 2018; Joo, Park, & Lim, 2018; Ma, Andersson, & Streith, 2005; Scherer, Tondeur, Siddiq, & Baran, 2018; Teo, Lee, & Chai, 2008). Pre-service teachers are a key sample within which to examine conceptions of digital literacy. This is the case for two primary reasons. First, they are undergraduate students, likely demonstrating the same deficits in digital literacy as have been documented in other college-level populations (Eshet-Alkali & Amichai-Hamburger, 2004). Second, they are pre-professionals, soon to be charged with teaching their own students about digital literacy. Indeed, pre-service teachers' conceptions about what constitutes digital literacy may have a profound effect not only on their own behaviors as learners, but also on their instructional practices and the digital literacy skills that they emphasize or neglect in teaching their future students about this concept. Teachers' beliefs on a variety of topics have been found to influence the nature of classroom instruction (Ertmer, 2005; Fives & Buehl, 2012; Pajares, 1992; Stuart & Thurlow, 2000), particularly where technology integration is concerned (Chen, 2011; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Inan & Lowther, 2010).

Recognizing the specific importance of examining digital literacy among pre-service teachers, Krumsvik (2008; 2014) introduced a framework for the professional digital competence that teachers need to meaningfully use technology in their classrooms and recognize its role in students' lives and in society (Krumsvik, 2008; 2014). In introducing the Digital Competence Model, developed in a Scandinavian context, Krumsvik (2008; 2011; 2014) suggest that teachers' professional digital competence includes four components: (a) basic ICT skills, (b) didactic ICT competence, (c) learning strategies, and (d) digital *bildung*. Basic ICT skills refer to teachers' hands on technology use, including adoption, adaption, appropriation, and innovation. Didactic ICT competence refers to teachers' pedagogical technology use or the use of technology to accomplish epistemic aims, related to students' knowledge building. Learning strategies require teachers to examine their own processes for learning about technology and to consider how such processes may translate to their students. Finally, digital *bildung* is a meta-awareness that connects teachers' technological competence to an understanding of the greater digitalization of society, as a whole. Informed by this broader framework, in this study we focus on the first component that Krumsvik (2008) identifies, pre-service teachers' basic ICT skills. Moreover, in recognition of their fundamental nature, we focus specifically on what pre-service teachers conceptualize these ICT competencies (here termed digital literacy or digital competence) as including.

1.3. Present study

In this study, we examine pre-service teachers' conceptions of digital literacy. Our focus on pre-service teachers' conceptions is motivated by a desire to understand how such beliefs may transfer to the instructional choices that teachers make in the classroom, with these decisions translating to students' academic experiences with digital literacy. We view such conceptions as the origin point for teachers' decision-making about curriculum, methods, and assessment when supporting students' digital literacy development. In examining conceptions of digital literacy, in this study we build on prior work by adopting a more culturally comparative approach. In particular, we juxtapose the digital literacy conceptions of pre-service teachers in the United States and Sweden. Comparing conceptions of digital literacy in the United States and Sweden allows for an informative cross-cultural investigation for a number of reasons. For one, these both represent developed nations where the importance of digital literacy has been emphasized by political, economic, and educational institutions. Indeed, both countries have competencies related to digital literacy or instruction with technology featured in their standards for teacher education (CAEP, 2018; OECD, 2015; Council of the European Union, 2018). At the same time, these two settings differ in the school contexts within which digital literacy may be expected develop. In particular, these settings differ in both their curricula and in their assessment practices with regard to digital literacy. While Sweden has a central national curriculum, emphasizing digital literacy, curricula in the United States are localized, with different states and districts differentially defining and emphasizing digital literacy in their instructional standards (Porter, McMaken, Hwang, & Yang, 2011; Schmidt, Whang, & McNight, 2005).

Second, while teachers in Sweden have been found to be quite concerned with students' performance on standardized assessments of digital literacy (Brante & Stang Lund, 2017), standardized assessments in the US have typically not tapped digital literacy (Davis et al., 2018). In particular, secondary students in Sweden are required to compose argumentative essays based on information presented across multiple texts as a part of their standardized assessment process. In the United States, standardized assessments are much more likely to target domain-general reading comprehension skills, manifest in relation to a single text. Research on digital literacy in Sweden has mainly followed two tracks; how digital technology is implemented in classrooms (e.g. Andersson & Sofkova-Hashemi, 2016; Bergdahl, Fors, Hernwall, & Knutsson, 2018; Sofkova Hashemi & Cederlund, 2017) or how students search and evaluate information on the Internet (Nygren & Guath, 2019; Sundin, 2015). Research concerning conceptions of digital literacy among pre-service teachers are not, to the best of our knowledge, available.

More generally, cross-cultural and cross-national comparisons have long been a tradition in beliefs research, providing key insights into the universality of conceptions of knowledge, information, and now digital literacy (List, Peterson, Alexander, & Loyens, 2018; Magionni, Riconscente, & Alexander, 2006; Muis & Sinatra, 2008). Examining conceptions across national settings that are similar yet distinct allows for their nature to be better understood. That is, it allows us to consider what aspects of conceptions of digital literacy may be commonly held among pre-service teachers in economically developed nations versus which aspects may be distinct. However, recent work has only begun to examine digital-literacy-related constructs comparatively (e.g., Cai & Gut, 2018; Davis et al., 2018; Noh,

2019). In this initial investigation, we seek to identify some emergent similarities and differences in pre-service teachers' digital literacy conceptions across two national settings. Our hope is that future investigations will examine such differences further and expand the analyses in this study to other national settings, similarly concerned with issues of digital literacy. In this study, we compare conceptions of digital literacy in the United States and in Sweden as a way of further examining not only the universality of such conceptions but also their manifestation within particular cultural, educational, and national contexts. We do this by collecting both quantitative and qualitative data of pre-service teachers' conceptions. First, pre-service teachers were asked to define their conceptions of digital literacy in an open-ended fashion. Then, students were asked to select those elements that they considered to be most essential for digital literacy, from a set of 24 options developed based on frameworks of digital literacy introduced in prior work (e.g., Ng, 2012). Thus, we focus on the following research questions:

1. What are pre-service teachers' conceptions of digital literacy in the United States?
2. What are pre-service teachers' conceptions of digital literacy in Sweden?
3. How do conceptions of digital literacy differ in the United States vis-à-vis Sweden?

2. Methods

2.1. Research design

This study employed an exploratory mixed methods design. This mixed-method approach allowed us to use qualitative results to inform our quantitative analysis (Creswell & Plano Clark, 2011). Such a design is especially useful when a clear theoretical framework does not yet exist (Creswell & Plano Clark, 2011), as was the case in this study, as pre-service teachers' conceptions of digital literacy have not yet been examined in prior work. We began with the coding of participants' open-ended definitions to get a sense of pre-service teachers' conceptions of digital literacy. Then, based on the themes emerging from the qualitative coding, we chose items from the quantitative portion of our survey to cluster into profiles of digital literacy conceptions. All data were collected at one time point in an electronic survey via Qualtrics (in the United States) and Google Forms (in Sweden). A comparison of contexts, samples, and methods across the two countries can be found in Table 1.

2.2. United States sample

In the United States, pre-service teacher preparation includes a bachelor's degree in elementary, middle grades, or secondary education, typically earned over four years. During those four years, pre-service teachers complete general education courses (e.g., educational psychology), methods classes (e.g., reading instruction), and a student-teaching practicum, during which they are placed in classrooms and supervised by a mentor teacher. Pre-service teachers pursuing secondary certification typically also complete content and methods courses (e.g., biology and biology instruction) in their subject area of interest.

Table 1
Comparison of samples and data collection across countries.

	United States	Sweden
Context		
Pre-Service Teacher Preparation	Bachelor's degree in elementary, middle grade, or secondary education, typically earned over four years	3.5 years for kindergarten-teacher; 4 years for 1st-6th grade; 4.5–5.5 years for grades 7-12
Preparation Program Focus	General education courses, methods classes, and a student-teaching practicum	Subject studies, educational science, and a placement in schools
Guiding Standards	Council for the Accreditation of Educator Preparation: "model and apply technology standards as they design, implement and assess learning experiences to engage students and improve learning."	Higher Education Ordinances: "be able to demonstrate the ability to safely and critically use digital tools in the educational setting and to take into account the role of different media and digital environments in educational settings."
Sample		
N	188	121
Sampling Method	Convenience, Voluntary	Convenience, Voluntary
Sampling Frame	Those enrolled in education majors at a large, public university in the United States	Those enrolled in pre-service training at four different universities in Sweden
Data Collection Method	Electronic survey in Qualtrics administered in a lab environment	Electronic survey in Google Forms, sent to participants to complete at a time and location of their choosing
Time Point	Fall 2017	Spring 2018
Methods		
Survey Language	English	Swedish, with responses translated into English by researcher
Open-Ended Question	Recently, there has been a push to teach students digital literacy or to develop students' 21st century literacy skills. How do you define digital literacy? What skills do you consider to be necessary for digital literacy?	How do you define digital literacy? What skills do you consider to be necessary for digital literacy?
Selected Response Instructions	Below we list different skills that have been associated with digital literacy. Please select the five (5) skills you consider to be most critical for digital literacy.	Below we list different skills that have been associated with digital literacy. Please select the six (6) skills you consider to be most critical for digital literacy.

