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Abstract

Recently it has been suggested that "digital natives", a generation of young people born into the digital age, are inherently technology-savvy. If this suggestion is correct, there could be profound implications for Information Systems research, which traditionally has conducted empirical research on "digital immigrants".

This paper looks at whether there are significant differences between digital natives and digital immigrants. Our findings suggest that there is a continuum rather than a rigid dichotomy between digital natives and digital immigrants. We propose that "digital nativity" can perhaps best be conceptualized as "digital fluency." Digital fluency is the ability to reformulate knowledge and produce information to express oneself creatively and appropriately in a digital environment. We propose a conceptual model that outlines factors that have a direct and indirect impact on digital fluency, namely demographic characteristics, organisational factors, psychological factors, social influence, opportunity, behavioural intention, and actual use of digital technologies.

Keywords: digital natives, digital immigrants, digital fluency, net generation, ICT fluency

1   Introduction

Recently it has been suggested that "digital natives", a generation of young people born into the digital age, are inherently technology-savvy (Prensky, 2001; Tapscott, 1998). By contrast, those who learnt to use computers at some stage during their adult life are described as "digital immigrants." If this suggested distinction is correct, potentially this has profound implications for Information Systems research, which traditionally has conducted empirical research on the older generation of "digital immigrants" (Vodanovich et al., 2010). Many of the assumptions of IS research, e.g. that users tend to resist new technology, are thrown into question.

This paper, therefore, looks at whether there are significant differences between digital natives and digital immigrants. Commonly there are two characteristics defining digital natives: age and accessibility. A sharp generational boundary is assumed in much of the literature (Jones and Czerniewicz, 2010). Although the exact cut-off year of birth varies, most of the previous research tends to treat digital natives and digital immigrants as mutually exclusive cohorts. However, some have suggested that digital nativity is perhaps better conceptualised as a continuum (Vodanovich et al., 2010). Accessibility to technology is obviously necessary for one to be a digital native. People may have better internet access in richer countries than the ones in poorer ones (Wallsten, 2005). However, empirical findings show that accessibility does not guarantee better technology usage (Ching et al., 2005; Li and Ranieri, 2010).

It appears that digital nativity and being technology-savvy may have a more complex relationship than previously thought. Hence this paper looks at whether there are significant difference between digital natives and digital immigrants. Our findings suggest that "digital nativity" can be perhaps better conceptualized as "digital fluency." Other words that might be used to describe one's capability, competence or skill of using technology are digital literacy (Gilster, 1997), computer literacy (Ktoridou and Eteokleous-Grigoriou, 2011), Information Technology (IT) literacy (Ferro et al., 2011), digital competence (Calvani et al., 2009; Li and Ranieri, 2010), and Information and Communication Technology (ICT) competency (Guo et al., 2008). The term we opt to use in this paper is "digital fluency". It is defined as "the ability to reformulate knowledge to express oneself creatively and appropriately, and to produce and generate information rather than simply to comprehend it" (National Research Council, 1999). It implies that being digitally fluent not only involves knowing how to engage with technology, but also be able to produce things of significance with the technology (Papert and Resnick , 1995). This goes beyond the notion of digital literacy, which focuses only on teaching learners to make syntactically correct expressions (National Research Council, 1999).

The purpose of this research project is therefore to explore whether there are significant differences between digital natives and digital immigrants. Hence, our first research question is: ***What are the differences between digital natives and digital immigrants?*** Since our literature review indicated that there are indeed some differences between these two groups and that one of the main differences was that of digital fluency, our second research question is: ***How do digital natives and digital immigrants differ in their digital fluency?*** Specifically, we try to answer these two research questions by 1) exploring the fundamental assumption of digital natives being homogeneously fluent in using technology; 2) discussing the dichotomy between digital natives and digital immigrants; 3) comparing their differences in digital fluency; 4) comparing their use and/or pattern of use of technologies; 5) generating insights into the characteristics that correlate to digital fluency, and 6) exploring the impact of digital fluency.

Since our research project is in its early stages, the approach we took was to investigate this topic through a systematic literature review. Despite the significant amount of research that has been conducted on digital natives since the end of 1990s, little effort has been made to provide a comprehensive review of current knowledge (Pittaway et al., 2004). The topics of digital native and digital fluency are cross-disciplinary and therefore we provide a multidisciplinary overview of the relevant theories and methods that have been used to study this topic. In the remainder of this paper,

we outline the methodology used for the review; present the evidence base; conduct a thematic review of the main interest areas; and propose a conceptual model through characteristics analysis. Finally, the discussion and conclusion are given in the last section.

