Digital technologies in construction management education: A digital natives' perspective

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Abstract
Digital technologies are becoming increasingly widespread across many industries. The big question is how competence development is able to support the adoption and use of digital technologies in a professional context. A lot of hope has been put on a natural change through the younger generations, who are considered to be naturally digitally fluent. This study employed a survey research approach to investigate how digital natives cope with the use of digital construction technologies in a construction management education context. Surprisingly, neither the previous use of other construction-specific software nor the students' age group had any impact on the perceived difficulty of the technology. In the context of using professional software applications in construction management education, this research indicates: first, general digital fluency does not necessarily translate into fluency in the use of professional software applications, and second, the gap between the different generations of students is marginal or non-existent.

Keywords: Digital technologies, construction management education, construction-specific software applications, digital natives, digital competence

1 Introduction

Digitalisation is changing both our personal and professional lives keeping us constantly connected and utilising endless amount of applications. Although the construction industry and construction management as a discipline have been traditionally poor in adopting new technology (Friedrich et al 2011, Vass 2015), digital technologies have started to make their way to the industry. Various applications have been adopted from other industries while others have been developed specifically for construction management purposes. The use of standard office software and email has been the industry norm for quite some time. Recently, more advanced applications, such as project management software, cloud computing and Building Information Modelling (BIM), have made their way to many companies and projects (Azhar et al 2015). Some companies have even gone beyond this with immersive technologies, drones and partly automated processes. Digital twins, smart cities, Internet of Things (IoT), digital and additive manufacturing processes, robotics, Artificial Intelligence (AI) and Machine Learning (ML) are the most recent topics already widely discussed and in use by some (Oesterreich & Teuteberg 2016, Puolitaival et al 2018).

Due to the constantly changing and growing adoption of digital technologies, the demand for digital literacy and for discipline-specific digital technology competences is also both changing and growing. Within the construction management discipline there are no longer any jobs, where digital technology competences would not be needed. As a basic minimum, one needs to be able to use office applications and email for communication (Puolitaival et al 2019). The digital

natives' cohort has been presented in the literature as a partial answer to the digital competence demand as the digital natives have been born with the technology and are therefore seen as natives in using it. Their first contact with digital technology might have already been in their first years using a tablet or a mobile phone to watch a video or play a simple game (Prensky 2001). It is unknown however, if this native ability could be capitalised upon when using digital technologies as an inseparable part of contemporary construction management employment.

There is a vast amount of literature on digital natives and how they cope with digital learning technologies. However, limited studies examine how digital natives cope with discipline-specific applications, and even fewer, if any, focusing on the construction management discipline. To fill this gap in the literature, this study's aim is to investigate how digital natives cope with the use of digital construction management technologies.

The paper starts with a Background section which provides the research context based on a review of the international body of literature, followed by a Research method, and Findings and Discussion sections. The Conclusions discuss also the study's limitations as well as recommendations for further research.

2 Background

2.1 Digital technologies in construction management education

In recent years, the discussions on digital technologies adoption in construction management education have focused on BIM education. This has included studies on curriculum development at programme level (Barison & Santos 2010, Joannides et al 2012, Puolitaival & Forsythe 2016), the adoption and implementation of BIM on construction management courses (Leite 2016), the use of BIM for planning and scheduling (Martin et al 2015), for estimating (McCuen et al 2017) and for site health and safety management in conjunction with 4D (Swallow & Zulu 2019). Most of the research has been case studies, but also some survey studies as the early ones by Barison and Santos (2010) 'Review and analysis of current strategies for planning a BIM curriculum' and Joannides et al (2012) 'Implementation of BIM into accredited programs in architecture and construction education'. Systematic literature reviews have examined learning theories, approaches and methods (Puolitaival & Kestle 2018), as well as BIM-enabled education (Witt & Kähkönen 2019). The challenges of BIM education have been discussed extensively from many viewpoints including rapidly evolving technology, the complexity of the topic, lack of expertise among staff, lack of resources and crowded curricula (Becerik-Gerber et al 2011, Huang 2018, Sack & Pikas 2013, Underwood et al 2015) to name a few.

