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Defining digital literacy development: An examination of pre-service teachers' beliefs

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ABSTRACT

We identify three conceptions of digital literacy development populating the literature: digital natives, skill-based, and sociocultural perspectives. We adopt a qualitative approach to examine pre-service teachers' beliefs about digital literacy development as aligned with each of these three perspectives. While pre-service teachers were most commonly found to hold skill-based perspectives on digital literacy development, digital natives aligned and sociocultural perspectives were also well-represented. We further identify perspectives on digital literacy development uniquely appearing in students' responses. These include pre-service teachers' conception of digital literacy development as autonomously developed, technology driven, or project based. We further examine the contexts within which pre-service teachers situate digital literacy as emerging; these include both formal and informal settings. The article concludes with a discussion of implications for instruction.

Students today may be *digital natives*, able to master technology only through their immersion in it (Prensky, 2001), or they may be *drawn to distraction*, crippled by the attentional and task-switching demands of gamified technology (Aagaard, 2015). Students may lack the critical skills necessary to evaluate information on the Internet, at the same time that they eschew traditional media organizations and resist the inaccessible nature of academic texts (Baumgartner & Morris, 2006; Colón-Aguirre & Fleming-May 2012; Flanagin & Metzger, 2007; Metzger, Flanagin, & Medders, 2010). As can be seen in these examples, a host of stereotypes and (mis-) characterizations populate the literature on students' digital literacy. These characterizations may be expected to effect how we investigate students' digital literacy, whether and what we teach students about digital literacy, and what we expect of today's 21st century learners. In addition to the research literature being rife with conceptions of digital literacy and how it may be developed, today's students themselves likely hold beliefs about their own digital literacy development. While students' own beliefs about digital literacy development may have profound impacts on their behaviors in learning situations requiring digital literacy, such beliefs have been under-examined in the literature.

At the same time, students' technology-related beliefs have commonly been examined in association with their behaviors in technology-rich contexts. These include their readiness to adopt new technologies and their extent of technology use. For instance, the Technology Acceptance Model positions technology adoption as the result of students' perceptions or beliefs about technology's usefulness and ease of use (Davis, 1989; Park, 2009; Teo, Luan, & Sing, 2008). Elsewhere, students' efficacy for technology use and self-perceptions of technology skills have been associated with both behavioral intentions and with actual use behaviors (Celik & Yesilyurt, 2013; McCoy, 2010; Mun & Hwang, 2003; Sadaf, Newby, & Ertmer, 2012; Teo & Noyes, 2011; Vekiri & Chronaki, 2008). While students' conceptions of digital literacy development can likewise be expected to be associated with behaviors, including effort expenditure, help-seeking, and social engagement, these have been considered in the literature only to a limited extent.

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Our goals in this paper are four-fold. First, we draw on diverse literature in education, psychology, and library/information sciences to identify three distinct approaches to or conceptions of digital literacy development. Then, we examine the alignment between these theoretical conceptions and undergraduates' own accounts of their digital literacy development. Third, we discuss additional conceptions of digital literacy development that undergraduates seem to hold, but that, nevertheless, have not yet been fully discussed in the literature. We also explore the contextual factors associated with students' understandings of their digital literacy development. Finally, we consider the theoretical and instructional implications that emerge from examining students' beliefs about digital literacy development.

1. Theories of digital literacy development

Based on a review of the literature on digital literacy, at least three conceptions of digital literacy and, therefore, of digital literacy development can be identified. We anchor our identification of these major conceptions of digital literacy in central theoretical and empirical works published in this field. These works includes Gilster's book, *Digital Literacy*, among the first to use this term to define: "Internet users, people who discover and evaluate content before deciding to put it to work" (1997, p. ix). This book forwards a highly functional view of digital literacy, aligned with the skill-based perspective on digital literacy development introduced in this paper. We further considered Prensky's (2001) essay defining digital natives as students inherently skilled in technology use. This essay has been cited over 20,000 times, according to Google scholar, albeit often in challenge. Nevertheless, it remains the subject of much, continued reanalysis and critique (e.g., Bennett, Maton, & Kervin, 2008; Hargittai, 2010; Kennedy, Judd, Churchward, Gray, & Krause, 2008; Margaryan, Littlejohn, & Vojt, 2011). Finally, we considered Lankshear and Knobel's (2003) seminal work on new literacies (2003). Using terms like mindsets, identities, and *ways of being in the world* (Gee, 1990, p. 142; Lankshear & Knobel, 2003), Lankshear and Knobel (2003), along with other new literacy scholars (Coiro, 2003; Coiro, Knobel, Lankshear, & Leu, 2008; Cope & Kalantzis, 2009; Mills, 2010), advance what has been termed a sociocultural view of digital literacy. Such a view moves away from skill-based conceptions of digital literacy, to look at digital literacy more holistically and contextually, as individuals' meaningful functioning in digital communities. We review each of these conception, in turn.

1.1. Digital literacy as an automatic process

While largely discounted based on empirical work, a much discussed perspective on digital literacy suggests that digital literacy is automatically acquired by students growing up as *digital natives* in the Internet age (Guo, Dobson, & Petrina, 2008; Margaryan et al., 2011). Prensky, originating the term digital natives, describes them thus: "Our students today are all 'native speakers' of the digital language of computers, videos games, and the Internet ... Digital immigrants typically have very little appreciation for these new skills that the natives have acquired and perfected through years of interaction and practice" (2001, pp. 3–4). Conceptions of today's students as digital natives have been critiqued and dismissed based on empirical work (Bennett et al., 2008; Kennedy et al., 2008). Indeed, students, considered to be digital natives, have been found to lack the skills necessary for critically evaluate Internet use, despite having early and prolonged exposure to technology (Li & Ranieri, 2010; Selwyn, 2009; Thomas, 2011), and exposure to technology has been found to be uneven across a variety of socio-demographic groups, contributing to a potential "digital divide" (Hargittai & Jennrich, 2016; Helsper & Eynon, 2013; Jackson et al., 2008; Jones, Ramanau, Cross, & Healing, 2010). Nevertheless, the perspective that students may be digital natives, acquiring technology skills through osmosis continues to populate the literature (Jones & Czerniewicz, 2010; Oblinger & Oblinger, 2005; Palfrey & Gasser, 2011; Tapscott, 2009). For instance, Wang, Myers, and Sundaram (2013) in articulating a model of digital fluency, suggest that digital literacy is the result of seven factors, including demographic characteristics, psychological factors and social influences, and the opportunity to use technology. In this way, Wang et al.'s (2013) model, echoes other conceptions of digital literacy development as an automatic process, occurring, in large part, simply through students' exposure to and use of various technological tools (Dingli & Seychell, 2015). Indeed, Judd (2018) in a recent review of search data found the term *digital natives* to still be prominent in both the educational technology literature and in popular search trends.

1.2. Digital literacy as a set of skills

Among the most prominent views of digital literacy, today, is that digital literacy may be understood as an inter-related set of skills or competencies necessary for success in the digital age. Such a conception dates back to Gilster (1997) who defined digital literacy thus: "Digital literacy is the ability to understand and use information in multiple formats from a wide variety of sources when it is presented via computers" (1997, p.1). He goes on to say that "acquiring digital literacy for Internet use involves mastering a set of core competencies" (1997, p. 2). Although Gilster (1997) himself does not list the competencies that may be necessary for the acquisition of digital literacy, these are identified by Bawden (2001, 2008) as including competencies associated with assembling information, reading and understanding multimedia and hypermedia texts, finding and critically evaluating information, and working collaboratively to communicate information. Since Gilster's (1997) competency-based definition, a variety of frameworks and taxonomies have been introduced to catalogue the skills that students need in the digital age (Berson & Berson, 2003; ICTL Panel, 2002; European Commission, 2007; Katz & Macklin, 2007; Koltay, 2011; Martin & Grudziecki, 2006; Webber & Johnston, 2017).