2   Literature review

For the initial phase of our literature review, we limited the scope to digital natives, digital immigrants and their IS use. Furthermore, we focussed on the domains of education, IS and computer assistant learning, and extended it to technology and science in general. The keywords were searched on databases that were related to the selected subjects including Infomit, ProQuest, EBSCO, Ovid, SAGE publications and Reed Elsevier databases. Only peer reviewed journal articles were selected. We followed the paper selection guidelines from Pittaway et al. (2004). The keywords generated from the research questions included *digital natives, digital immigrants, net generation, millennials* and *generation Y*. Similarly, *digital literacy, competence* and *fluency* were used as keywords for digital fluency. The keywords were constructed with operators into search strings and tested for accuracy in the search engine. The search string was formulated as follows: [(digital native* OR digital immigrant* OR net generation OR millennial* OR generation Y OR "generation-Y") AND tech* AND (competen* OR literacy OR fluen*)]. The search was filtered by scholarly articles if the option was available in the search engine. We added search criterion to be 1999 and onwards as this is after the term "net generation" was first coined. Our search was applied on citation and abstract resulting in 526 articles. All search results were exported to reference management software for further analysis. Duplicates and citations without author were removed manually from the software (96 articles).The citations were then reviewed according to the inclusion and exclusion criteria. The main criterion for including a journal paper is that the paper describes both digital natives/digital immigrants and digital fluency. We excluded non peer-reviewed articles. Two stages were undertaken to reduce the number of citations. We first analysed the titles of articles according to the exclusion criteria (208 articles excluded). Following a further abstract analysis, we applied both inclusion and exclusion criteria and according to their relevance (113 articles excluded), papers were separated into A (37), B (40) and C (31) lists. The A list contains articles that are most relevant for the review, followed by B and C. In order to provide a structured review process, two further analysis steps were taken. First, their keywords and abstracts were examined; this allows key themes to emerge and enables us to gain a holistic view of the evidence base. Secondly, all articles were reviewed to ensure papers were categorised into the most relevant theme.

Our literature search revealed that digital natives and digital fluency are studied mainly in the education field. The top two journals contributing to the review were Computer & Education (24%) and Information, Communication & Society (11%).The sample of papers in this review leans towards young people or digital natives, with 32 papers focussed on student participants, which accounts for about 86% of all A list papers. When the year of publication is considered, it is clear that this subject of study and the evidence base is very recent. For example, more than 80% of the papers were published after 2010. Moreover, there is one special issue on "Learning, the Net Generation and Digital Natives" in Learning, Media and Technology in 2010, issue 4, and a special section on the net generation in the Journal of Computer Assisted Learning in 2010. We also noticed that this topic started to appear in the IS literature from 2010 with two articles in Information Systems Research.

3   Thematic review

A keyword analysis illustrates the nature of the papers reviewed for this study. After consolidation, the top categories of keywords were *education level, participant type, digital divide, IS type, gender, IT literacy/fluency, digital natives/net generation, ethnicity, Internet*, *self-efficacy*, *digital immigrants* and *diffusion and adoption*. Several themes emerged from the keyword analysis namely: digital divide (14 articles), digital competence (4), pattern and preference of IS use (8), IS use in education (4), ICT integration (3), IS adoption and diffusion (4).

3.1   Digital Divide and Digital Competence

The concept of "digital divide" is a heavily discussed topic in both political and academic fields. Initially it was defined with respect to computer ownership or basic access to the Internet (Barron et al., 2010), but the concept extended to a wider scope later on. After a decade of debate in various domains, there is still no agreement on its definition, extent, or impact (Dewan and Riggins, 2005). Gil-Garcia et al. (2006) characterise it as the "relationship between ICTs and groups of individuals, who are situated within a complex arrangement of social, environmental, political, and economic issues". Digital divide is sometimes referred as digital inequality, but inequality of what? In the following discussion, we briefly outline the evolution of the digital divide debate and illustrate how it is related to our research questions.

Digital access divide: As the popularity of the Internet grew rapidly during the mid-1990s, policy makers and social scientists worried about the distribution of Internet access (Dimaggio and Hargittai, 2001). Since the National Telecommunications Information Administration published its first report "Falling Through the Net: A Survey of the Have Nots in Rural and Urban America" in 1995, many analyses have been written on the inequalities of accessibility (Hargittai, 2002). The meaning of "access" varyies from study to study, however it generally refers to whether one has the means to connect to the Internet or other IS if one chooses to (Dimaggio and Hargittai, 2001). This level of divide includes both hardware access as well as use of software (Wei et al., 2011). This view tends to neglect the influence of digital fluency (Ferro et al., 2011). Digital access is almost a prerequisite for gaining digital fluency, but itself is not sufficient to determine one's digital fluency (Fischer, 2005).