The literature on the wider digital technologies in education context include Wood and Madgwick (2016) 'Embedding emerging technology in built environment education' where they discuss not just BIM but also virtual and augmented reality (VR and AR), 3D laser scanning, drones, and wearable and mobile technology; Tayeh et al (2020) 'Information systems curriculum for construction management education' discussing advanced modelling, scripting, use of game engines, robotics and automation in construction; and Rehman et al (2018) 'Competence development in advanced and emerging construction technologies' discussing smart built environment, advanced construction technologies such as additive manufacturing and digital fabrication, green BIM and advanced computational design. There are also studies focusing only on a single digital technology in construction management education context such as Azhar and Salman (2018) study on the use of virtual and mixed reality (VR and MR) in a classroom and Kim and Irizarry (2021) on augmented reality (AR) both of which have strong connection with BIM as the virtual environment.

2.2 Digital natives

"Digital natives" is a term popularised by Prensky (2001) describing students born after 1980, who have grown up immersed in digital technology and have developed certain characteristics through intensive exposure to computer games and videos (Prensky 2001). Digital natives are comfortable with multi-tasking, reliant on graphics for communication and thrive on instant gratifications and rewards (Akçayır et al 2016). Digital natives have a natural inclination for

connectivity using social media extensively through mobile devices (Kiroff & Puolitaival 2021). It is argued that this has a significant impact on their ways to operate (Sarkar et al 2017). Digital natives are sometimes also called 'generation Y' and 'generation Z' separating them by birth years to those ones born between 1980 and 1994, and those ones born after 1994. However, there is some controversy in the discussion. Some studies highlight that the age group from 1980 and after is far from homogenous when it comes to access and use of digital technologies, and digital competence, and argue that there are no unbridgeable differences between those who can be classified as digital natives or digital immigrants (Bennet et al 2008, Helsper & Eynon 2010). Prensky himself has abandoned the term 'digital natives' since and rather talks about digital wisdom (Prensky 2009) that everyone should pursue without any age limits.

2.3 Digital competence

Digital competence is a relative new concept which has evolved from the concepts of digital literacy competence and information and communication technology (ICT) competence (Ilomäki et al 2016). There are various definitions of digital competence in the literature which offer alternative viewpoints. One of the early definitions of digital competence is by Punie (2007) defining digital competence loosely as "competences that are necessary for employment, education and training, self-development and participation in society" (p. 185). Ilomäki et al (2016) definition "(1) technical competence, (2) the ability to use digital technologies in a meaningful way for working, studying and in everyday life, (3) the ability to evaluate digital technologies critically, and (4) motivation to participate and commit in the digital culture" (p. 655) introduces the term 'critically evaluate'. Vieru (2015) focuses more on employment in their definition "to investigate and solve work-related problems and develop a collaborative knowledge body while engaging in organizational practices within a specific organizational context" (p. 6718). All these definitions include the ability to use digital technology in a meaningful way for participation in the society. In a work-related context this is seen as critically evaluating content, creating content, problem-solving, and communicating and collaborating via digital means.

2.4 Research context

Three-year Bachelor of Construction undergraduate degrees sit at level 7 on the New Zealand Qualifications Framework and are offered by a number of Universities, and Institutes of Technology under the umbrella of the New Zealand Institute of Skills and Technology (NZIST). The Bachelor of Construction degree in this research is delivered by one of the Institutes of Technology under the NZIST. This tertiary provider also offers a one-year Graduate Diploma in Construction Project Management programme, as a pathway to project management for architecture and engineering graduates, and for those ones with extensive construction industry experience but no formal qualification at level 7. The degree programme curriculum includes a mix of compulsory and elective courses at levels 5, 6 and 7 and it has three majors: Construction Economics, Construction Management and Property Development. The Graduate Diploma includes three courses at level 6 and five at level 7. Two of the courses are unique to the Graduate Diploma and the rest are common with the degree. This study focused on students enrolled in the Advanced BIM in Construction course in semester 2, 2019. This is a level 7 elective course, which can be taken by students enrolled in any of the three majors, as well as the Graduate Diploma students. The course was designed by the authors of this research and was first launched in 2015. The course has the following learning outcomes:

1. Evaluate the application of advances in BIM to the NZ construction industry.
2. Develop techniques for the application of BIM to the construction management process.

The course has a high proportion of self-directed learning, 118 hours out of a total of 150. The course introduces BIM processes widely in construction management context.