Eshet-Alkalai (2004) developed a conceptual framework for digital literacy that defines digital literacy as, in fact, a compilation of five different literacies, including: (a) photo-visual literacy, (b) reproduction literacy, (c) information literacy, (d) branching literacy, and (e) socio-emotional literacy. Photo-visual literacy is defined as to the ability to "read" and produce symbols, beyond text,

necessary for communication in the digital age. Reproduction literacy refers to students' capacity for synthetic thinking, or the ability to create "new combinations from existing information" (p. 98). Branching literacy refers to students' skills in information navigation, or their ability to move across the hypertexts and multimedia sources that characterize information on the Internet. Information literacy refers to the skills involved in critically evaluating content online. Finally, socio-emotional literacy refers to the skills necessary for online communication and collaboration. In an early investigation of these various literacies, [Eshet-Alkali and Amichai-Hamburger \(2004\)](#) asked participants to complete a set of tasks tapping these various literacies, including identifying bias in news stories (i.e., information literacy), planning a trip to Spain (i.e., branching literacy), and participating in a chat-room (i.e., socio-emotional literacy). Comparing these various literacies among high school students, college students, and adults, high school students were found to perform better on tasks tapping photo-visual literacy and branching literacy, while adults performed better on reproduction literacy and information literacy tasks ([Eshet-Alkali & Amichai-Hamburger, 2004](#)); results that seem to run counter to the students as digital natives narrative introduced by [Prensky \(2001\)](#).

Building on work by [Eshet-Alkalai's \(2004\)](#), [Ng \(2012\)](#) presents a conceptual framework that considers digital literacy to manifest at the intersection of students' technical, cognitive, and socio-emotional competencies. The technical dimension encompasses students' skills in being able to use various Internet and communication technologies. The cognitive dimension refers to students' abilities to engage in the cycle of searching for, evaluating, and creating information in digital contexts, including the ability to both use and produce digital sources. Finally, the socio-emotional dimension refers to students' skills in responsible Internet use, including observing netiquette, protecting safety and privacy, and recognizing and combatting abuse. Foundational to all three of these facets of digital literacy, is *critical literacy* or the recognition that information on the Internet is created by someone for some purpose, and should be evaluated as such.

Incorporating work from both [Eshet-Alkalai \(2004\)](#) and [Ng \(2012\)](#), among others, [van Laar, van Deursen, van Dijk, and de Haan \(2017\)](#) conducted a systematic review of the competencies included in common definitions of digital literacy and in definitions of related constructs, including 21st century skills, information literacy, and new media literacy. Across an examination of 75 studies, [van Laar et al. \(2017\)](#) determined digital literacy and related constructs to be composed of seven core and five contextual skills. While core skills may be considered to be functional in nature or necessary for task completion, contextual skills may be considered to be more strategic or facilitative of core skill implementation. Core skills include a (a) technical dimension, as well as (b) information management, (c) communication, (d) collaboration, (e) creativity, (f) critical thinking, and (g) problem solving. Contextual skills include (a) ethical awareness, (b) cultural awareness, (c) flexibility, (d) self-direction, and (e) life-long learning. Although more expansive than the competencies identified by [Eshet-Alkalai \(2004\)](#) and [Ng \(2012\)](#), [van Laar et al. \(2017\)](#), nevertheless, address core skills related to technology use (i.e., technical) and cognitive (i.e., information management, critical thinking, problem solving) and socio-emotional (i.e., collaboration, cultural awareness) dimensions of digital literacy.

Although the skill-based understandings of digital literacy, introduced by scholars from [Bawden \(2001\)](#) to [van Laar et al. \(2017\)](#), offer no developmental perspective on digital literacy, *per se*, we can infer that such a perspective would conceptualize digital literacy development as a process of skill acquisition. While conceptualizing digital literacy as a set of skills outlines a pragmatic approach for facilitating students' digital literacy development, it does not fully capture the digital experiences of today's students. Indeed, as suggested by the progenitors of skill-based theories of digital literacy, themselves, a broader conception of digital literacy is needed to understand students' digital lives and identity formation on the Internet ([Knobel & Lankshear, 2008](#)). To this end, sociocultural perspectives on digital literacy have emerged.

1.3. Sociocultural perspectives on digital literacy

Sociocultural perspectives are ones that emphasize the literacy aspects of digital literacy and, therefore, view digital literacy as connected to students' meaningful participation in a variety of online communities ([Limberg, Sundin, & Talja, 2012](#); [Mills, 2010](#); [Perry, 2012](#)). [Knobel and Lankshear \(2006\)](#) consider a sociocultural perspective on digital literacy to include students' engagement in "socially recognized ways of generating, communicating, and negotiating meaningful content as members of Discourses through the medium of encoded texts" (p. 255). As such, the acquisition of digital literacy may be considered to reflect a kind of social apprenticeship or the process of entering into and participating in a variety of digital communities, including those reflected in blogs, fan fiction, and videogames ([Gee, 2014](#); [Hartley, McWilliam, Burgess, & Banks, 2008](#); [Ito et al., 2009](#); [Knobel & Lankshear, 2006](#)). Through its focus on digital literacy as the intentional and gradual process of engaging in the situated social practices and with the cultural tools of particular digital communities, a sociocultural perspective on digital literacy stands in diametric opposition to the digital natives perspective introduced by [Prensky \(2001\)](#) and others ([Palfrey & Gasser, 2011](#); [Thomas, 2011](#)). Such a perspective on digital literacy, as gradually emergent through meaningful participation, is reflected in the Conceptual Framework of Emergent Digital Literacy Development ([Naumann, Finger, & Neumann, 2017](#)) and in empirical work, examining children's engagement in various digital literacy-related practices, across both home and online environments ([Marsh, Hannon, Lewis, & Ritchie, 2017](#); [Merchant, 2015](#); [Toohey et al., 2015](#)).

We can look to sociocultural theory more broadly to understand its perspective on how students may develop digital literacy. Drawing on work by [Wenger \(1998, 2000, 2010\)](#) students' emergent digital literacy may be conceptualized as their process of entering into digital social learning systems or communities of practice. Individuals' engagement in any social learning system can be thought of as encompassing participation and reification. While *participation* refers to students' engagement in the activities, conversations, and processes of particular communities, *reification* reflects students' production of the physical and conceptual artifacts valued by these communities. Applied to digital literacy, we might expect that students develop digital literacy, within the particular digital communities that they are a part of, through the dual processes of participation and reification or knowledge production. For

instance, students belonging to Fan Fiction communities online may engage both in participation (e.g., commenting on a story, subscribing to an author) and reification (e.g., writing fan fiction), with both of these processes requiring digital skills and contributing to the emergence of digital literacy. In this way, a socio-cultural perspective may be considered to move beyond only conceptualizing digital literacy as a set of skills and competencies, to contextualizing those skills within the practices of various digital social learning systems.

1.4. Students' own beliefs about digital literacy development

Beyond the three conceptions of digital literacy defined above, limited research has looked at students' own beliefs regarding how digital literacy may be developed. What has been well-established is that students express a great deal of confidence in their own digital literacy, even when such confidence may be unfounded (Katz & Macklin, 2007; Ng, 2012; Prior, Mazanov, Meacheam, Heaslop & Hanson, 2016; Wilkinson, 2006) and that students report frequent and ubiquitous technology use (Calvani, Fini, Ranieri, & Picci, 2012). Nevertheless, more needs to be understood regarding students' beliefs about digital literacy development. Indeed, a variety of fields have found learners' beliefs to be associated with both behaviors and performance (Bandura, 1989; Dweck, Chiu, & Hong, 1995; Pintrich & Schrauben, 1992; Schoenfeld, 1989; Zimmerman, Bandura, & Martinez-Pons, 1992). Within the context of digital literacy, beliefs about its development may dictate whether or not students conceptualize themselves as digitally literate, seek out resources to learn more about digital literacy, adopt and make use of new digital resources, or elect to expend the effort necessary to master new skills and technologies associated with digital literacy. In this study we first examine students' own beliefs about digital literacy development, in light of the approaches discussed in the first section of this article (i.e., digital natives, skills-based, and sociocultural perspectives). Moreover, we use students' own beliefs to further articulate how these varied conceptions of digital literacy development may be understood by students themselves. Finally, we examine additional aspects of digital literacy development, articulated by students but not yet reflected in the literature, to understand the potential variability in conceptions of digital literacy development. We close with a discussion of the implications that students' beliefs about digital literacy development may hold for instruction.

2. Methods

2.1. Participants

Participants were 188 undergraduate students at a large, public university in the United States. The sample was majority female (81.91%, $n = 154$; male: 17.02%, $n = 32$) and majority White (86.70%, $n = 163$). Further, the sample was 2.13% African American ($n = 4$), 3.19% Asian ($n = 6$), Latino ($n = 6$), and biracial or multiracial ($n = 6$). One student (0.53%) reported Native American ethnicity. The majority of the sample were freshman (52.13%, $n = 98$) and sophomores (38.83%, $n = 73$). The remaining students were juniors (4.26%, $n = 8$) and seniors (2.66%, $n = 5$). One student did not report demographic information.