Digital skill and use divide: The declining cost of ICT made it more accessible and hence resulted in researchers shifting their emphasis to the skills and use of digital technology (Goode, 2010). This refers to inequality of IS capability or "the ability to use the technology" and it is considered as a second-level digital divide (Kvasny and Keil, 2006). Van Dijk and van Deursen (2008) explain four types of digital skills, namely instrumental skills, formal digital skills, informational skills and strategic skills. Although the physical access divide seems to be closing in the most developed countries, digital skills and the use divide persists or has widened (van Dijk, 2006). Digital fluency is both a determinant of the digital divide and a divide itself (Ferro et al., 2011). It is often included as a dimension for digital divide models (van Dijk and van Deursen, 2008; Ferro et al., 2011). Studies have covered its definition (Huffaker, 2005), its measurement (Li and Ranieri, 2010), its correlated factors (Jones et al., 2010; G. Kennedy et al., 2010) and its impact (Goode, 2010). This level of divide is closely related to our research into how digital fluency is different between digital natives and digital immigrants.

Digital outcome divide: Extending the digital divide framework from Dewan and Riggins (2005), Wei et al. (2011) add a third level of digital outcome divide based on studies that show that students with lower computer self-efficacy have poorer learning outcomes. Zhao, Huang and Wang (2010) echo similar sentiments, where students with high levels of Internet self-efficacy are positively related to exploratory behaviours. Moreover, having used the Internet at school and home resulted in better academic performance than those with lower self-efficacy.

3.2   Patterns and preference of IS use

Many researchers investigate users' preferences and behaviours based on technology-based activities. These papers show that one's digital fluency varies significantly from one activity to another and digital natives are not a homogenous group (Grimley and Allan, 2010; Hosein et al., 2010; Malliari et al., 2011). Commonalities in activities such as text messaging, instant messaging and social networking exist among digital natives (Kaare et al., 2007; Valtonen et al., 2010). This may be due to the fact that social networking tools gained their popularity mainly through the past decade.

3.3 Education

The concepts of digital native and digital immigrant originated in the education field. It is therefore not surprising to find that many of the articles in this review focus on students' use of ICT knowledge for education purposes. There has been growing interest in the integral role ICT can play within education (Grimley and Allan, 2010; Hosein et al., 2010; Malliari et al., 2011). This not only concerns hardware integration and implementation in teaching institutions, but also relies on "software", the teaching personnel's ability to use and transfer knowledge by technologies. Other researchers centred their studies on the relationship between technology skills and academic performance (Luu and Freeman, 2011; Papastergiou et al., 2011; Selwyn, 2008). Based on a hypothesised ICT-scientific literacy relationship, Luu and Freeman (2011) suggest that students with prior ICT knowledge, more Internet surfing experience and basic ICT self-efficacy earned higher scientific literacy scores. This provides the potential benefit of promoting the integration of ICT in science education or education in general.

3.4 IS adoption and diffusion

Adoption and diffusion is an important topic in the IS field. The Technology Acceptance Model (Davis, 1989) is widely used in the IS acceptance literature and has been tested under many contexts (Moore and Benbasat, 1991; Davis et al., 1989; Koufaris, 2002). It suggests that the perceived usefulness and perceived ease of use influence one's decision on adoption of a new technology. For example, Hargittai and Litt (2011) look at the adoption of Twitter. They find that the acceptance of Twitter is not randomly distributed, and the result indicates that interest in celebrities and entertainment news is an important predicator for using the service. In addition, Twitter's service is offered through many channels such as web, mobile phone or even text message; hence, its ease of use enhanced its diffusion rate.

In summary, our thematic review regarding this topic has shown that four key themes have emerged in the academic literature: digital divide and digital competence; patterns and preference of IS use; education; and adoption and diffusion.

4 A conceptual model of digital fluency

In an attempt to integrate the existing literature, we propose a preliminary conceptual model of digital fluency. Our model incorporates seven factors: ***demographic characteristics, psychological factors, social influences, educational factors, behavioural intention, opportunity*** and ***actual use of technology***. We acknowledge that conflicting results for many of these factors have been observed in the literature. In addition, the literature indicates that some factors are correlated. That is, they may have influences on each other as well as direct impact on digital fluency. This further complicates the research area. We discuss each factor in turn.