To some extent, instruction in digital literacy is well-represented in teacher education programs in the United States. Specifically, the Council for the Accreditation of Educator Preparation (CAEP) lists among its standards for teacher preparation programs that teachers be able to: “model and apply technology standards as they design, implement and assess learning experiences to engage students and improve learning.” Nevertheless, being able to use technology as a part of instruction does not ensure that teachers develop well-formed conceptions of digital literacy and understand how it may be developed and assessed in their students (Simard & Karsenti, 2016).

Participants were 188 undergraduate students at a large, public university in the United States. This was a convenience sample with voluntary participation. Students cannot be considered to be representative of pre-service teachers in the United States. Students, 18 and older, enrolled in an educational psychology course that constitutes an introductory class for the teacher education program were invited to participate for extra credit. In the sample, 38.30% (n = 72) were interested in teaching at the early elementary level (i.e., Pre-Kindergarten to 2nd grade), 31.91% (n = 60) were interested in teaching elementary school (i.e., 3rd-5th grade), 15.43% (n = 29) of students wanted to teach middle school (i.e., 6th-8th grade), while 31.91% of the sample was interested in teaching high school (n = 60, 9th-12th grade). As a note, these percentages do not add up to 100% as students could indicate that they were interested in teaching more than one grade level. Some students (n = 9) further specified their grade preference as *other*, indicating that they were interested in teaching special education, English as a second language, or post-secondary students. Data were collected in Fall 2017, approximately two months into the semester. Data were collected as part of a broader study examining students' conceptions of digital literacy (List, 2019) and multiple text task performance, a task associated with digital literacy; however, data are uniquely presented in this study.

2.3. Swedish sample

Swedish teacher education differs in length, depending on which age group pre-service teachers are aiming to teach. To become a kindergarten-teacher, students study for 3.5 years; to teach up to 6th grade, students study for four years. To teach grades 7–12, students need to study for 4.5–5.5 years, depending on how many subjects they intend to teach. Swedish teacher education programs consist of three interwoven parts: one is subject studies, another is educational science (e.g. knowledge about the teaching profession and schools as social, pedagogical, and didactic environments), and the third is placement in schools, where pre-service teachers develop skills in planning and delivering lessons, classroom management, and relationship building with students. Standards for teacher education programs, found in the Higher Education Ordinances (SFS, 2018:1053), address digital literacy by asking students to “be able to demonstrate the ability to safely and critically use digital tools in the educational setting and to take into account the role of different media and digital environments in educational settings.”

Participants were 121 pre-service teachers at four different universities in Sweden. This was also a convenience sample with voluntary participation and was not representative of Sweden, as a whole. Invitations to the survey were sent to contacts at the universities with a request that it be sent out to pre-service teachers in their first semester of study. Invitations to participate were distributed via email and via the learning management systems used by various universities. Among participants, 38.01% (n = 46) planned to teach Kindergarten, 15.70% (n = 19) intended to teach in primary school, 28.10% (n = 34) in middle school, 8.26% (n = 10) in school-years 7-9, and 8.26% (n = 10) in school years 10–12. One participant (0.83%) was not sure about the grades they intended to teach and one participant (0.83%) reported an intent to teach another age group. Data were collected in Spring 2018. Participants had studied for approximately four weeks in their teacher education programs prior to responding to the survey.

2.4. Measures

Participants in the U.S. and Sweden were asked to complete parallel measures of their conceptions of digital literacy. Conceptions of digital literacy were assessed using open-ended and selected-response questions. All questions were asked in an electronic survey with participants typing their responses to the open-ended question and selecting their responses from a list for the selected-response question.

2.4.1. Open-ended question

Pre-service teachers' conceptions of digital literacy were first assessed using an open-ended question. Specifically, participants were asked: *Recently, there has been a push to teach students digital literacy or to develop students' 21st century literacy skills. How do you define digital literacy? What skills do you consider to be necessary for digital literacy?* This question was developed to, on the one hand, contextualize digital literacy skills for those who may not have been familiar with the construct; and, on the other hand, allow responses to be as undirected as possible. This is why, “how do you define digital literacy” was the focal question. Nevertheless, a follow-up prompt, asking participants to identify the skills that they associate with digital literacy, was included for those experiencing challenges responding to the prompt. This prompt was consistent with the skill-oriented examination of this construct that has been found to characterize the bulk of prior work (Ng, 2012).

2.4.1.1. Coding process. While using a top-down coding scheme based on prior research (e.g., Eshet-Alkalai, 2004; Ng, 2012) was initially attempted, pre-service teachers' definitions of digital literacy were found to be more limited than those populating the literature. Therefore, a bottom-up coding scheme was adopted. Conceptions of digital literacy were coded through a four-step process. Initially, the first and second authors of the paper independently reviewed participants' definitions of digital literacy to identify any

patterns or categories to emerge. The authors then discussed these patterns and, together, categorized responses according to these patterns. Once categories could be consistently identified in pre-service teachers' responses, authors created working definitions for each of these categories and identified prototypical examples. Third, authors independently coded responses for a second time, placing them into the common categories established. Finally, authors again came together to corroborate their coding and to establish inter-rater consistency. This four-step process was carried out first for participants in the United States and then for those in Sweden, with consistent categories identified across these two settings. Raters coded the open-ended responses first, separately from examining the selected-response, skill-preference question.

2.4.1.2. Coding scheme. Pre-service teachers' open-ended conceptions of digital literacy were placed into one of four categories, considered to progress in sophistication (see Fig. 1). Specifically, participants' open-ended definitions were coded as reflecting technology-focused, digital reading, goal-directed, and critical use-based conceptions of digital literacy. These categories were created to be mutually exclusive, such that responses were placed into one and only one category of digital literacy conceptions. Additionally, these categories were created to be exhaustive, with as many responses as possible classified into these four categories.

Coding categories and sample responses are presented in Table 2. For the U.S. sample, Cohen's kappa inter-rater agreement was 0.81, based on 40 student responses (21.28% of the sample; exact agreement: 85.00%). For the Swedish sample, two raters coded 36 student responses (29.75% of the sample), with Cohen's kappa inter-rater agreement equal to 79.17%, indicating strong agreement (exact agreement: 83.33%). In instances when responses could conceivably be placed into more than one category, the more sophisticated category was selected. For instance a response such as: *Digital literacy is reading, writing, and comprehending through materials on a digital screen (for example, computers, television, cellular device, tablet.) For digital literacy, someone needs to be competent in regular literacy and also have knowledge about technologies,* could be placed either into the digital reading category or into the technology-focused category because of its insistence that digital literacy requires "knowledge about technologies." In such an instance, the more sophisticated digital reading category was selected. At times, students identified skills not explicitly mapping onto our digital literacy framework. For instance, one student defined digital literacy as: *The skills necessary for digital literacy are being capable of using technology and being proficient in its use. Also, being able to communicate through technology,* with "communicating through technology" constituting a unique response and one not expressly included among the conceptions of digital literacy that we identified. Nevertheless, in this case, the response was placed into the technology-focused category because of its focus on the role of technology in facilitating communication. More generally, the decision approach we adopted in classifying response with unique skills identified was determining the category of best-fit.