The students in our sample were purposefully recruited from two educational psychology classes, constituting introductory courses for pre-service teachers and students majoring in education. This sample of undergraduate education majors was targeted for two primary reasons. First, we were particularly interested in the beliefs about digital literacy development of pre-service teachers because such conceptions may have a particularly strong effect on whether and how these undergraduates may later elect to teach digital literacy to their students. Second, we were interested in capturing the beliefs of freshman and sophomore pre-service teachers, in particular, since we considered such beliefs to be more directly influenced by students' experiences in K-12 education and naïve conceptions of digital literacy development, as compared to beliefs that may develop following their completion of methods courses in education.

2.2. Data sources

Data were collected as part of a larger study examining pre-service teachers' conceptions of and skills in digital literacy. Analyses in this study are based on a survey administered to students prior to their completion of a multiple text task. While the survey focused on digital literacy, the multiple text task asked students to research and write about a controversial socio-scientific issue based on information presented across a library of six digital texts. As a part of the digital literacy survey, students were asked to respond to the prompt: *As a college student, you have well-developed skills in digital literacy. How or where did you learn digital literacy skills? Please be specific.* Students were further asked to report whether any of their classes had a unit expressly dedicated to digital literacy and to explain the nature of this unit. Nevertheless, analyses in this paper are based primarily on students' responses to the survey question tapping their conceptions of digital literacy development.

2.2.1. Analysis approach

A qualitative approach to data analysis was adopted in this study as we wanted to richly describe students' conceptions of digital literacy development. Moreover, the adoption of a qualitative approach was considered to be aligned with the descriptive approaches to conceptualizing digital literacy forwarded in the literature (Eshet-Alkalai, 2004; Knobel & Lankshear, 2006; Prensky, 2001). At the same time, atypical of qualitative studies, a large sample of undergraduate students participated in this study. Recruiting a large number of students allowed us to garner further insights about the prevalence of different conceptions of digital literacy development among pre-service teachers.

Responses were analyzed using both top-down and bottom-up approaches. Initially students' open-ended responses were classified as reflecting conceptions of digital literacy development aligned with digital natives, skill-based, and sociocultural perspectives. Students' beliefs about digital literacy development were able to reflect more than one of these perspectives simultaneously. Following this initial coding, common and distinctive features of responses placed into each of these categories were identified. Responses unable to be aligned with digital natives, skill-based, or sociocultural perspectives were labeled as other. Then, a bottom-up coding approach was adopted to identify other themes in students' understandings of digital literacy development, not captured in the three approaches determined through our review of the literature. Beyond considering students' conceptions of digital literacy development holistically, responses were further coded to generally characterize the context within which students described their digital literacy development as emerging. Specifically, responses were coded for whether they identified digital literacy development as occurring in elementary, middle, or high school or in college as well as whether digital literacy development was situated within formal (i.e., in school or in class) or informal (e.g., at home, from friends) contexts.

Two raters independently scored 43 student responses, corresponding to 22.87% of the sample. Cohen's kappa inter-rater agreement for categorizations of students' responses as digital natives, skill-based, or sociocultural in nature was 0.66, indicating moderate agreement. Cohen's kappa for designations of students' positioning of digital literacy development as occurring in formal or informal settings was $\kappa = 0.86$, indicating strong agreement. All disagreements were resolved through discussion.

3. Results

Students' conceptions of digital literacy development are first presented as aligned with the three perspectives on digital literacy development identified in the literature. Then, additional themes to emerge from students' descriptions of digital literacy development, but not fully captured in the literature, are identified. Finally, the contexts within which students consider digital literacy to unfold are explored.

We were first interested in examining the extent to which students' beliefs about digital literacy development reflected (a) conceptions of themselves as digital natives, (b) adopted a skills-based perspective on digital literacy development, or (c) reflected a sociocultural understanding of digital literacy development. Students' responses, presented throughout the results, were, in some cases, lightly edited to correct for errors in spelling or grammar.

3.1. Literature-based conceptions of digital literacy

3.1.1. Digital natives perspective

A digital natives aligned perspective on digital literacy development was one which conceptualized digital literacy development as unfolding automatically or effortlessly, as a natural consequence of today's students' being immersed in the technological affordances of the digital age. A response typical of a digital natives aligned perspective included: "I don't feel that I learned digital literacy skills; I just grew up using technology on an everyday basis, so I feel comfortable using technology for things that are academically related." Noteworthy in this response is both that it conceptualizes digital literacy as inevitably occurring as a result of prolonged exposure to technology and that it identifies an emotional component to digital literacy development, as reflected in this student's expression of feelings of comfort or familiarity with technology. In another digital natives-aligned response a student explained: "I feel like I never really learned digital literacy skills. I feel like I am so accustomed ... that I never needed to be taught, like my grandparents had to be taught. I grew up using these systems so it was easy for me to learn. I think it is important for people to start using technology at a young age so it can help them in their future." Typical of other students' answers, this response emphasized digital literacy development as requiring technology exposure at a young age and presented a generational contrast between this student and their grandparents' experiences with digital literacy. Such an age and generation-based conceptualization of digital literacy development is similar to the distinction introduced by Prensky (2001) in his contrasting of digital natives with digital immigrants. In our sample, 18% of student responses ($n = 34$) were found to reflect a digital natives perspective on digital literacy development.

3.1.2. Skills perspective

Skill-based understandings of digital literacy development tended to adopt a componential approach and to consider digital literacy development to involve the acquisition of a set of skills or competencies necessary for functioning in the digital age. A skill-based perspective was reflected in responses such as: "I had a computer class that I had to take that taught us how to type on the keyboard, identify reliable websites from fake websites, how to make power points, and how to do graphic animation." In this case, typical of a skill-based understanding of digital literacy development, this student defined digital literacy as the result of mastering a set of skills, including those related to technology use *per se* (e.g., typing, graphic animation) and those related to knowledge building within digital environments (e.g., evaluating websites). In particular, the skills that this student identifies as components of digital literacy reflect both technical (i.e., using a keyboard) and cognitive (e.g., evaluating websites, making power points) aspects of Ng's (2012) digital literacy framework. Moreover, such skills correspond to reproduction literacy (i.e., making power points), photo-visual literacy (i.e., graphic animation), and information literacy (i.e., identifying reliable websites), as identified by Eshet-Alkalai (2004). Another student, focusing more on the knowledge building aspects of digital literacy skill development, discussed skills thus: "... I was taught from a young age how important it is that when doing research, you find a reliable source. I was also taught to rephrase what you read online into your own words to avoid plagiarism. In addition, with digital literacy, I was taught to understand what the author is stating and then comparing it with similar or different opinions." This student identified digital literacy development as

requiring the acquisition of a set of fairly high-level cognitive skills. At the same time, this student discussed such skills as independent of one another and as disconnected from any purpose for their use. Contrasted with sociocultural understandings, skill-based perspectives emphasized the particular competencies that students may be expected to master, as a part of becoming digitally literate, in a fairly decontextualized fashion or as ends onto themselves, rather than as connected to becoming a part of a digital community or a social learning system. Indeed, skill-based descriptions rarely emphasized any social aspects of digital literacy development, at all. Skill-based perspectives on digital literacy development were predominant in our sample, reflected in 54% ($n = 102$) of student responses.

3.1.3. Socio-cultural perspective

Distinct from sociocultural perspectives forwarded in the literature, students in our sample nested their digital literacy development within the social context of their schools and classrooms, rather than associating digital literacy with gaining entry into digital communities on the Internet. Consistent with a sociocultural perspective, these students considered digital literacy to be acquired socially, through a process of assimilating into a social learning system. But students identified the social learning system that they were gaining entry into as being extant in their classrooms, rather than online. In one example of a sociocultural perspective on digital literacy development, a student explained:

“I started to develop digital literacy skills in middle school, where we were assigned to complete our first research paper while being given multiple platforms to research off of. We were taught how to create a bibliography and cite our sources, we were taught how to properly look for information that was accurate and relevant, and what databases and websites to look through. This continued almost every single year during my remaining years at my town's local public school, as librarians and teachers alike would teach us how to search for, cite, and use any meaningful and proper information.”

Unlike only a skill-based perspective on digital literacy development, this student understood digital literacy as achieved through their development of a knowledge artifact (i.e., a research paper) valued by their teachers. Indeed, this student described engaging in a variety of activities associated with reification or the formation of a product (i.e., a research paper) according to the practices and using the tools (e.g., databases) of the social learning system of their school. Moreover, they identify their digital literacy development as emerging through their repeated interaction with librarians and teachers and through their adoption of the standards for research papers held by their social learning system (i.e., through alignment, Wenger, 2000).