4.1 Demographic characteristics

Age is one of the determinants used to differentiate between digital natives and digital immigrants. Some studies show that age is significantly and inversely relate to digital fluency (Li and Ranieri, 2010; Salajan et al., 2010). Yet, when including participants with wider range of age groups, the results suggest otherwise (Guo et al., 2008; Hosein et al., 2010). Keyword analysis shows that ***gender, gender studies*** and ***gender differences*** appears as keywords in 9 papers Studies show some level of gender difference within the digital natives group (Hosein et al., 2010; Tømte and Hatlevik, 2011). Yet, these studies establish a positive relationship between digital fluency and frequency of use for both female and male. Gender differences also exist in the intention towards technology use, especially interest in technologies and self-confidence in technology use (Volman et al., 2005). In many ways, people in society communicate and reinforce gender-based stereotypes (Martin et al.,

1995). For example, females are found to use ICT for educational purpose more often (Selwyn, 2008), and are more interested in design oriented activities (Selwyn, 2008). On the other hand, males are more likely to play computer games (Nasah et al., 2010), sharpen programming language expertise (Nasah et al., 2010) or use living technologies in general (Hosein et al., 2010). Traditionally, demographic and **socioeconomic status** factors are considered as the main determinants of the digital divide (Ferro et al., 2011). The socioeconomic status is predictive of technology use (Ching et al., 2005), sophistication of usage (Ferro et al., 2011), and activities (Hargittai, 2010). For example, the ones from more privileged backgrounds use the Internet in more informed ways for a greater number of activities (Hargittai, 2010). However, a New Zealand study shows that low socioeconomic pre-teens choose to perform technology related activities equally if not more than high socioeconomic counterparts (Grimley and Allan, 2010). **Ethnicity and nationality** are significant influences in many examples, but the differences are reflected through ethnic differences in interest (Hargittai and Litt, 2011), socioeconomic status (Volman et al. 2005), opportunities of technology usage (Hargittai, 2010; Ferro et al., 2011), and ability to speak English (Ferro et al., 2010; Gudmundsdottir, 2010).

4.2   Educational and psychological factors

Some studies show that students' digital fluency differs according to *educational factors*, for example, school (Li and Ranieri, 2010), university mode of study (Hosein et al., 2010), and support of computer learning at school (Goode, 2010). Some schools provide better technology or media education activities to promote the technology skills building than others (Li and Ranieri, 2010). From a social networking perspective, students that have more technology skilled classmates are at advantage as interest and expertise might be shared informally (Barron et al., 2010). The educational factors provide insights into how the external environmental factors would affect one's digital fluency. *Psychological factors* such as computer anxiety, computer self-efficacy and aging anxiety are sometimes barriers that stop seniors from using technology (Jung et al., 2010). On the other hand, intrinsic personal interest is a motivation for people to use and improve their technological knowledge. In the more generic technology-based activity such as information seeking task, personal characteristics are less influential (Malliari et al., 2011).

4.3   Social influences

Social influences from family (Goode, 2010; Zhao et al., 2010), peers (Kaareet al., 2011), and superiors (Zhao et al., 2010) contribute to the development of technology skills. For example, van den Beemt et al. (2010) showed that friends and family ignite one's interest of using interactive media. Bennett and Maton (2010) discovered that lecturer's approach of technology use impacts students' expectation of learning. These findings show that social influences could influence one's technology use and hence the proficiency of use. Among these influences, social support from school has a greater effect on teenagers than other form of social influences (Zhao et al., 2010).

4.4   Behavioural intention to use

The behavioural intention to use technology is another determinant on one's actual technology use (Sykes et al., 2009; Ktoridou et al., 2011; Ferro et al., 2011). There is substantial body of empirical support for the relationship between the behavioural intention and actual behaviour (Davis, 1986, 1989; Koufaris, 2002; Lu et al., 2003). The behavioural intention to use technology is influenced by many variables such as **demographic characteristics** (Li and Ranieri, 2010; Ching et al., 2005; Ferro et al., 2011; Hargittai, 2010; Hosein et al., 2010; Tømte and Hatlevik, 2011; Volman et al., 2005; Hargittai and Litt, 2011; Volman et al., 2005; Gudmundsdottir, 2010), **organisational factors** (Li and Ranieri, 2010; Barron et al., 2010; Hosein et al., 2010; Goode, 2010), **psychological factors** (Hargittai and Litt, 2011; Jung et al., 2010; Malliari et al., 2011) and **social influences** (Goode, 2010; Kaare et al., 2011; Thornham and McFarlane, 2011; Zhao et al., 2010; Cotten et al., 2011; Gudmundsdottir, 2010).