2.4.2. Selected-response question

After defining digital literacy in an open-ended fashion, pre-service teachers were asked to select the skills that they considered to be essential for digital literacy, from a list provided. Specifically, participants were told: *Below we list different skills that have been associated with digital literacy. Please select the five (5) skills you consider to be most critical for digital literacy.*

The list of skills that pre-service teachers could select from are included in Table 4. List items were generated through a four-step process. First, researchers reviewed the literature base to identify key components of digital literacy, with technological, cognitive, and socio-emotional aspects of digital literacy identified, as per Ng (2012). Second, four researchers in the field of digital literacy were asked to generate a list of skills that they considered to be essential for digital literate. Third, researchers compared and corroborated the skills they identified, with common skills, identified across researchers, selected for inclusion and skills uniquely identified by only one researcher analyzed for inclusion or exclusion. This list of common skills was also compared to literature-based definitions of digital literacy to ensure that all concepts were addressed, with additional items generated, as needed. Finally, once a comprehensive list of skills involved in digital literacy was developed, researchers reviewed this list once again with the goal of paring it down as much

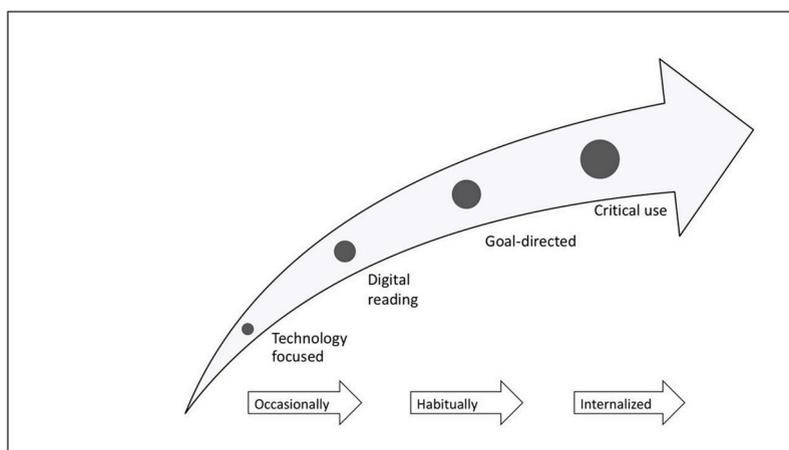


Fig. 1. Framework for progression of digital literacy conceptions.

Table 2
Summary of coding categories for open-ended responses.

	Definition	Example
Technology Focused	An understanding of digital literacy that is technology driven and focused on mastering specific technological tools (e.g., computers, Internet use).	I consider digital literacy to be having an understanding of technology and how it works. The skills I consider necessary would be typing, using a computer like programs such as Google and Microsoft Word, and being able to use an iPhone correctly.
Digital Reading	An understanding of digital literacy that is focused on the translation of traditional print literacy to digital contexts and all that entails.	I would define digital literacy as readings and information being available online. You can not only access one piece of information online, you can access multiple sources all at once. Skills I think are necessary are knowing how to use and navigate a computer, Reading skills, and focus.
Goal Directed	An understanding of digital literacy that is focused on using digital tools to accomplish specific tasks.	... I would describe it as figuring out ideas and concepts that you need to through a more digital use and reading what you need in order to complete that.
Critical Use	An understanding of digital literacy that sees it as the reflective and evaluative process of using technology and reading digitally, to accomplish task goals.	I would define digital literacy as the ability to have an understanding and the ability to be digitally savvy, whether that be knowing what technological resource to use and when or understanding the implications of the digital age. I consider an open mind and maturity necessary to be necessary for digital literacy.

Table 3
Categories of open-ended responses by country.

	United States		Sweden	
	n	%	n	%
Technology Focused	74	39.36%	43	35.50%
Digital Reading	53	28.19%	2	1.70%
Goal Directed	33	17.55%	33	27.30%
Critical Use	23	12.23%	20	16.50%
Other	5	2.66%	23	19.00%

Table 4
Endorsement of selected-response items by country.

	United States		Sweden	
	n	%	n	%
1. Searching for and selecting relevant information ^b	45	23.94%	99 ^a	81.82%
2. Integrating and synthesizing information from different sources	47	25.00%	22	18.18%
3. Critically evaluating source trustworthiness ^b	59 ^a	31.38%	88 ^a	72.73%
4. Comparing and contrasting information across different sources ^b	19 ^a	10.11%	41	33.88%
5. Using a variety of technology tools (e.g., Excel, YouTube, Quizlet)	74 ^a	39.36%	43	35.54%
6. Selecting the best technology tools for different tasks (e.g., Prezi vs. Powerpoint)	47	25.00%	43	35.54%
7. Enjoying using technology	19 ^a	10.11%	21	17.36%
8. Being willing to learn and adopt new technology	59 ^a	31.38%	54 ^a	44.63%
9. Using and understanding multimedia (e.g., videos, infographics)	54	28.72%	26	21.49%
10. Creating multimedia (e.g., videos, infographics)	29	15.43%	18	14.88%
11. Writing (e.g., research papers) based on information on the Internet	42	22.34%	22	18.18%
12. Creating projects or presentations based on information on the Internet	41	21.81%	15 ^a	12.40%
13. Forming connections between different pieces of information	30	15.96%	18	14.88%
14. Changing existing views based on new information	6 ^a	3.19%	10 ^a	8.26%
15. Using prior knowledge to evaluate information on the Internet	22	11.70%	27	22.31%
16. Taking individual responsibility for finding information ^b	9 ^a	4.79%	31	25.62%
17. Collaborating using technology tools (e.g., GoogleDocs)	45	23.94%	39	32.23%
18. Gathering information to make decisions and learn about topics of interest	48	25.53%	17	14.05%
19. A willingness to search for information to answer questions	21 ^a	11.17%	24	19.83%
20. Forming a personal understanding of information	31	16.49%	23	19.01%
21. Using reliable search platforms (e.g., library databases) to find information	86 ^a	45.74%	38	31.40%
22. Taking notes and organizing information	36	19.15%	13 ^a	10.74%
23. Looking for and understanding different perspectives	26	13.83%	26	21.49%
24. Communication and sharing information on the Internet (e.g., blogs, Wikis, social media)	41	21.81%	27	22.31%

Note.

^a Significant differences within country when comparing to proportion of item selected by chance.

^b Significant differences between country on proportion of item selection.

as possible. This resulted in a final 24-item list of digital literacy skills identified. Skill descriptions were then phrased to be both maximally inclusive and distinct from one another. Participants were given the opportunity to write-in any skills they considered to be essential, when completing this measure; however, none added any skills as essential for digital literacy. This was the case across both national settings.

2.5. United States procedures

Data for this study were collected as part of a larger examination of pre-service teachers' multiple text use in the digital age but are uniquely presented in this manuscript. These analyses are based on pre-service teachers' responses to a researcher-designed survey of digital literacy. Participants completed the digital literacy survey in a computer lab, with a researcher present, using the Qualtrics survey platform. Responses were typed by participants within the electronic survey platform.

2.6. Swedish procedures

2.6.1. Measure translation

The Swedish author received an English version of the survey from the first author and did an initial translation of the survey from English to Swedish. A professional translator at the Swedish author's home university then reviewed this translation. This was followed by a discussion between the translator and the Swedish author to clarify the meaning of words and phrases, before a final, Swedish version of the survey was created.

When the survey was translated into Swedish, the term 'digital literacy' was changed to 'digital competency.' This was done for two main reasons. First, the term *literacy* is not easily translated into Swedish and the connotation of this term is not readily interpreted by lay-people. Second, the Swedish government has recently introduced an initiative to strengthen citizens' *digital competence*, making this concept widely familiar to a Swedish audience and especially to pre-service teachers. Indeed, a revision of the national curriculum to strengthen digital competence among students was launched in July 2018 (Skolverket, 2018).

Moreover, a recent literature review addressing the use of the terms digital literacy vis-a-vis digital competence is aligned with our differential use of these terms (Spante, Hashemi, Lundin, & Algers, 2018). Spante et al. found that within the Swedish context, *digital literacy* is considered to be a more research-based term, while *digital competence* is a more policy-relevant construct (Spante et al., 2018). Furthermore, Spante et al. confirmed geographical differences in the use of these terms. While the term digital literacy was found to be more frequently used in English-speaking studies, conducted in the United Kingdom and the United States, studies from Scandinavia, Spain, and Italy more commonly use the term digital competence. Nevertheless, we considered both the terms digital literacy and digital competence to convey the same concept to students, with the latter more appropriate for use with the Swedish sample.

Again, responses were typed by participants within the electronic survey platform. Swedish students responded to the survey in Swedish and Swedish responses were translated into English by the second author prior to coding.

2.6.2. Differences from U.S. Survey

A few important differences distinguished the Swedish digital literacy survey from that used with the U.S. sample. First, when selecting the skills considered to be essential for digital literacy, participants in Sweden were asked to select six, rather than five, skills from the list of 24 provided. Second, the digital literacy skills that participants were asked to choose from were presented in the same order, rather than randomized, for the Swedish sample.

Despite these inconsistencies in administration, we considered the assessments of pre-service teachers' conceptions of digital literacy across the United States and Sweden to be largely comparable. This was the case for two reasons. First, pre-service teachers' open-ended responses were collected in the same way across these two settings. This resulted in consistency with regard to how categories of conceptions of digital literacy were determined. Second, in addition to comparing the absolute percent of students selecting particular digital literacy skills as essential, across settings, we also examined the proportion of participants selecting particular digital literacy skills, above chance. In other words, beyond comparing the percent of participants selecting a particular skill in the United States vis-a-vis Sweden, within each setting, we also considered the extent to which a skill was disproportionately endorsed (i.e., above 5/24 or 20.83% in the United States and above 6/24 or 25.00% in Sweden) by learners. This served to mitigate any selection inflation that may have resulted from students in Sweden being able to select six, rather than five, skills as essential for digital literacy. A final difference across these contexts was that pre-service teachers in the U.S. sample completed the digital literacy survey online, in a lab setting, with a researcher present, whereas those in Sweden completed the survey online at a time and location of their choosing.