Indeed, in many cases students adopting socio-cultural perspectives on digital literacy development, viewed their classrooms and schools as social learning systems that were heavily digital in nature. This is further reflected in one student's response: “As I went into middle and high school, we started doing a lot more online learning, posting blog posts and submitting assignments online. Google Docs became a big part of my classes as that was how we communicated with each other as well as our teacher.” Using technology tools or developing digital literacy as a means toward a social or participatory end (e.g., communicating with one another) seems central to understanding sociocultural perspectives on digital literacy development. Sociocultural understandings on digital literacy development were reflected in 30% ($n = 56$) of student responses.

3.1.4. Integrated perspectives on digital literacy development

Digital natives, skill-based, and sociocultural perspectives on digital literacy development have been introduced in the theoretical literature as largely distinct from one another. At the same time, several students' responses reflected perspectives on digital literacy development that unified some or all three of these perspectives. For instance, one student described their digital literacy development as:

“In middle school, my class would go to the computer lab and our computer teacher showed us how to format papers, design presentations on many different outlets, and how to find reliable websites. He would tell us that some websites had fake information that was not reliable and others (such as .org and .edu sites) had excellent information. I also learned about digital literacy in high school, when I was told for the first time that I had to create a website. I had no clue how to do this but luckily my father was able to help. He manages and creates website training programs for companies and he was able to show me the best way to create a website and how to make it appealing to the eye. Finally, growing up in this generation has allowed me to figure things out on my own as well. Our generation knows everything about technology, or so it seems, and just by being around advanced technology all the time enabled me to use media outlets much easier than my parents.”

In this single response, all three of the conceptualizations of digital literacy development, identified in the literature, can be recognized. To start, this student's observation that: “... Our generation knows everything about technology, or so it seems, and just by being around advanced technology all the time” is reflective of a digital natives-like perspective, as introduced by Prensky (2001). Emblematic of such a perspective, this student is further attending to generational differences in technology use between them and their parents. As a secondary point, this student is further conceptualizing digital literacy development as a componential process of skill acquisition. This is evidenced through this student's listing of skills taught to them by their computer teacher including, “how to format papers, design presentations ... and how to find reliable websites.” At the same time, a sociocultural perspective on digital literacy development is evidenced through this student's focus on reification, or skill development aimed toward the production of a website. A sociocultural perspective is further evidenced in this student's identification of their father as a social figure able to teach them about best practices in website design. Indeed, we can see this student articulating how digital literacy is both a set of processes that they can participate in (i.e., the making of the website) and the ability to create a socially meaningful product (i.e., the website itself). Nevertheless, this student's beliefs about digital literacy development may not be fully aligned with a sociocultural

perspective, as articulated in the literature. Missing from their description is a sense of which social learning system their development of digital literacy may enable them to become a part of.

Another student's response demonstrated the often close association between skill-based and sociocultural approaches to digital literacy development. This student described their digital literacy development as follows:

“In elementary school, we had a, ‘computer class,’ where we learned how to use PowerPoint, Word, and improved our typing skills. Because of our young age, we didn't go too in depth with the programs because we didn't have a use for them yet. We started with making cards for our parents in Word and creating PowerPoints on our favorite foods, activities, and animals ... In later schooling, each subject area helped add some form of digital literacy to my knowledge. Business and math classes helped with Excel, or Google sheets, and English developed how to format a paper based on what format we needed to use.”

Typical of a skill-based approach to digital literacy development, this response lists a host of tools and skills necessary for students to master in order to become digitally literate. At the same time, moving beyond only a skills-based approach, this response emphasizes the social dimensions of digital literacy development. Specifically, acquiring digital literacy skills enabled this student to share aspects of themselves with others and to connect with their parents. Moreover, this student evidenced a recognition of the disciplinary aspects of digital literacy development, with certain digital literacy skills and tools allowing for meaningful participation within particular domain or disciplinary communities.

We were further interested in the correspondence among students' approaches to digital literacy development. A chi-squared test of association determined that holding a digital natives aligned perspective on digital literacy development was significantly associated with adopting a skill-based approach, $X^2(1) = 4.29$, $p < 0.05$, Cramer's $V = 0.15$. There was no significant association between students' adoption of digital natives and sociocultural approaches to understanding digital literacy development ($p = 0.38$), nor between students adopting skill-based and sociocultural perspectives ($p = 0.09$).

3.2. Students' conceptions of digital literacy, beyond the literature

In addition to conceptualizing students' beliefs about digital literacy development through the three theoretical lenses forwarded in the literature (i.e., digital natives, skill-based, and sociocultural perspectives), we were further interested in identifying aspects of students' beliefs about digital literacy development not fully captured through these approaches. Four such additional conceptions of digital literacy development were identified and are described.

3.2.1. Autonomy

Related to a digital natives perspective, some students described digital literacy as acquired autonomously, through their own independent exploration of various technological tools. An autonomy-focused understanding of digital literacy development is similar to a digital natives perspective in that it describes the process of acquiring digital literacy as an independent one, on the part of students, receiving limited support from parents or teachers. At the same time, an autonomy-focused approach can be contrasted with a digital natives perspective. Prensky (2001) and others emphasize the effortless and osmotic nature of acquiring digital literacy for natives immersed in technology from a young age. As a counterpoint, students adopting an autonomy-focused perspective, conceptualized digital literacy development as a deliberate and effortful process, just one undertaken independently of, rather than with, curricular and social support. An autonomy-focused approach to understanding digital literacy development was reflected in responses such as: “Due to the fact that my parents grew up in an older, different generation and were new to this technology (and not specifically accepting of it), I was forced to take in this information and technology at a young age and figure it out for myself. This type of situation is why I consider myself to be digitally literate today.” Just like Prensky (2001) and other students whose beliefs about digital literacy development aligned with a digital natives perspective, this student thought of digital literacy development in generational terms. At the same time, this student conceptualized the process of digital literacy development as more effortful and active than was envisioned by Prensky (2001).

The active nature of digital literacy development, aligned with an autonomy-focused perspective, is further evidenced in this student's response: “I feel like I taught myself digital literacy for the most part. Neither of my parents use much technology at all and I actually end up teaching them most of the time ... but I picked up most of my knowledge about the Internet through trial-and-error on my own.” Tied to an autonomy-focused understanding of digital literacy development, this student viewed digital literacy as iteratively developed through experimentation or through tinkering and trial and error (Ito et al., 2009). Additionally reflected in this response, as well as in other responses adopting an autonomy-based understanding of digital literacy development, was digital literacy as enabling students to help others use technology. Reflective of a more sociocultural approach, these perspectives emphasized the knowledge sharing aspects of digital literacy development, be they students learning from more expert others or themselves serving as experts in technology use.

3.2.2. Technology tools

A number of students discussed developing digital literacy specifically as a result of being given access to and using particular technological tools, including laptops and cell phones. The role of technology tools can be seen as reflected in digital natives, skill-based, and sociocultural understandings of digital literacy. A digital natives perspective specifically emphasized digital literacy as the result of students' prolonged experiences with a variety of technological tools. As one student explained: “I think I learned digital literacy skills from ‘toys’ I had when I was younger like my DS and iPod. As more different types of technology became incorporated into my life, I developed more advanced digital literacy by using them.” The seemingly seamless transition to digital literacy through

the course of technology use, described in this response, seems aligned with a digital natives approach to digital literacy development.

Skill-based perspectives looked at students' ability to use various technology tools as components of digital literacy skill development. In a skill-based approach to technology use, students described mastering a variety of technological tools. For example, one student explained: "In high school, everyone was given a Chromebook, so we eventually become more and more efficient using laptops ..." Within this description, the knowledge of how to use various technological tools is considered to be among the competencies that students need to acquire as a part of becoming digitally literate.

Finally, sociocultural perspectives looked at students' technology use as a part of their engagement with particular cultural artifacts in socially-prescribed ways. More aligned with a sociocultural perspective on digital literacy development, another student's response was as follows: "I also went to a STEM high school, and we all were given a school-issued laptop that served as both a personal and school laptop. Having my own computer made me even more excited to learn how to use it, and I also needed to understand how to use it for school projects (because of the STEM nature of my school)." In this response, access to and the use of certain technological tools is described by this student as part of what defined their school as a STEM-focused social learning system.