4.5   Opportunity

The opportunity factor includes both the accessibility and the opportunity to use technologies to facilitate daily activities. Accessibility, as discussed, relates to the levels of access to technologies. Other opportunities such as faster Internet connections, infrastructures (Stern, Adams, and Elsasser, 2009) and technological support from others (Goode, 2010) are also important. Differences in opportunities to participate in creative fluency-building activities were tied to home access to tools, size of the non-home access network and use of broader resources (Barron et al., 2010). The analysis on *organisational factors* and *demographic characteristics* in the previous sections indicate their impact on one's opportunity to use technology. Studies show that owning a computer, having access to a computer or the Internet at home does not affect one's fluency in using technology (Li and Ranieri, 2010; Ching et al., 2005). On the other hand, Brown and Czerniewicz (2010) find that there is a deepening digital divide in South Africa; they label young people that have no opportunity or accessibility to use technology as "digital strangers". Likewise, Goode (2010) discovers that the student participants with limited home, school computer access and support from others would continue to suffer from low digital fluency throughout high school and university. Students with home Internet or computer access have the highest self-efficacy (Zhao et al., 2010; Wei et al., 2011) and are able to conduct more sophisticated tasks (Barron et al., 2010).

4.6   Frequency and type of technology use

The research literature shows that experience and frequency of technology use are significantly related to one's digital fluency for overall technology use (Li and Ranieri, 2010), generic use (Malliari et al., 2011), and specific technology-based activities (Papastergiou, 2011; Cotton et al., 2011). The positive relationship between frequency and fluency remains until user reaches optimum efficiency (Hosein et al., 2010). Researchers have tried to move the focus towards the types of activities instead of particular technologies (Kennedy et al., 2009; Malliari et al., 2011). Many large-scale studies show that except for social networking, web 2.0 related activities are less understood and less engaged by digital natives (Kennedy et al., 2007, 2008; Menchen-Trevino and Hargittai, 2011). The technology-based activities studies, rather than the accessibility ones, highlight the significant variances across different demographic groups (Bennett and Maton, 2010). They show that some common activities are indeed engaged in frequently by young people. (Bennett and Maton, 2010; Jones and Healing, 2010) Hence, type of activity is considered as a mediating factor for digital fluency. Many studies use frequency and type of technology to create typology, this allow the generation of distinct types of user profile or user groups (Tømte and Hatlevik, 2011; Valtonen T., 2010; Grimley and Allen, 2010). For example, 'social networkers' are commonly female, and they use social networking software on a daily basis but rarely use other applications, whereas 'all-rounders' frequently use a wide range of software and evaluate their ICT skills the highest (Valtonen et al., 2010). In summary, the use of technology is positively associated with digital fluency with technology-based activity as the mediating factor.

4.7   Conceptual model

Our analysis of the literature illustrates a complicated picture. However, we think it is possible to suggest a tentative conceptual model for digital fluency as shown in figure 1.
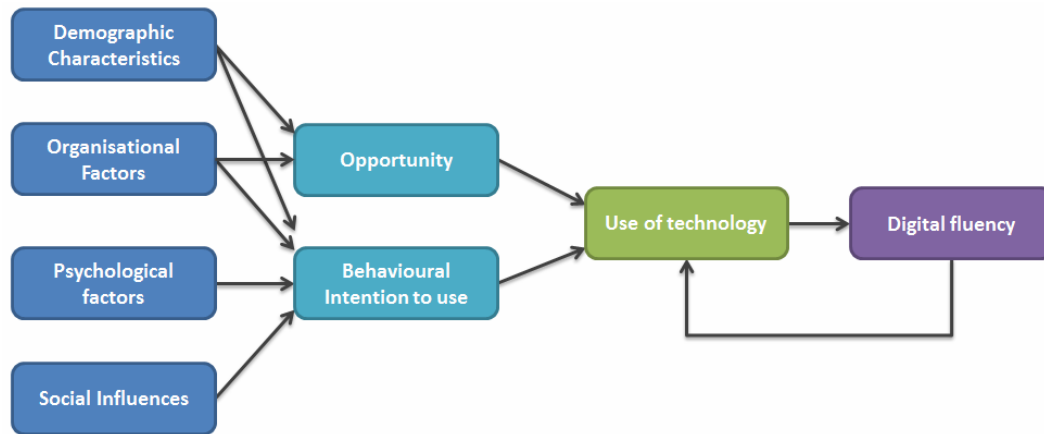
Figure 1.   Conceptual model of digital fluency.