2.7. Data analysis procedures

Data analysis procedures were identical for both samples. We began with the qualitative portion of our analysis, coding the open-ended responses via the four-step process outlined above. Coding was done manually with the use of Excel for tracking. Pre-service teachers' open-ended conceptions of digital literacy were coded into one of four categories (i.e., technology-focused, digital reading, goal directed, critical use), with responses unable to be otherwise coded placed into the *other* category.

We then quantitatively examined pre-service teachers' selections of the skills or competencies that they considered to be essential for digital literacy. First, we examined the frequency with which participants selected various skills as essential for digital literacy.

Second, cluster analysis was used to see whether patterns in participants' digital literacy conceptions could be determined based on a subset of skills selected. Next, a subset of digital literacy skills, of the 24 that participants had to choose from, were selected for use in a cluster analysis. The goal of the cluster analysis was to identify patterns in pre-service teachers' skill selections and examine the extent to which these mapped on to conceptions of digital literacy identified based on their open-ended responses. Due to limitations in sample size, all twenty-four skills could not be included in our cluster analysis. Rather, four skills were chosen as predictors for clustering (i.e., "using a variety of technology tools;" "using and understanding multimedia;" "gathering information to make decisions and learn about topics of interest;" and "critically evaluating source trustworthiness"). These four skills were selected by researchers based on their alignment with the four conceptions of digital literacy identified in participants' open-ended responses.

A two-step cluster analysis was performed with pre-service teachers' selection of these four skills, or not, used as binary predictor variables. Two-step clustering was selected as the preferred clustering algorithm for three primary reasons. First, two-step clustering has been described as an effective clustering method due to its integration of hierarchical and partition-based approaches to clustering (Sarstedt & Mooi, 2014, pp. 273–324). Second, two-step cluster analysis did not require a specific number of clusters to be designated a-priori (Norušis, 2011); rather, the optimal number of clusters was determined based on the Bayesian Information Criteria (BIC). The exploratory nature of this study resulted in our preferring this statistical basis for cluster determination. Finally, two-step clustering is able to use both continuous and categorical variables as predictors (Norušis, 2011), the latter of which were used in this study. Due to the binary nature of the four predictors used in our analyses, clusters were determined based on the log-likelihood distance.

Finally, we examined the relation between categories of digital literacy conceptions, determined based on participants' open-ended responses, and cluster membership, determined based on participants' answers to the selected response question. A chi-squared test of association was used to determine whether the categories that pre-service teachers were placed into, based on their open-ended responses, corresponded to their cluster membership. All quantitative analysis was performed in SPSS 23.0.

3. Results

Conceptions of digital literacy, gathered via open-ended and selected response questions, were first examined independently within each national setting (RQ1 and RQ2), and then compared across contexts (RQ3).

3.1. RQ1: What are pre-service teachers' conceptions of digital literacy in the United States?

For the first research question, we examined U.S. pre-service teachers' open-ended and selected response conceptions of digital literacy.

3.1.1. Open-ended

See Table 3 for the frequency of pre-service teachers placed into each category. A chi-squared goodness of fit test determined membership to be disproportionately distributed across categories [$\chi^2(4, n = 188) = 76.04, p < .01$, Cramer's $V = 0.32$].

3.1.2. Selected-response

Selected-responses were analyzed in terms of frequency of selection, profiles of selection, and the association between open-ended and selected-response profiles.

3.1.2.1. Frequency of skill selection. See Table 4 for the frequency with which pre-service teachers selected each item. Four items were chosen by more than 30% of respondents as essential for digital literacy. A chi-squared goodness of fit test was used to determine whether participants selected each of the 24 available skills to a disproportionate extent. As participants in the U.S. were asked to select 5 out of 24 skills, each skill had a 20.83% chance of being selected at random. We were interested in whether any skills were disproportionately over or under selected, relative to chance (i.e., 20.83%). Nine skills were found to be disproportionately selected as essential for digital literacy, based on a Bonferroni-adjusted alpha of .002. These skills are indicated in Table 4 via an α .

Table 5

Centroids for selected-response clusters in the U.S. Sample.

	Cluster 3	Cluster 1	Cluster 4	Cluster 5	Cluster 2
	Technology Focused	Digital Reading	Goal Directed	Critical Use	Limited
	21.81% ($n = 41$)	15.96% ($n = 30$)	25.53% ($n = 48$)	20.74% ($n = 39$)	15.96% ($n = 30$)
Using a variety of technology tools	1.00 (0.00)	0.00 (0.00)	0.44 (0.50)	0.31 (0.47)	0.00 (0.00)
Using and understanding multimedia	0.42 (0.50)	1.00 (0.00)	0.13 (0.33)	0.03 (0.16)	0.00 (0.00)
Gathering information to make decisions	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Critically evaluating source trustworthiness	0.00 (0.00)	0.30 (0.47)	0.23 (0.42)	1.00 (0.00)	0.00 (0.00)

Note: Clusters ordered by progression of conceptualizations. For validation, a series of chi-squared tests were performed to ensure that the clusters identified varied in their endorsement of the target skills examined as essential for digital literacy. As expected, the five clusters identified were found to differ in their selection of items reflecting using a variety of technology tools [$\chi^2(4, n = 188) = 103.70, p < .01$, Cramer's $V = 0.74$], using and understanding multimedia [$\chi^2(4, n = 188) = 108.99, p < .01$, Cramer's $V = 0.76$], gathering information to make decisions [$\chi^2(4, n = 188) = 188.00, p < .01$, Cramer's $V = 1.00$], and critically evaluating sources [$\chi^2(4, n = 188) = 119.37, p < .01$, Cramer's $V = 0.80$], as essential for digital literacy.

3.1.2.2. Cluster analysis. Based on the four binary predictors, five clusters were identified and found to have a good fit to the data (Silhouette measure of cohesion = 0.60). See Table 5 for cluster centroids. Cluster one consisted of pre-service teachers who predominantly selected the item “using and understanding multimedia” as essential for digital literacy (15.96%, $n = 30$). This cluster was labeled *Digital Reading*. Cluster two, labeled *Limited* (15.96%, $n = 30$), reflected pre-service teachers not selecting any of the four skills examined as essential for digital literacy. Cluster three consisted of those selecting the item “using a variety of technology tools” as essential for digital literacy (21.81%, $n = 41$). This cluster was labeled *Technology Focused*. Cluster four reflected pre-service teachers who selected the item “gathering information to make decisions and learn about topics of interest” (25.53%, $n = 48$) and was labeled *Goal-Directed*. Finally, cluster five included those who selected the item “critically evaluating source trustworthiness” (20.74%, $n = 39$) as essential for digital literacy. This cluster was labeled *Critical Use*. Clusters were validated using a series of chi-squared tests. See Table 5.

3.1.2.3. Open-ended categories and selected response clusters. A significant association was determined [$\chi^2(16, n = 188) = 39.03, p < .01$, Cramer’s $V = 0.23$], indicating that cluster membership was associated with categories identified from pre-service teachers’ open-ended responses. Based on an examination of standardized residuals, members of the *Critical Use* cluster were significantly over-represented in the *critical use* category (6.38%, $n = 12$) and underrepresented in the *digital reading* category (1.06%, $n = 2$). Members of the *Technology Focused* cluster were significantly underrepresented in the *critical use* category (0.00%, $n = 0$). See Table 6 for a summary of category and cluster membership.

3.2. RQ2: What are pre-service teachers’ conceptions of digital literacy in Sweden?

For the second research question, we examined Swedish pre-service teachers’ conceptions of digital literacy based on their answers to open-ended and selected-response questions.

3.2.1. Open-ended

See Table 3 and Fig. 2 for frequencies of category membership. Pre-service teachers in Sweden most commonly conceptualized digital literacy as *technology focused* (35.50%, $n = 43$), while the next most populated category reflected those with *goal-directed* (27.30%, $n = 33$) conception of digital literacy. However, a substantial number of pre-service teachers in Sweden composed responses that, unable to be otherwise coded, were placed into the *other* category (19.00%, $n = 23$). A chi-squared goodness of fit test determined participants’ category membership to be disproportionately distributed across categories [$\chi^2(4, n = 121) = 38.96, p < .01$, Cramer’s $V = 0.28$].

3.2.2. Selected-response

Selected-responses were again analyzed in terms of frequency of selection, profiles of selection, and the association between open-ended and selected-response profiles.