3.2.3. *Project focused*

Reflective of both skill-based and sociocultural perspectives on digital literacy development, some students considered digital literacy development to involve the creation of some tangible product or outcome, be it a research paper, a presentation, or a website. Similar to the construct of reification, introduced by Wenger (2010), these students understood their development of digital literacy as a means of creating some outcome of value. This was reflected in responses such as: "Also, I use digital literacy a lot in my English class, where I post two blogs every week, and must incorporate quotes and reputable sources to support my claims." Such descriptions built on skill-based understandings of digital literacy by drawing together or organizing digital literacy skills according to those needed to develop a specific product. Moreover, such perspectives often emphasized the collaborative or social aspects of both project formation, specifically, and digital literacy development, more generally. As one student explained: "I specifically remember one project in about 4th grade where we had to work with a partner and make a power point about an endangered animal. This project was completely online. All of our research and developing the power point was on the computer." Reflected in this response, as well as in others, is the collaborative or inter-personal aspect of adopting a project-based conception of digital literacy development.

3.2.4. *Lack of digital literacy*

An assumption made in eliciting students' beliefs about their digital literacy development is that students, indeed, conceptualize themselves as having well-developed skills in digital literacy. At the same time, we found several instances of students who identified limitations in their digital literacy skills, particularly as compared to their peers. This was reflected in responses such as: "Compared to most students my age, my digital literacy skills are lacking. When teachers wanted to implement certain resources such as Excel or PowerPoint I would learn how to do it, surface level knowledge, but I never had a digital literacy crash course to learn about it on a deeper level." Evidenced in this perspective is a conception of digital literacy as dependent on contextual demands or what may be required across a variety of situations. One student describes the differences in expectations around digital literacy held by teachers in high school versus professors in college: "The thing was that I hadn't really written college level papers before so I was at a loss as to what to do. Thankfully, I took English 15 in my spring semester of freshmen year and it was this professor that hammered down the importance of using today's technology to get ahead." We were interested in further understanding the contextual aspects of students' digital literacy development. We specifically wanted to examine where and at what age students identified digital literacy as emerging.

3.3. *Context of digital literacy*

Two contextual aspects of digital literacy were examined for their occurrence within students' open-ended responses. Specifically, we considered whether students identified their digital literacy development as occurring in formal or informal contexts as well as in elementary, middle, or high school, or in college. Across both of these contextual factors, we found there to be a great deal of variability in students' descriptions of the contexts within which digital literacy may emerge.

3.3.1. *Formal and informal contexts*

The first distinction to emerge is the extent to which students considered themselves to have developed digital literacy in formal or informal settings. Indeed, a large number of students reported having learned digital literacy in formalized, structured school and classroom contexts. A description of formalized instruction in digital literacy was reflected in responses such as:

"My high school had a specific seminar for digital literacy that taught us how to integrate technology into our ability to learn ... Our school began a one to one system ... where every students has a laptop in order to help build a technologically advanced education. When they integrated this program the administration found it necessary to test students on their digital literacy before entrusting them with a school provided computer. The seminar lasted a week and required an one hour course every day. Each teacher taught a different module on digital literacy and then the students used the computers to take a test on that specific module ... No student was allowed to take their computers home until the modules were completed and had a 100%."

Notable about this response was not only the structured nature of the seminar in which this student was asked to partake but also that it included an assessment component associated with determining students' degree of digital literacy development. More

commonly students just generally described learning digital literacy as a part of classes in computers or social studies. The scope of digital literacy learning occurring within formal contexts is further expressed in this response:

“I remember starting to learn digital literacy skills in elementary school, specifically in library class. There, we would use laptops to complete different activities ... In middle school and high school, my digital literacy skills were more thoroughly enhanced because we were constantly required to use technology to read articles, collaborate with peers on projects, and do research. All of these instances, my teachers taught me methods that made me more skilled ...”

This response is reflective of students whose experiences included learning about digital literacy as a part of both supplemental instruction (e.g., library or computer class) and in core academic subjects. Collectively formal contexts for learning about digital literacy featured instruction, activities, and assignments directed toward fostering digital literacy development. The majority of students, or 84% of the sample ($n = 157$), described their digital literacy development as occurring within formal contexts.

Many students also reported developing digital literacy within informal contexts for learning. Typically, these included students learning digital literacy from their parents, older siblings, or peers. One student's response articulated how their informal digital literacy learning prepared them for later academic classes on digital literacy: “I was fortunate to have access to a computer growing up. Many times the computer had to be repaired because myself or my brother had done something to give it a virus or damage information stored on it ... curiosity compelled us to explore the computer and its abilities ... By the time I entered Middle School, I understood the basic functions and abilities of your average late 2000s computer.” Reflected in this response is an autonomy-focused understanding of digital literacy development, emerging through this student's iterative experimentation process of trial and error. Moreover, this student's experience of digital literacy development was guided by their brother. Indeed, social aspects of digital literacy development were often described as occurring within informal settings. Other students also described the role that early technology exposure had in helping them to master digital literacy in out-of-school contexts. As one student describes: “I had access to my parents' computer and internet access from a young age ... I've always associated computers and the internet with learning and fun.” Clear in this student's response is that providing students with the opportunity to engage in and develop digital literacy in out-of-school contexts serves to help students develop positive affect as well as a high degree of efficacy for digital literacy. Half of the sample (50%, $n = 94$) situated their digital literacy development as occurring within an informal setting.

Also common was students describing digital literacy as being developed across both formal and informal settings. In some cases, students considered digital literacy development across settings to be redundant. For instance, the student who had access to their parents' computer from a young age went on to report: “I explored different programs on the computer independently ... I also had classes in school that taught me about digital literacy, but the lessons were usually reviews for me.” In other cases, students seemed to assign particular realms to digital literacy as manifest in formal and informal settings. For instance, one student explained: “When I started school, I learned how to use the Internet to search for information and use PowerPoint and Word to demonstrate my knowledge ... as I got my own phone and iPod and used them to communicate with my friends and play games.” This student conceptualized digital literacy as encompassing both skills gained in formal classroom settings and used to complete academic tasks and skills associated with technology use for entertainment and communication and applied in more informal settings.

3.3.2. Grade level of digital literacy development

In addition to examining digital literacy acquisition in formal and informal settings, the context of digital literacy development was further explored to determine whether students situated their digital literacy development as occurring in elementary, middle, or high school, or in college. In terms of the educational stage of digital literacy acquisition, a remarkable variety of responses were reported. While some students reported first being exposed to technology even before starting elementary school, others identified Advanced Placement classes in their last years of high school as well as courses in college as settings for digital literacy development. Specifically, responses ranged from: “I learned digital literacy at home from a young age, starting with when I was four years old and would play educational computer games” to “Some of my digital literacy skills come from high school projects but most of them come from my early college experience. I had specific classes that invited someone from the library to come in and teach us how to use the databases.”

At the same time, the majority of students described their digital literacy experiences as building on one another and iteratively emerging through progressive years in school. This is reflected in responses such as: “In 3rd grade they offered a program called ‘FastMath’ that taught me how to type and do math. In middle, I was introduced to programs such as Word and PowerPoint and taught how to use them properly. My freshman year of high school I was enrolled in a mandatory computer course, which went over different computer programs.” This student's response reflects how formal learning contexts, in particular, may be structured to support students' progression in digital literacy development. This response further reflects the balanced split among students situating their digital literacy development in elementary (38%, $n = 72$), middle (27%, $n = 51$), and high (35%, $n = 66$) school.

4. Discussion

This study had four goals. First, we interrogated the literature to identify three approaches to conceptualizing digital literacy development. Second, students' conceptions of digital literacy development were connected to dominant paradigms available in the literature. Third, students' descriptions introduced new understandings of digital literacy development (e.g., autonomy-focused, project-based, and technology-focused) that were able to be integrated into conceptions forwarded in the literature. Finally, contextual aspects of digital literacy development were examined to identify where and when students considered themselves to acquire digital literacy. Drawing on these analyses, a number of implications may be derived.