An additional relationship is postulated to indicate that the digital fluency influences the action of technology use. This produces a reciprocal relationship between technology use and digital fluency. Several studies suggest that improvement in digital fluency increases the self-efficacy (Ktoridou and Eteokleous-Grigoriou, 2011) and internet use (Ferro et al., 2011). Therefore, the use of technology is influenced by: 1) opportunity – contextual constraint relates to a behaviour; 2) intention – the willingness or need to perform an action and 3) ability (which means digital fluency in our context) – to have the skills and capabilities required to proceed the task (Hughes, 2007). Digital natives and digital immigrants are different in their age and accessibility by definition. Hence, the age and accessibility contribute to part of the demographic and opportunity factors in this model. The mixed result of existing research on digital fluency can be accounted for by other variables derived from the literature. The model goes some way towards answer our research questions. Specifically, the differences in pattern or behavioural intention of use between digital natives and digital immigrants are the major factors that lead to the disparity in digital fluency.

5   Findings

Although the main focus of this paper has been to derive a conceptual model from a reasonably comprehensive review of the literature, we have gathered some preliminary data. We conducted semi-structured interviews with nine individuals with different background from a leading global computing product and service company. The preliminary data findings provide some insight to the research objectives and are summarised in table 1.

Research objectives	Literature review findings	Preliminary data findings
Verify digital natives are homogeneously fluent in technology	Digital natives are not homogenously fluent in technology.	Digital native interviewees are digitally fluent in our sample.
Verify dichotomy between digital natives and immigrants	Digital natives are not necessarily more fluent at technology than digital immigrants.	All interviewees (digital immigrants and natives) evaluate themselves as digitally fluent in general, except for content creation related activities.
Compare differences in digital fluency	Differences in digital fluency are affected by the factors illustrated in the model proposed.	Socioeconomic status, organisational factors and opportunity to technology use were similar; however psychological and social aspects and intention towards technology are very different.
Compare use and/or pattern of use of technologies	Intention of using a particular technology depends on demographic, psychological, organisational factors and social	Participants vary in their preferences in technology use significantly. Social networking tools are more commonly used by digital natives, but the levels of usage vary significantly among

	influences.	digital immigrants.
Identify characteristics that influence digital fluency	Characteristics analysis illustrates the relationships between factors and digital fluency.	Interviews confirm the factors in the conceptual model that relate to digital fluency, the significance among relationships is varied.
Explore the impact of digital fluency	Certain level of digital fluency is required in order for one to use technology. Increased fluency increases the frequency of use.	All participants are already fluent in using technology. Generally confident with regards to using technologies or adopt new technology and have their own opinions towards using them.

Table 1.   Research objectives and findings summary.

6   Discussion and conclusions

Given the recent interest in digital natives and digital immigrants in information systems research (Vodanovich et al., 2010), this paper contributes to the debate by providing a systematic review of the literature. The tentative conceptual model derived from literature suggests there are indeed differences between digital natives and digital immigrants. Several interesting features stand out from the model. For example, digital fluency is explained by other factors beyond age and accessibility; also, the reciprocal relationship between actual use and digital fluency implies a potential virtuous circle to improve one's digital fluency. Alternatively, this could also imply a vicious circle, which deepens the digital divide.

Several limitations are associated with the systematic review. The first limitation that there a very limited amount of literature on this topic in the IS field. Second, researchers sometimes use different keywords than the ones we specified.

Our research highlights a number of areas in need of future research. One of the shortcomings is the lack of theory and conceptual definition on digital natives and digital immigrants. A second issue is the lack of IS and interdisciplinary research. The term digital natives and digital immigrants by nature are related to IS or the computing field. However, until now they have mainly been discussed in the education sector.

Current research has predominantly utilised quantitative methods to measure digital fluency. While our exploratory research provides some insights, this research area would also benefit from more large-scale qualitative studies. Last but not the least; a tool to measure digital fluency could be useful. Some existing measurement tools have been used to test digital competency (Calvani et al., 2009; Li and Ranieri, 2010b), frequency of technology use (Margaryan et al., 2011) and self-efficacy (Zhao et al., 2010).

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