3.2.2.1. Frequency of skill selection. See Table 4 for the frequency with which each selected response item was endorsed. Two items were chosen by a substantial majority of respondents. These were items stating that “searching for and selecting relevant information” (81.82%, $n = 99$) and “critically evaluating source trustworthiness” (72.73%, $n = 88$) were essential for digital literacy.

A chi-squared goodness of fit test was used to determine whether pre-service teachers selected any of the 24 available skills to a disproportionate extent. As participants in Sweden were asked to select 6 out of 24 skills as essential for digital literacy, each skill had a 25.00% chance of being selected at random. We were interested in whether any skills were disproportionately over or under selected, relative to the 25.00% threshold. Six items were found to be disproportionately endorsed by pre-service teachers, based on a Bonferonni-corrected alpha of .002. These skills are indicated in Table 4 via an α .

3.2.2.2. Cluster analysis. Cluster analysis found a five-cluster solution to be a good fit to the Swedish data (Silhouette measure of cohesion = 0.70). See Table 7 for cluster centroids. Cluster one included pre-service teachers who selected the item “critically evaluating source trustworthiness” (35.54%, $n = 43$) as essential for digital literacy. This cluster was labeled *Critical Use*. Cluster two

Table 6

Frequency of selected-response clusters by open-ended categories for U.S. Sample.

	Cluster 3 Technology Focused 21.81% ($n = 41$)	Cluster 1 Digital Reading 15.96% ($n = 30$)	Cluster 4 Goal Directed 25.53% ($n = 48$)	Cluster 5 Critical Use 20.74% ($n = 39$)	Cluster 2 Limited 15.96% ($n = 30$)
Technology Focused	20 (10.64%)	13 (6.91%)	13 (6.91%)	18 (9.57%)	10 (5.32%)
Digital Reading	16 (8.51%)	10 (5.32%)	14 (7.45%)	2 (1.06%)	11 (5.85%)
Goal Directed	3 (1.60%)	6 (3.19%)	12 (6.38%)	6 (3.19%)	6 (3.19%)
Critical Use	0 (0.00%)	1 (0.53%)	7 (3.72%)	12 (6.38%)	3 (1.60%)
Other	2 (1.06%)	0 (0.00%)	2 (1.06%)	1 (0.53%)	0 (0.00%)

Note: Clusters ordered by degree of sophistication.

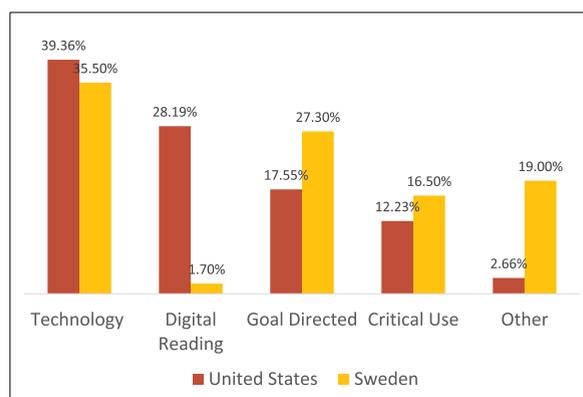


Fig. 2. Bar graphs of open-ended responses by country.

reflected pre-service teachers selecting the item “using a variety of technology tools” as essential for digital literacy (17.36%, $n = 21$) and was labeled *Technology Focused*. However, those in this cluster also endorsed the item “critically evaluating source trustworthiness” as essential for digital literacy. Although those in the *Technology Focused* cluster endorsed two items as essential for digital literacy, we favored the technology-focused explanation in naming this cluster as it was the only cluster in which all participants chose the technology focused skill. This decision was further made because we considered pre-service teachers’ very high endorsement of the item “critically evaluating source trustworthiness” as essential for digital literacy to partially be a statistical artifact attributable to its order of presentation (i.e., first).

Cluster three consisted of pre-service teachers who endorsed the item “using and understanding multimedia” as essential for digital literacy (19.01%, $n = 23$). This cluster was labeled *Digital Reading*. Cluster four was labeled as *Limited* (14.05%, $n = 17$), for the most part consisting of those not endorsing any of the four target skills as essential for digital literacy, however it did contain seven participants (41.18%) that chose the *Technology-Focused* skill. We decided to label it *Limited* for consistency. Cluster five reflected pre-service teachers who selected the item “gathering information to make decisions and learn about topics of interest” (14.05%, $n = 17$) as an essential competency for digital literacy. This item was labeled *Goal-Directed*. Clusters were again validated using a chi-squared test of association. See Table 7.

3.2.2.3. *Open-ended categories and selected response clusters.* In contrast to results for the U.S. sample, there was not a significant association between pre-service teachers’ conceptions of digital literacy category membership, determined based on open-ended responses and cluster membership [$X^2(16, n = 121) = 15.18, p = .51$]. See Table 8 for a summary of category and cluster membership.

3.3. RQ3: How do conceptions of digital literacy differ in the U.S. Versus Sweden?

To answer the third research question, we were interested in comparing conceptions of digital literacy in the United States vis-a-vis Sweden. We first compared pre-service teachers’ conceptions of digital literacy as captured via the open-ended question, then as reflected in their skill selections as captured by the selected response question, and finally, as determined via cluster analysis.

3.3.1. Open-ended responses across national contexts

In both the United States and Sweden, four categories of conceptions of digital literacy were identified, with pre-service teachers

Table 7

Centroids for selected-response clusters in Swedish sample.

	Cluster 2	Cluster 3	Cluster 5	Cluster 1	Cluster 4
	Technology Focused	Digital Reading	Goal Directed	Critical Use	Limited
	17.36% ($n = 21$)	19.01% ($n = 23$)	14.05% ($n = 17$)	35.54% ($n = 43$)	14.05% ($n = 17$)
Using a variety of technology tools	1.00 (0.00)	0.39 (0.50)	0.35 (0.49)	0.00 (0.00)	0.41 (0.51)
Using and understanding multimedia	0.00 (0.00)	1.00 (0.00)	0.18 (0.39)	0.00 (0.00)	0.00 (0.00)
Gathering information to make decisions	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Critically evaluating source trustworthiness	1.00 (0.00)	0.65 (0.49)	0.53 (0.51)	1.00 (0.00)	0.00 (0.00)

Note: Clusters ordered by progression of conceptualizations. We validated our cluster solution by testing whether students in each of the five clusters identified varied according to their endorsement of the four skills examined as essential for digital literacy. As anticipated, chi-squared analyses determined that, indeed, the clusters differed in their endorsement of items reflecting using a variety of technology tools [$X^2(4, n = 121) = 62.16, p < .01$, Cramer’s $V = 0.72$], using and understanding multimedia [$X^2(4, n = 121) = 106.36, p < .01$, Cramer’s $V = 0.94$], gathering information to make decisions [$X^2(4, n = 121) = 121.00, p < .01$, Cramer’s $V = 1.00$], and critically evaluating source trustworthiness [$X^2(4, n = 121) = 73.34, p < .01, p < .01$, Cramer’s $V = 0.78$], as essential for digital literacy.

Table 8
Frequency of selected-response clusters by open-ended categories for Swedish Sample.

	Cluster 3 Technology Focused [& Critical]	Cluster 1 Digital Reading	Cluster 4 Goal Directed	Cluster 5 Critical Use	Cluster 2 Limited [& Technology]
	17.36% (n = 21)	19.01% (n = 23)	14.05% (n = 17)	35.54% (n = 43)	14.05% (n = 17)
Technology Focused	11 (9.09%)	6 (4.96%)	6 (4.96%)	12 (9.92%)	8 (6.61%)
Digital Reading	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (1.65%)	0 (0.00%)
Goal Directed	4 (3.31%)	7 (5.79%)	4 (3.31%)	16 (13.22%)	2 (1.65%)
Critical Use	4 (3.31%)	6 (4.96%)	3 (2.48%)	4 (3.31%)	3 (2.48%)
Other	2 (1.65%)	4 (3.31%)	4 (3.31%)	9 (7.44%)	4 (3.31%)

Note: Clusters ordered by progression of conceptualizations.

defining digital literacy as technology focused, digital reading, goal-directed, or as requiring critical use, as well as an other category. A chi-squared test of association was used to determine whether the prevalence of these categories was consistent across national settings. The chi-squared was significant [$\chi^2(4, n = 309) = 55.36, p < .01$, Cramer's $V = 0.42$], indicating differences in the prevalence of category membership across the two countries. Based on an examination of standardized residuals, participants in the U.S. were significantly overrepresented in the *Digital Reading* category (28.19%, $n = 53$) whereas participants in Sweden were underrepresented in that category (1.70%, $n = 2$). In contrast, respondents in Sweden were significantly overrepresented in the *Other* category (19.00%, $n = 23$) whereas respondents in the United States were underrepresented in that category (2.66%, $n = 5$). See Table 3 for the prevalence of open-ended category membership in the United States and Sweden.