To start, the digital natives perspective, introduced by Prensky (2001), was found to be well-represented in students' conceptions of digital literacy development. Indeed, a sizable minority of students (18.09%) considered their digital literacy to emerge somewhat naturally or effortlessly, only through their exposure to and immersion in technology. This demonstrates a troubling persistence to the digital natives narrative in the mainstream, despite its repudiation in the empirical literature (Bennett et al., 2008; Helsper & Eynon, 2013). Indeed, holding a digital natives-aligned set of beliefs may carry with it a number of limitations (Kolikant, 2010). For one, students considering themselves to be digital natives may become discouraged when experiencing challenges mastering technological tools. For another, these students may use technology tools only superficially, without engaging more critically or effortfully in technology use. Finally, given that the sample of students examined in this study consisted of preservice teachers, their holding beliefs reflective of a digital natives perspective, may result in these future teachers neglecting to sufficiently or appropriately instruct their own students in digital literacy. Indeed, if teachers expect their students to automatically acquire digital literacy, only by virtue of being members of a digital generation (Oblinger & Oblinger, 2005), this may serve to perpetuate superficial understandings of and limitations in the mastery of digital literacy. A viable strategy for developing the beliefs of students holding digital natives perspectives may be to support these students to adopt more autonomy focused beliefs, or to conceptualize digital literacy development as the result of iterative tinkering and trial and error. Indeed, one key insight to emerge from this study is the distinction between digital natives and autonomy-focused understandings of digital literacy development, differing in their conceptions of learners as passive or active actors in their digital literacy development.

Skill-based conceptions of digital literacy development seemed predominant among students' responses. This echoes the volume of literature identifying the skills that students need to master in order to become digitally literate (Calvani et al., 2012; Greene, Yu, & Copeland, 2014; Eshet-Alkalai, 2004; Gui & Argentin, 2011; Van Deursen & Van Dijk, 2011). The range of skills reported in students' responses was also remarkable. As conceptualized in Ng's (2012) framework, students attend to technological aspects of digital literacy development (e.g., learning to type), much more frequently than they do to cognitive (e.g., information synthesis) or critical (e.g., source evaluation) aspects of digital literacy. Indeed, a minority of students specifically identified mastering skills like corroborating sources or determining website credibility as key components of digital literacy (26.06% of the sample, $n = 49$). Moreover, socio-emotional aspects of digital literacy development, in particular, seemed to be almost entirely missing from students' responses, these included the skills necessary for communication, collaboration, privacy maintenance, and identify formation online. This dearth is concerning, given the variety of socioemotional-based challenges with technology use recently confronting students, teachers, and schools. These include issues of cyber-bullying, sexting, and the preponderance of viral Internet hoaxes (e.g., Tide Pod challenge, cinnamon challenge) among others (Mitchell, Finkelhor, Jones, & Wolak, 2012; Smith, Liebelt, & Nogueira, 2014). This misalignment between preservice teachers' beliefs about what may constitute a critical digital literacy skill and the skills that experts identify as necessary for digital literacy (Ng, 2012), suggests the need to identify a common set of skills necessary for students to develop for digital literacy. Moreover, an additional point to emerge from this study is the need to identifying developmental trajectories for skill development. In particular, understanding the developmental trajectories of students' socioemotional digital competencies, seems critical as students confront technology at increasingly younger ages (Christakis, 2014; Kabali et al., 2015; Radesky, Schumacher, & Zuckerman, 2015).

It should further be noted that many of the digital skills students identified were surface-rather than deep-level in nature. Dinsmore and Alexander (2012, 2016) identify the difference between surface versus deep-level strategies as between strategies aimed only at the superficial processing or encoding of information (e.g., navigation, digital reading) vis-à-vis processes aimed at the transformation or manipulation of content for learning (e.g., synthesis, evaluation). Nevertheless, more work is needed to understand which digital literacy skills, in particular, may be conceptualized as surface- or deep-level in nature. At the same time, viewing students' digital literacy skills as moving from more surface-level to deeper-level competencies may be a variable avenue for conceptualizing the trajectory of digital literacy skill development.

As a final point, sociocultural approaches to digital literacy development were not fully elaborated in students' responses. For instances, one student described their digital literacy development thus: "I believe it was a combination of ... collaboration and learning from friends, and some teacher assistance. Mainly I learned how to do things out of ... my friends explaining things to me." Consistent with a sociocultural perspective, this student clearly identifies digital literacy as developed socially (i.e. through their friends and teachers). At the same time, this student's articulation of a sociocultural perspective is somewhat limited in that they do not fully articulate the social learning system or community within which their social development of digital literacy is nested. In part, this is understandable as sociocultural conceptions represent a much more integrated and abstract approach to understanding digital literacy development, as compared to skill-based perspectives. At the same time, sociocultural approaches may underlie many students' conceptions of digital literacy development. In particular, students holding a digital natives perspective on digital literacy development may have been, in part, guided by their understanding of the digital demands of culture and society. This is reflected in responses such as: "I do not think I could point out a specific time how or where I learned digital literacy skills. I think growing up in a generation that uses technology A LOT, I just learned as I started to grow up." Although not expressly sociocultural in nature, this student's understanding of digital literacy development is clearly one informed by their conception of society as a technology rich culture.

There seems to be value in conceptualizing digital literacy development as more sociocultural in nature. To the extent that students describe viewing their schools and classrooms as digital social learning systems, it seems necessary to set explicit norms and standards around what constitutes meaningful participation in these systems and how such participation may emerge. Indeed, sociocultural perspectives on digital literacy development seem to be viable means of integrating socioemotional competency into students' conceptions of digital literacy development. In other words, if students view the process of becoming digitally literate as one of entering into a digital community, they may better attend to the social processes involved in becoming a part of such a community.

Students reported developing digital literacy across a range of formal and informal contexts and developmental stages. For instance, while some students described developing digital literacy through their schools' deliberately designed digital literacy curricula, other students described digital literacy development as occurring in a more ad-hoc fashion, for instance, through their playing of math or typing-based computer games. Given this variety of contexts, supporting students to identify what digital literacy skills they are using within specific contexts, their nature, and effectiveness, seems critical. This process of identification may be referred to as students' development of a meta-awareness of digital literacy. Although we only examined students' reports of the contexts of digital literacy development, there is evidence that teachers need further clarification on this issue as well. A 2013 study of Advanced Placement and National Writing Project middle and high schools teachers, arguably the most likely to instruct their students in digital literacy, concluded that while: "teachers in the study generally agreed on what skills are needed ... there was less consistency in their opinion of when these skills should be taught and by whom" (Purcell et al., 2012, p. 48).

This study contributes to the literature on digital literacy development in at least four ways. First, we examine the alignment between students' own conceptions of digital literacy development and those articulated in the literature. Indeed, we are among the initial efforts not only to understand the nature of digital literacy but also to consider students' conceptions of its development. Second, we examine the relative prevalence of various conceptions of digital literacy development in a sample of pre-service teachers, a critical population to examine. Third, we enrich conceptions forwarded in the literature with ideas somewhat uniquely introduced by learners (e.g., project-based conceptions of digital literacy developed). Finally, we identify several instructional mechanisms whereby digital literacy development may be fostered.

4.1. Limitations

Despite the strengths of this study, a number of limitations must be acknowledged. First, data for this study were drawn from students' open-ended survey responses. While this approach allowed us to collect a large number of responses, to capture the range and variability in students' conceptions of digital literacy development, other methodological approaches like interviews and focus groups, may have allowed for richer qualitative data to be collected and for students' responses to be further probed. Indeed, these approaches have been used successfully in prior research (Ng, 2012). Further work adopting mixed-methods approaches is needed to better understand the depth and nuance of students' conceptions of digital literacy development. Moreover, there is a specific need to tie students' conceptions of digital literacy development to their demonstrated skills in digital literacy. This may provide evidence for the relative adaptiveness of some beliefs over others.

In articulating their beliefs in this study, students were asked to describe the processes and mechanisms that they considered to contribute to digital literacy development. Nevertheless, more work is needed to understand how students define what digital literacy is and how students view digital literacy in relation to learning. Moreover, it is necessary to understand whether and how students distinguish among digital literacy and related concepts, like information literacy, ICT literacy, and 21 century literacy, among others.

As a final point, students in this study represented a sample of pre-service teachers early in their educational program. More work is needed to understand how students' conceptions of digital literacy development change as they progress through education classes and enter the classroom as teachers. Moreover, while undergraduates enrolled in education courses were specifically targeted for this study, due to our interest in the conceptions of digital literacy development of pre-service teachers, these students were likely not representative of all undergraduates, pursuing other majors. Indeed, prior work has found students' epistemic beliefs, or beliefs about knowledge and knowing, to differ in association with their domain or area of study (Hofer, 2001; Paulsen & Wells, 1998; Trautwein & Lüdtke, 2007). We may expect conceptions of digital literacy development to be similarly differentiated. An interesting direction for future work would be to examine how the conceptions of digital literacy development of education majors compare to those of students pursuing other majors, particularly those in fields associated with the information sciences and with technology to a greater extent. Differences in conceptions of digital literacy development across majors are especially important to consider, given that such differences have been found in individuals' endorsement of intelligence mindsets. For instance, students pursuing majors in STEM fields (e.g., biology, Dai & Cromley, 2014; computer science, Flanigan, Peteranetz, Shell, & Soh, 2017; math, Shively & Ryan, 2013) have been found to strongly endorse entity theories of intelligence, considering intelligence to be fixed or innate, rather than incremental or able to be improved over time. The extent to which such fixed or entity-focused beliefs extend to understandings of digital literacy development remains an open question. Nevertheless, it may be the case that students, across majors, may specifically differ in the extent to which they align with a digital natives-based perspective on digital literacy development, considering digital literacy to be more innate, rather than emergent in nature.

4.2. Conclusion

In this study we examine how students conceptualize their digital literacy development. We found students to hold at least three conceptions of how digital literacy may develop. These were conceptions reflecting digital natives, skill-based, and sociocultural approaches to digital literacy development. Moreover, students were found to elaborate on these conceptions in a variety of ways, including by furthering autonomy-focused, project-based, and technology-focused conceptions of digital literacy development. Nevertheless, across all of the approaches students largely demonstrated the fundamental recognition that digital literacy is a developmental process – justifying this topic as an area of inquiry requiring further work.

References

- Aagaard, J. (2015). Drawn to distraction: A qualitative study of off-task use of educational technology. *Computers & Education*, 87, 90–97.
- Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, 44(9), 1175–1184.
- Baumgartner, J., & Morris, J. S. (2006). The Daily Show effect: Candidate evaluations, efficacy, and American youth. *American Politics Research*, 34(3), 341–367.
- Bawden, D. (2001). Information and digital literacies: A review of concepts. *Journal of Documentation*, 57(2), 218–259.
- Bawden, D. (2008). Origins and concepts of digital literacy. *Digital literacies: Concepts, policies and practices*, 30, 17–32.
- Bennett, S., Maton, K., & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. *British Journal of Educational Technology*, 39(5), 775–786.
- Berson, I. R., & Berson, M. J. (2003). Digital literacy for effective citizenship. *Social Education*, 67(3), 164–167.
- Calvani, A., Fini, A., Ranieri, M., & Picci, P. (2012). Are young generations in secondary school digitally competent? A study on Italian teenagers. *Computers & Education*, 58(2), 797–807.
- Celik, V., & Yesilyurt, E. (2013). Attitudes to technology, perceived computer self-efficacy and computer anxiety as predictors of computer supported education. *Computers & Education*, 60(1), 148–158.
- Christakis, D. A. (2014). Interactive media use at younger than the age of 2 years: Time to rethink the American academy of pediatrics guideline? *JAMA Pediatrics*, 168(5), 399–400.
- Coiro, J. (2003). Reading comprehension on the internet: Expanding our understanding of reading comprehension to encompass new literacies. *The Reading Teacher*, 56(5), 458–465.
- Coiro, J., Knobel, M., Lankshear, C., & Leu, D. J. (Eds.). (2008). *Handbook of research on new literacies*. Mahwah, NJ: Lawrence Erlbaum.
- Colón-Aguirre, M., & Fleming-May, R. A. (2012). "You just type in what you are looking for": Undergraduates' use of library resources vs. Wikipedia. *The Journal of Academic Librarianship*, 38(6), 391–399.
- Cope, B., & Kalantzis, M. (2009). "Multiliteracies": New literacies, new learning. *Pedagogies: International Journal*, 4(3), 164–195.
- Dai, T., & Cromley, J. G. (2014). Changes in implicit theories of ability in biology and dropout from STEM majors: A latent growth curve approach. *Contemporary Educational Psychology*, 39(3), 233–247.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340.
- Dingli, A., & Seychell, D. (2015). *The new digital natives*. Berlin, Germany: Springer.
- Dinsmore, D. L., & Alexander, P. A. (2012). A critical discussion of deep and surface processing: What it means, how it is measured, the role of context, and model specification. *Educational Psychology Review*, 24(4), 499–567.
- Dinsmore, D. L., & Alexander, P. A. (2016). A multidimensional investigation of deep-level and surface-level processing. *The Journal of Experimental Education*, 84(2), 213–244.
- Dweck, C. S., Chiu, C. Y., & Hong, Y. Y. (1995). Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychol. Inq.* 6(4), 267–285.
- Eshet-Alkalai, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia*, 13(1), 93–106.
- Eshet-Alkali, Y., & Amichai-Hamburger, Y. (2004). Experiments in digital literacy. *CyberPsychology and Behavior*, 7(4), 421–429.
- European Commission (2007). *A European approach to media literacy in the digital environment*. Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM%3A2007%3A0833%3AFIN%3AEN%3APDF>.
- Flanagin, A. J., & Metzger, M. J. (2007). Digital media and youth: Unparalleled opportunity and unprecedented responsibility. In M. Metzger, & A. Flanagin (Eds.). *Digital media, youth, and credibility*. MacArthur foundation series on digital media and learning (pp. 5–28). Cambridge, MA: The MIT Press.
- Flanigan, A. E., Peteranetz, M. S., Shell, D. F., & Soh, L. K. (2017). Implicit intelligence beliefs of computer science students: Exploring change across the semester. *Contemporary Educational Psychology*, 48, 179–196.
- Gee, J. P. (2014). *What video games have to teach us about learning and literacy*. New York: St. Martin's Press.
- Gee, J. P. (1990). *Social Linguistics and Literacies: Ideology in Discourses, Critical Perspectives on Literacy and Education*. London [England]: New York.
- Gilster, P. (1997). *Digital literacy*. New York: John Wiley.
- Greene, J. A., Seung, B. Y., & Copeland, D. Z. (2014). Measuring critical components of digital literacy and their relationships with learning. *Computers & Education*, 76, 55–69.
- Gui, M., & Argentin, G. (2011). Digital skills of internet natives: Different forms of digital literacy in a random sample of northern Italian high school students. *New Media & Society*, 13(6), 963–980.
- Guo, R. X., Dobson, T., & Petrina, S. (2008). Digital natives, digital immigrants: An analysis of age and ICT competency in teacher education. *Journal of Educational Computing Research*, 38(3), 235–254.
- Hargittai, E. (2010). Minding the digital gap: Why understanding digital inequality matters. In S. Papathanassopoulos (Ed.). *Media perspectives for the 21st century* (pp. 231–240). New York: Routledge.
- Hargittai, E., & Jennrich, K. (2016). The online participation divide. *The communication crisis in America, and how to fix it* (pp. 199–213). New York: Palgrave Macmillan.
- Hartley, J., McWilliam, K., Burgess, J., & Banks, J. (2008). The uses of multimedia: Three digital literacy case studies. *Media International Australia*, 128(1), 59–72.
- Helsper, E. J., & Eynon, R. (2013). Distinct skill pathways to digital engagement. *European Journal of Communication*, 28(6), 696–713.
- Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Educational Psychology Review*, 13(4), 353–383.
- ICTL Panel (2002). *Digital transformation: A framework for ICT literacy*. Educational Testing Service.
- Ito, M., Horst, H. A., Bittanti, M., Stephenson, B. H., Lange, P. G., Pascoe, C. J., ... Martínez, K. Z. (2009). *Living and learning with new media: Summary of findings from the digital youth project*. Cambridge, MA: MIT Press.
- Jackson, L. A., Zhao, Y., Kolenic, A., III, Fitzgerald, H. E., Harold, R., & Von Eye, A. (2008). Race, gender, and information technology use: The new digital divide. *CyberPsychology and Behavior*, 11(4), 437–442.
- Jones, C., & Czerniewicz, L. (2010). Describing or debunking? The net generation and digital natives. *Journal of Computer Assisted Learning*, 26(5), 317–320.
- Jones, C., Ramanau, R., Cross, S., & Healing, G. (2010). Net generation or Digital Natives: Is there a distinct new generation entering university? *Computers & Education*, 54(3), 722–732.
- Judd, T. (2018). The rise and fall (?) of the digital natives. *Australasian Journal of Educational Technology*, 34(5).
- Kabali, H. K., Irigoyen, M. M., Nunez-Davis, R., Budacki, J. G., Mohanty, S. H., Leister, K. P., et al. (2015). Exposure and use of mobile media devices by young children. *Pediatrics*, 136, 1044–1050.
- Katz, I. R., & Macklin, A. S. (2007). Information and communication technology (ICT) literacy: Integration and assessment in higher education. *Systemics, Cybernetics and Informatics*, 5(4), 50–55.
- Kennedy, G. E., Judd, T. S., Churchward, A., Gray, K., & Krause, K. L. (2008). First year students' experiences with technology: Are they really digital natives? *Australasian Journal of Educational Technology*, 24(1), 108–122.
- Knobel, M., & Lankshear, C. (2006). Digital literacy and digital literacies: Policy, pedagogy and research considerations for education. *Nordic Journal of Digital Literacy*, 1(01), 12–24.
- Knobel, M., & Lankshear, C. (2008). Digital literacy and participation in online social networking spaces. In C. Lankshear, M. Knobel, & M. Peters (Eds.). *Digital literacies: Concepts, policies and practices* (pp. 249–278). New York: Peter Lang.
- Kolikant, Y. B. D. (2010). Digital natives, better learners? Students' beliefs about how the internet influenced their ability to learn. *Computers in Human Behavior*, 26(6), 1384–1391.
- Koltay, T. (2011). The media and the literacies: Media literacy, information literacy, digital literacy. *Media, Culture & Society*, 33(2), 211–221.
- van Laar, E., van Deursen, A. J., van Dijk, J. A., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, 72, 577–588.
- Lankshear, C., & Knobel, M. (2003). *New literacies: Changing knowledge and classroom learning*. Open University Press.