3.3.2. Selected responses across national contexts

We then examined differences in the prevalence of individual skills selected as essential for digital literacy across the United States and Sweden. A series of chi-squared tests of association, one for each item, were performed, with alpha adjusted to 0.002 for multiple comparisons using Bonferroni's correction. Four items showed significant differences in their patterns of endorsement, by country. Table 4 summarizes the prevalence of skill selections in the United States and Sweden with significant differences between countries designated via a *b*.

3.3.3. Cluster analysis across national contexts

Finally, we examined whether cluster membership was proportionate across the two national settings. Conceptually, the clusters identified in the United States and Sweden paralleled one another. Nevertheless, a chi-squared test of association determined the proportion of cluster membership to vary by country [$\chi^2(4, n = 309) = 11.99, p = .02$, Cramer's $V = 0.20$]. An examination of standardized residuals indicated that pre-service teachers in Sweden were significantly overrepresented in the *Critical Use* cluster (35.54%, $n = 43$) whereas pre-service teachers in the U.S. were underrepresented in this cluster (20.74%, $n = 39$). See Table 9 and Fig. 3 for the prevalence of cluster membership in the United States and Sweden.

4. Discussion

The aim of the present study was to examine U.S. and Swedish pre-service teachers' conceptions of digital literacy through open-ended and selected response survey questions and to establish whether there were any differences in conceptions of digital literacy across the two contexts. Drawing on pre-service teachers' open-ended responses, we were able to identify four clearly discernible categories (*technology focused*, *digital reading*, *goal-directed*, and *critical use*) reflecting distinct conceptions of digital literacy. These four categories were found to manifest across both the U.S. and Swedish samples. Moreover, these categories were found to be conceptually consistent with patterns in pre-service teachers' selected responses asking them to identify the skills or competencies that they consider to be essential for digital literacy, as determined via cluster analysis. Looking across open-ended and selected responses, at least four conclusions may be drawn.

4.1. Categories of conceptions of digital literacy

First, each of the four conceptions identified reflected a definition of digital literacy found in prior research, to varying extents. A technology-focused conception of digital literacy was consistent with the construct of *digital propensity* common in the literature on ICT

Table 9
Frequency of selected-response cluster membership by country.

	Technology Focused	Digital Reading	Goal Directed	Critical Use	Limited
United States	41 21.81%	30 15.96%	48 25.53%	39 20.74%	30 15.96%
Sweden	21 17.36%	23 19.01%	17 14.05%	43 35.54%	17 14.05%

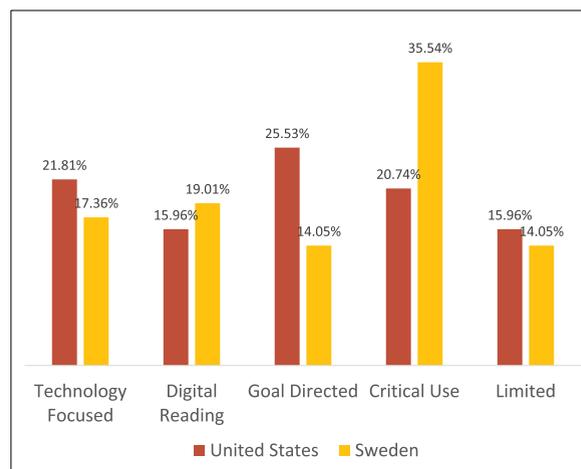


Fig. 3. Cluster membership by country.

literacy (Nasah, DaCosta, Kinsell, & Seok, 2010). Digital propensity emphasizes that digital literacy is the result of access to and use of technology and is often assessed via students' reports of their technology use (Margaryan, Littlejohn, & Vojt, 2011; Thompson, 2013). Digital reading, while less emphasized in literature-based definitions of digital literacy, has been examined in work comparing students' reading and strategy use when presented with texts digitally or in print (Brown, 2001; Mangen, Walgermo, & Brønnick, 2013; Peterson & Alexander, 2020; Singer & Alexander, 2017a; 2017b). Given the notable differences that emerge, pre-service teachers' focus on digital reading as a component of digital literacy seems well-grounded.

Goal-directed conceptions of digital literacy are well-represented in the literature. Indeed, a number of process models have been introduced (Brand-Gruwel, Wopereis, & Walraven, 2009; Rouet & Britt, 2011) viewing digital literacy as reflective of the process of information problem solving or of resolving task goals via technology and information use on the Internet (Mills, 2006). Finally, conceptions of digital literacy as requiring critical use are those most commonly represented in the research literature as well as in policy documents setting out standards for digital literacy (Bawden, 2008; Coiro, 2003; Koltay, 2011; OECD, 2015).

Comparing pre-service teachers' open-ended conceptions of digital literacy to frameworks specified in the literature (Eshet-Alkalai, 2004; Ng, 2012) reveals several points of overlap as well as distinction. First, both Eshet-Alkalai (2004) and Ng (2012) recognize competence with technology to be a necessary, yet insufficient, component of digital literacy. Our participants commonly defined digital literacy only as synonymous with fluent technology use, as reflected in *technology focused* conceptions of digital literacy. Second, Eshet-Alkalai (2004) introduces notions of branching literacy and photo-visual literacy, seemingly reflected in pre-service teachers' *digital reading*-aligned conceptions of digital literacy. Both of these literacies recognize the characteristics of reading on the Internet that make it a distinct process for learners, as compared to print-based reading. These characteristics include the hyperlinked or interconnected nature of information online (i.e., branching literacy) and its simultaneous presentation via a variety of modalities (i.e., photo-visual literacy). Third, Eshet-Alkalai (2004) introduces the notion of information literacy as including students' abilities to analyze and critically evaluate information on the Internet. Such analysis and evaluation-focused conceptions of digital literacy are reflected in the *critical use* category identified in pre-service teachers' open-ended responses.

Interestingly, the ability to satisfy task demands, consistent with the *goal-directed* category of digital literacy conceptions, is absent from many frameworks of digital literacy (Bawden, 2008; Eshet-Alkalai, 2004; Ng, 2012). Instead, frameworks of digital literacy define the range of skills or competencies that students need to master in order to be able to accomplish task goals. Nevertheless, the prevalence of goal-directed conceptions of digital literacy across both the U.S. and Swedish samples suggests the need for existing digital literacy frameworks to better incorporate the purpose or goals of students' skill use into their definitions of digital literacy.

4.2. Technology dominance

Across the four profiles identified, pre-service teachers' conceptions of digital literacy were dominated by a focus on the fluent use of technology. Of course, this technological focus is likely reflective of participants' experiences growing up in a digital society (Conole, De Laat, Dillon, & Darby, 2008; Kennedy, Judd, Dalgardno, & Waycott, 2010; Thompson, 2013). Nevertheless, there are at least two further explanations for the prominence of technology use in pre-service teachers' understandings of digital literacy. The first, rather self-evident, explanation concerns the difference between asking participants to define digital vis-a-vis "traditional" literacy. When thinking about "traditional" literacy, reading-related behaviors are central. Whereas when asked to define digital literacy, pre-service teachers may focus on what makes this type of literacy distinct from its more traditional counterpart. For pre-service teachers, this distinction between digital and traditional literacy may, reasonably, be the savvy and fluent use of technology. However, participants' conceptions of technology use, within the context of digital literacy, were found to be largely superficial in nature and largely lacking in the recognition of the Internet as a unique, epistemic environment (Tsai, 2004).

Another explanation for the technology focus when defining digital literacy is the concrete nature of technology. The fluent use of

technology is easier to recognize and assess than is engagement in critical reasoning. In other words, whereas making a video clip, as a technological facet of digital literacy, can be demonstrated with ease, it is more challenging to determine whether the critical evaluation of information has taken place. Consequently, the concrete or behavioral nature of technology use seems to move it to the forefront of many pre-service teachers' definitions. Although technology use, doubtlessly, is an important component of digital literacy, both policy-based (e.g., OECD, EU) and research-based definitions of digital literacy emphasize that skills like critical thinking, source evaluation, and integration are needed as well (OECD, 2015; Visser, 2013). Indeed, these definitions suggest that a sophisticated conception of digital literacy is one that is marked not only by the fluent, but also by the critical use, of technology. As such, digital literacy may be expected to represent not only a skillset but also a collection of dispositions or critical attitudes toward information.