- Limberg, L., Sundin, O., & Talja, S. (2012). Three theoretical perspectives on information literacy. *Hum. IT: J. Inf. Technol. Stud. Hum. Sci.* 11(2).
- Li, Y., & Ranieri, M. (2010). Are 'digital natives' really digitally competent?—a study on Chinese teenagers. *British Journal of Educational Technology*, 41(6), 1029–1042.
- Margaryan, A., Littlejohn, A., & Vojt, G. (2011). Are digital natives a myth or reality? University students' use of digital technologies. *Computers & Education*, 56(2), 429–440.
- Marsh, J., Hannon, P., Lewis, M., & Ritchie, L. (2017). Young children's initiation into family literacy practices in the digital age. *Journal of Early Childhood Research*, 15(1), 47–60.
- Martin, A., & Grudziecki, J. (2006). DigEuLit: Concepts and tools for digital literacy development. *Innovation in Teaching and Learning in Information and Computer Sciences*, 5(4), 1–19.
- McCoy, C. (2010). Perceived self-efficacy and technology proficiency in undergraduate college students. *Computers & Education*, 55(4), 1614–1617.
- Merchant, G. (2015). Apps, adults and young children: Researching digital literacy practices in context. *Discourse and digital practices* (pp. 156–169). Routledge.
- Metzger, M. J., Flanagin, A. J., & Medders, R. B. (2010). Social and heuristic approaches to credibility evaluation online. *Journal of Communication*, 60(3), 413–439.
- Mills, K. A. (2010). A review of the “digital turn” in the new literacy studies. *Review of Educational Research*, 80(2), 246–271.
- Mitchell, K. J., Finkelhor, D., Jones, L. M., & Wolak, J. (2012). Prevalence and characteristics of youth sexting: A national study. *Pediatrics*, 129(1), 13–20.
- Mun, Y. Y., & Hwang, Y. (2003). Predicting the use of web-based information systems: Self-efficacy, enjoyment, learning goal orientation, and the technology acceptance model. *International Journal of Human-Computer Studies*, 59(4), 431–449.
- Neumann, M. M., Finger, G., & Neumann, D. L. (2017). A conceptual framework of emergent digital literacy. *Early Childhood Education Journal*, 45(4), 471–479.
- Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education*, 59(3), 1065–1078.
- Oblinger, D., & Oblinger, J. L. (2005). *Educating the net generation*. Brockport Bookshelf. 272 <http://digitalcommons.brockport.edu/bookshelf/272>.
- Palfrey, J. G., & Gasser, U. (2011). *Born digital: Understanding the first generation of digital natives*. New York: Basic Books.
- Park, S. Y. (2009). An analysis of the technology acceptance model in understanding university students' behavioral intention to use e-learning. *Educational Technology & Society*, 12(3), 150–162.
- Paulsen, M. B., & Wells, C. T. (1998). Domain differences in the epistemological beliefs of college students. *Research in Higher Education*, 39(4), 365–384.
- Perry, K. H. (2012). What is literacy?—A critical overview of sociocultural perspectives. *The Journal of Language & Literacy Education*, 8(1), 50–71.
- Pintrich, P. R., & Schrauben, B. (1992). Students' motivational beliefs and their cognitive engagement in classroom academic tasks. *Student Perceptions in the Classroom*, 7, 149–183.
- Prensky, M. (2001). Digital natives, digital immigrants part 1. *On the Horizon*, 9(5), 1–6.
- Prior, D. D., Mazanov, J., Meacham, D., Heaslip, G., & Hanson, J. (2016). Attitude, digital literacy and self efficacy: Flow-on effects for online learning behavior. *The Internet and Higher Education*, 29, 91–97.
- Purcell, K., Rainie, L., Heaps, A., Buchanan, J., Friedrich, L., Jacklin, A., ... Zickuhr, K. (2012). *How teens do research in the digital world*. Pew Internet & American Life Project.
- Radesky, J. S., Schumacher, J., & Zuckerman, B. (2015). Mobile and interactive media use by young children: The good, the bad, and the unknown. *Pediatrics*, 135(1), 1–3.
- Sadaf, A., Newby, T. J., & Ertmer, P. A. (2012). Exploring pre-service teachers' beliefs about using Web 2.0 technologies in K-12 classroom. *Computers & Education*, 59(3), 937–945.
- Schoenfeld, A. H. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education*, 20(4), 338–355.
- Selwyn, N. (2009). Faceworking: Exploring students' education-related use of facebook. *Learning, Media and Technology*, 34(2), 157–174.
- Shively, R. L., & Ryan, C. S. (2013). Longitudinal changes in college math students' implicit theories of intelligence. *Social Psychology of Education*, 16(2), 241–256.
- Smith, E., Liebelt, E., & Nogueira, J. (2014). Laundry detergent pod ingestions: Is there a need for endoscopy? *Journal of Medical Toxicology*, 10(3), 286–291.
- Tapscott, D. (2009). *Grown up digital: How the net generation is changing your world*. New York: McGraw-Hill.
- Teo, T., Luan, W. S., & Sing, C. C. (2008). A cross-cultural examination of the intention to use technology between Singaporean and Malaysian pre-service teachers: An application of the technology acceptance model (TAM). *Journal of Educational Technology & Society*, 11(4), 265–280.
- Teo, T., & Noyes, J. (2011). An assessment of the influence of perceived enjoyment and attitude on the intention to use technology among pre-service teachers: A structural equation modeling approach. *Computers & Education*, 57(2), 1645–1653.
- Thomas, M. (Ed.). (2011). *Deconstructing digital natives: Young people, technology, and the new literacies*. New York: Routledge.
- Toohey, K., Dagenais, D., Fodor, A., Hof, L., Nuñez, O., Singh, A., et al. (2015). “That sounds so coooool”: Entanglements of children, digital tools, and literacy practices. *Tesol Quarterly*, 49(3), 461–485.
- Trautwein, U., & Lüdtke, O. (2007). Epistemological beliefs, school achievement, and college major: A large-scale longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology*, 32(3), 348–366.
- Van Deursen, A., & Van Dijk, J. (2011). Internet skills and the digital divide. *New Media & Society*, 13(6), 893–911.
- Vekiri, I., & Chronaki, A. (2008). Gender issues in technology use: Perceived social support, computer self-efficacy and value beliefs, and computer use beyond school. *Computers & Education*, 51(3), 1392–1404.
- Wang, Q. E., Myers, M. D., & Sundaram, D. (2013). Digital natives and digital immigrants. *Business & Information Systems Engineering*, 5(6), 409–419.
- Webber, S. A., & Johnston, B. (2017). Information literacy: Conceptions, context and the formation of a discipline. *J. Inf. Lit.* 11(1), 156–183.
- Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.
- Wenger, E. (2000). Communities of practice and social learning systems. *Organization*, 7(2), 225–246.
- Wenger, E. (2010). Communities of practice and social learning systems: The career of a concept. *Social learning systems and communities of practice* (pp. 179–198). London: Springer.
- Wilkinson, K. (2006). Students computer literacy: Perception versus reality. *Delta Pi Epsilon Journal*, 48(2), 108–120.
- Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal*, 29(3), 663–676.