4.3. Profiles progressing in sophistication

In addition to identifying four profiles among pre-service teachers' conceptions of digital literacy, we further argue that these profiles can be conceptualized as distinct from one another and as progressing in sophistication. In particular, we may expect pre-service teachers becoming more sophisticated in their conceptions of digital literacy to move from focusing on technology use as necessary for digital literacy to recognizing that the critical use of technology is essential as well. Indeed, as may be expected of digital literacy conceptions progressing in sophistication, comparatively fewer pre-service teachers in our sample understood digital literacy as requiring the critical use of technology (14% of total sample), as compared to those defining digital literacy only as technology focused (38% of total sample). This was the case across both the United States and Sweden. This theorized progression in sophistication adds further nuance to the development of professional competence related to digital literacy introduced by Krumsvik (2008; 2011; 2014). In particular, Krumsvik (2008) in defining teachers' professional digital competence introduces a Model of Digital Competence For Teachers and Teacher Educators. Within this framework, Krumsvik suggests that as teachers grow in their professional competence, they enhance their basic ICT skills and didactic ICT competence, come to understand their strategies for technological learning, and develop digital bildung (i.e., a meta-awareness of the connection between their own digital competence and societal digitalization). Like Krumsvik (2008; 2011), we adopt a progressive or development-focused view on pre-service teachers' digital literacy and specifically address how pre-service teachers' conceptions of what these include may develop through the course of their education.

Moreover, the four profiles identified can be understood as componential in nature. In other words, pre-service teachers whose open-ended responses were placed into the critical use category, considered the most sophisticated of the four definitions of digital literacy, were expected to conceptualize digital literacy in terms of its less sophisticated components (e.g., technology use or digital reading). This was exemplified in responses such as: "Digital literacy would be the process of finding and understanding digital literature to obtain factual knowledge or evidence about a topic. To be digitally literate requires proper search skills and an understanding of acceptable sources." In this response is reflected the simultaneous recognition that digital literacy involves reading that is digital (i.e., digital literature), goal-directed (i.e., process of finding ... to obtain factual knowledge), and critically-evaluative (i.e., an understanding of acceptable sources) in nature. This is further consistent with an understanding of digital literacy as a set of inter-dependent or inter-related competencies (Eshet-Alkalai, 2012, 2004; Ng, 2012), rather than as discrete skills able to identified and isolated.

4.4. Prevalence in digital literacy profiles across settings

Beyond placing pre-service teachers into the four digital literacy profiles identified, we were also interested in the relative prevalence of pre-service teachers' profile membership across the two national settings (i.e., the United States and Sweden).

4.4.1. Open-ended profiles across national settings

We first examined profile membership, by country, as manifest in participants' open-ended responses. Pre-service teachers in both the United States and Sweden were most commonly represented in the technology-focused profile of conceptualizing digital literacy, while being under-represented in the critical use profile. Again, this pattern of findings is consistent with an account of these four digital literacy profiles as progressing in sophistication. Due to a dearth of prior research examining conceptions of digital literacy among pre-service teachers cross-culturally, direct comparisons to prior work are not possible. However, the patterns that we identify are largely in line with several trends in prior research. These include the increased prevalence of digital reading and writing in academic settings (Mangen et al., 2013; Salmeron, Strømsø, Kammerer, & Stadtler, 2018; Trakhman, Alexander, & Silverman, 2018) and the emphasis on critical analysis and evaluation manifest in today's Internet age (Braasch, Braten, Stromso, Anmarkrud, & Ferguson, 2013; Britt, Rouet, Blaum, & Millis, 2019).

At the same time, an important difference to emerge across the two national settings was pre-service teachers' definitions of digital literacy as reflecting digital reading. While such a conception of digital literacy was commonly reported in the U.S. sample, it was almost absent among the conceptions of Swedish pre-service teachers. In part, this difference in profile membership may be explained by differences in term use across these two settings (i.e., digital literacy in the United States vis-a-vis digital reading in Sweden). The use of the term *literacy* with the U.S. sample may have prompted participants to associate digital literacy with traditional notions of literacy, involving reading and writing. As such, pre-service teachers in the United States logically conceptualized digital literacy as reading and writing with technology, consistent with the digital reading profile. As a contrast, the term digital competency used in the Swedish survey did not similarly emphasize traditional aspects of reading and writing. Rather, the use of the term competence may have called to mind for pre-service teachers the behavioral aspects of digital literacy, including proficiency in technology use, most associated with technology-focused conceptions of digital literacy. This was reflected in some digital literacy definitions from the

Swedish sample suggesting that digital literacy required knowledge or skills in programming. Such definitions were largely absent from the U.S. sample.

Another difference to emerge across national settings was the large number of participants placed into the “other” category, when defining digital literacy, in the Swedish sample. For the most part, pre-service teachers placed into the “other” category were non-responsive (e.g., writing “I don’t know” or “Knowledge, know how to teach”). We attributed this difference in response quality to differences in the manner in which surveys were administered. Given that Swedish participants completed the surveys independently and online, a lower degree of response quality may be understandable.

4.4.2. Selected-response clusters across national settings

We then examined cross-national differences in pre-service teachers’ answers to the selected response question by comparing the cluster solutions generated across the United States and Sweden, as well as their relative size. To start, cluster definitions differed across national settings. In the United States, clusters corresponded to participants’ endorsement of a single item reflecting technology-focused, digital reading, goal-directed, or critical use-based conceptions of digital literacy. As a contrast, in Sweden, pre-service teachers endorsing the item corresponding to critical use were placed into two different clusters—one where only the critical use item was selected and the other where selection of the critical use item was also accompanied by selection of the technology-focused item. We understood this selection pattern to be the result of items not being randomized for Swedish participants, leading to Swedish participants over-endorsing the critical use item, which appeared first in the list of competencies potentially considered essential for digital literacy.

Another explanation may be that the Swedish curriculum emphasizes critical thinking to a greater extent than does the curriculum in the United States. For example, the general part of the Swedish curriculum for compulsory school states that students shall develop their ability to critically review information, facts, and circumstances as well as be given “the opportunity to develop a critical and responsible approach to digital technology, to see opportunities and understand risks, as well as to evaluate information” (p. 5, [Skolverket, 2018](#)). This emphasis on critical thinking, as a component of digital literacy, may have resulted in a higher number of Swedish pre-service teachers endorsing the item corresponding to the critical evaluation of information as essential for digital literacy.

Consistent with policy initiatives pushing for the greater recognition of critical thinking as a part of digital literacy, substantially more pre-service teachers in Sweden were placed into the critical use cluster (35.54%) than the technology-focused cluster (17.36%). In contrast to Sweden, curricula in the United States have often been critiqued for their neglect of critical thinking, a deficit that was intended to be ameliorated through new policy initiatives, such as the Common Core Standards ([Ennis, 1989](#); [Wagner, 2008](#)). This contrast in policy and curricula may be, in part, responsible for difference in critical use cluster representation across Sweden and the United States. In particular, whereas 35.54% of pre-service teachers in Sweden were classified into the critical use profile, only 20.74% of pre-service teachers in the United States belonged to this cluster. This was the only significant difference in the proportion of cluster membership found across the two national settings.

At the same time, considering digital literacy to require critical thinking is not the same thing as actually thinking critically while completing technology-related learning tasks. Indeed, just like undergraduate students in the United States ([List, Alexander, & Stephens, 2017](#); [Britt & Aglinskas, 2002](#)), Swedish students have been found to demonstrate superficial, rather than deep-level source evaluation ([Francke & Sundin, 2012](#)), and Swedish teachers have noticed deficits in critical reading among upper secondary school students ([Brante & Stang Lund, 2017](#)). Nevertheless, we consider identifying critical thinking as a key goal in curricula and having students and teachers recognize it as such, to be an important first step to further integrating critical thinking, particularly about digital literacy, into school instruction.

4.5. Contributions to prior research

This study was carried out to inform the developing literature on what teachers in the digital age need to know for digital competence ([Krumsvik, 2008](#); [2014](#)). While prior work has identified the digital and pedagogical competencies that pre-service teachers need ([Güneş & Bağçivan, 2018](#); [Krumsvik, 2008](#); [2014](#)) and examined undergraduates’ attitudes toward and beliefs about digital literacy ([Garcia-Martin & Garcia-Sanchez, 2017](#); [Marangunic & Granić, 2015](#)), we contribute to the literature by asking a more fundamental question – how do pre-service teachers conceptualize the competence in digital literacy that they are expected to develop. In doing so, we identify four distinct and discernible profiles of digital literacy conceptions. While aspects of these profiles have been considered in frameworks of digital literacy ([Eshet-Alkalai, 2012](#); [Ng, 2012](#)), this study is unique in establishing various skills as defining the conceptions of digital literacy that pre-service teachers hold. These conceptions both echo trends with regard to technology use and critical evaluation identified in prior work and correspond to a newly proposed trajectory for pre-service teachers’ development of conceptions of digital competence. This framework is able to inform both pre-service teacher preparation and assessment in the area of digital literacy and, potentially, teachers’ own conceptions of activities related to digital literacy, as they occur in their classrooms. Moreover, we both validate these four profiles of conceptions of digital literacy across diverse national settings (i.e., in the United States and Sweden) and suggest potential pathways whereby unique national educational policy settings may be associated with pre-service teachers’ conceptions, as reflected in the emphasis on critical evaluation found among Swedish participants. As such, this study is unique in connecting individual pre-service teachers’ psychological conceptions of digital literacy with broader national and educational trends.

4.6. Limitations

Despite the strengths of this study, a number of limitations must be acknowledged. First, in this study our aim was to extend prior work investigating pre-service teachers' understandings of digital literacy (Burnett, 2011; Martinovic & Zhang, 2012) by explicitly asking them to define and describe this construct. This methodological approach stands in contrast to survey and other self-report measures that have tried to get at pre-service teachers' conceptions of digital literacy indirectly, for instance by asking them to self-report the ICT-activities that they use in the classroom (Hargittai, 2009; Prior, Mazanov, Meacheam, Heaslip, & Hanson, 2016). Nevertheless, our methodological approach was limited in that it did not comprehensively tap all of pre-service teachers' conceptions of digital literacy or how these may be employed in classroom settings. Moreover, a methodology that asked participants to select those skills that they considered to be essential for digital literacy, rather than rating the list of skills as a whole offered both benefits and limitations. On the one hand, this allowed us to distill only those skills, from extensive taxonomies found in prior work (see van Laar, van Deursen, van Dijk, & de Haan, 2017 for a review), that pre-service teachers considered to be essential for digital literacy and require pre-service teachers to make judgments regarding skills' relative importance, as they are often required to do in classroom settings. On the other hand, asking teachers to evaluate or rate all skills represents an important direction for future work and one that would allow for further scale development and validation.

Second, this study was limited by focusing only on one particular group: pre-service teachers, early in their educator preparation programs. Even though this group was expected to be familiar with digital literacy, we may have received an incomplete picture of pre-service teachers' understandings of digital literacy, as we chose to focus on a group of students early in their teacher preparation programs, typically not yet receiving much formal instruction in digital literacy and how it may be developed in students. Further research should investigate changes in conceptions of digital literacy among pre-service teachers throughout their degree programs as well as following their practicum placements in the classroom. More generally, replicating this study with a larger sample, representing other majors and areas of study as well as national, cultural, and educational settings remains an important area for future work. Finally, examining pre-service teachers' conceptions of digital literacy with nationally representative samples remains an important step for future work.

Third, a number of methodological differences emerged across administrations of the digital literacy survey in Sweden and the United States. These differences included participants in Sweden being asked to select the six skills they consider to be essential for digital literacy, rather than the five skills that participants were asked to select in the U.S., and the digital literacy items presented to the Swedish sample not being randomized. Although we tried to address these issues in our analyses in various ways (e.g., using proportions of those selecting particular digital literacy items, rather than percentages), these discrepancies may, nevertheless, have biased the comparisons that we are able to make across settings and represent a substantial limitation. Moreover, there were a large number of Swedish participants whose open-ended responses were placed into the "other" category. This pattern of categorization is understandable given that Swedish participants were completing the study voluntarily, with no compensation, and at a time and location of their choosing. Nevertheless, the volume of participants coded into the other category (19.00%) may be responsible for the non-significant association between open-ended categories of digital literacy conceptions and cluster membership found in the Swedish sample. This lack of an association may further have been exacerbated by the extremely low representation of Swedish participants' open-ended responses placed into the digital reading category (1.65%).

Finally, the cluster analysis undertaken in this study was a result of decision making, on the part of researchers. Limitations in sample size and conceptual difficulties precluded our including all 24 digital literacy skills in a single cluster analysis; we therefore considered it preferable to select a subset of items for inclusion. We selected those items that corresponded to the four digital literacy profiles identified, based on students' open-ended responses. Nevertheless, the clusters identified and their interpretation is likely to change if a different subset of items were selected. For instance, we elected to exclude the item: "Searching for and selecting relevant information", despite it being selected by a large percentage of participants in both Sweden and the United States. We excluded this item because of the frequency with which it was endorsed. To the extent that the goal of cluster analysis is to find meaningful yet distinctive patterns in the data, the relative popularity of this item made its inclusion in cluster analysis unappealing from a statistical standpoint. As a result of this methodological decision and others, we consider further developing and validating objective measures of pre-service teachers' digital literacy to be an important avenue for future work. For instance, Garcia-Martin and Garcia-Sanchez (2017) examined pre-service teachers' use and perceptions of various technology platforms (e.g., Twitter, Google Docs) across four years; similar cross-sectional and longitudinal work can be used to examine the development of pre-service teachers' conceptions of digital literacy, if valid and reliable measures were developed.

4.7. Implications

Based on pre-service teachers' answers to open-ended and selected-response questions, we propose a framework for understanding different conceptions of digital literacy. We see pre-service teachers' conceptions of digital literacy as falling along a continuum of sophistication, from those who consider digital literacy to only be technology focused, to those who consider digital literacy to require critically reflective technology use. This framework for categorizing conceptions of digital literacy is presented in Fig. 1.

As displayed in Fig. 1, each of the four categories of digital literacy conceptions is componential in nature, such that the critical use category includes a greater volume of knowledge and skills, that are more sophisticated in nature, than other categories (e.g., technology focused). This greater sophistication is associated with a more complex view of digital literacy, considering more components of digital literacy and their inter-relation. Further, Fig. 1 demonstrates how a more sophisticated conception of digital literacy may develop. Of course, students do not develop such dispositions automatically or only through repeated exposure to technology. Rather,

purposeful and quality instruction is needed. In academic settings, we view students as moving from using technology only occasionally, when externally prompted to do so, to habitually, based on their own volition. Ultimately, students may internalize the use of technology as a fundamental mechanism for learning and interacting with the world. This internalization of technology use may lead students to develop the dispositions and habits of mind necessary for critical evaluative technology use.

Teachers, then, are tasked not only with critically evaluating technology for their own personal use but also for use in their classrooms. Standards for pre-service teacher preparation, when describing critically evaluative technology use, ought to include both the ability to evaluate sources and information quality and the skills needed to critically appraise apps, software, and social media for classroom use. This may include understanding how apps are gamified to prolong engagement or how social media is used as a method of personal and meta data collection (Selwyn and Pangrazio, 2018). Future teachers should know how to critically assess software or applications used in their teaching and understand how their choice of technology impacts both their students' academic experiences in the classroom and their technological lives, online (e.g., what student information may be public or collected by corporations).

4.7.1. Implications for pre-service teacher development

The framework introduced in Fig. 1 is not only descriptive. It may also be used to guide pre-service teacher instruction in digital literacy. We found many pre-service teachers to only conceptualize digital literacy as technology driven. This constitutes a relatively impoverished understanding of digital literacy and does not include an appreciation of the need to teach critical thinking within digital contexts. For pre-service teachers, this may limit the skills that they themselves master and emphasize in their future classrooms. Teacher preparation programs can, therefore, use the framework introduced in Fig. 1 to guide the conceptions of digital literacy that they forward throughout their courses. Our proposed framework can be used as both a design and didactic tool to create lessons incorporating and assessing all four conceptions of digital literacy, as they develop in association with teachers' learning about digital literacy. Further, when pre-service teachers plan lessons, they can use the framework as a supporting tool, by asking themselves questions such as: What technology was used during this lesson? Which types of digital reading were students exposed to and asked to engage in? What was the goal of this lesson or activity? Did the lesson or activity require students to engage in evaluation or reflection? Ultimately, the categories identified in our framework are functionally focused on helping pre-service teachers and their future students identify the purposes of technology use. We, therefore, view this framework as a way of helping teachers build students' meta-technological awareness, or explicit reasoning regarding how they are using technology and why. We also believe that such meta-technological awareness ought to progress in sophistication as pre-service teachers develop their instructional capacities.

5. Conclusion

There exists a gap between how policy organizations (e.g., OECD, PISA, EU, and the American Library Association, 2018) and pre-service teachers define digital literacy. Definitions introduced in policy documents reflect all four levels of digital literacy conceptions included in our proposed framework, while (too) many participants, from both Sweden and the United States, were found to hold a more superficial understanding of digital literacy, focusing only on its technological aspects. This gap needs to be addressed by educational institutions on all levels; however, addressing this gap within pre-service teacher preparation programs may serve to translate more complex conceptions of digital literacy to K-12 classrooms. If pre-service teachers come to hold more sophisticated conceptions of digital literacy, they may implement more sophisticated digital literacy activities into their instruction and engage their students in critical reasoning about technology to a greater extent.

Author contributions

The first (Alexandra List) and second (Eva Brante) authors were responsible for paper conceptualization, data collection and analysis, and manuscript composition and revision. The third author, Holly Klee, was responsible for data analysis, manuscript conceptualization, composition, and revision.

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