To understand the study context further it needs to be noted, that unlike most undergraduate construction programmes in Europe or in North America, New Zealand construction degrees do not include engineering subjects. Instead there is a base of construction technology courses with limited structural calculations and a greater focus on the major. As a result, when the students

graduate they are responsible for using Building Information Models for viewing, analysing and simulation purposes, not for design. This has direct implications for the selection of software applications on the course. Similarly, the industry context in New Zealand has an influence on the software application selection on the course. Autodesk applications, Revit and Navisworks Manage, have been selected as they are commonly used in the local industry.

3 Research method

The study employed a survey research approach with the aim to answer the research question: How do digital natives cope with the use of digital construction management technologies. The focus was on the students enrolled in the Advanced BIM in Construction course in semester 2, 2019. Survey approach was used to find out factual information about the student groups, more specifically generations X, Y and Z, on the course: what they do, what they think and who they are, in an attempt to establish patterns of activity within those groups (Denscombe 2014).

Questionnaires, developed specifically for this study, were the major methods of empirical data collection. Two sets of questionnaires, 'start of course' and 'end of course', with a mix of both open-ended and closed questions were used at the very beginning and end of the course. The 'start of course' questionnaire included four main sections: demographic information (11 items), access to hardware and the Internet (5 items), use of general computer-based technologies and social media applications (5 and 17 items respectively), and use of specialist computer-based technologies (16 items). The 'end of course' questionnaire included three main sections: course content (4 items), acquiring new skills (11 items) and general comments (8 items).

Purposive sampling, which involved all students on the Advanced BIM in Construction course, was used for this study. These students were in the best position to provide information (Cavana et al 2001) regarding the use of more advanced BIM software applications and in addition there was a spread through the generations X, Y and Z for comparison. Although the intention was to capture all students' starting point on the course, 8 out of the 32 students (75% participation) did not take part in the 'start of course' survey due to late enrolments. All students (100% of the class) took part in the 'end of course' survey.

4 Findings and discussion

4.1 Demographic data

As this study investigated the digital natives' perspective on digital technologies in construction management education, the data was categorised and analysed using the three groups identified in the literature:

1. Students born before 1980, called generation X, who are considered as digital immigrants rather than digital natives
2. Students born between 1980 and 1994, called generation Y, and considered as digital natives
3. Students born after 1994, called generation Z and considered as digital natives.

The first group was the smallest, only three students belonged to generation X. One was born in 1969 and two were born in 1979. The rest of the students were divided equally between the other two groups. The generation Y group had a spread from 1981 to 1993 as birth years and generation Z from 1995 to 1999.

The proportion of international and English as second language (ESL) students on the course was high, 47% and 78% respectively. International and ESL students were present in all three identified groups. Seven students were enrolled in the Graduate Diploma and the rest, 25, in the Degree programme. Nine of the students had a previous construction related qualification at a:

- Diploma level (L6): quantity surveying, construction management
- Degree level (L7): architecture, civil engineering, building services, engineering science
- Masters level (L8): engineering, management science, business administration.

Most of the students (22) had some construction industry experience either office-based or on-site-based. For the majority of them the experience was limited to 1-2 years. It needs to be noted that the third-year courses on the Degree are delivered in a block format rather than on a

weekly basis to enable and encourage work in the industry. Hence, a large proportion of the students work either part or full time.

4.2 General digital technology use prior to the course

Digital divide, which refers to the gap between demographics and regions that have access to modern ICTs and those that do not have access or have restricted access, is reality even in the wealthiest parts of the world (van Deursen & van Dijk 2019), New Zealand not being an exception (Sylvester et al 2017). The digital divide within the study sample was relatively small with only one generation X student who, unlike the rest, had-limited access to computer hardware and the Internet. Another student (generation Y) had limited access to the Internet, but unlimited access to computer hardware. At the other end of the spectrum, there were seven students who had unlimited access to all types of technology including mobile phone, tablet, laptop, PC and the Internet. These seven students were spread relatively evenly across the different generations.

The most common use of digital technology was, unsurprisingly, social media applications. However, the oldest student, born in 1969, did not use any social media applications or sites. The other two generation X students both used Facebook and Facebook Messenger; in addition, one used YouTube, and the other LinkedIn and WhatsApp. With generation Y the use of social media applications was wider, as expected. Each student in that group used on average eight applications while the generation Z students used on average seven applications. Instagram and WeChat were popular with both, generation Y and Z. LinkedIn and WhatsApp were less popular with the youngest students, instead QQ and QZone were used. These findings confirm similar claims in the literature about the digital literacy skills of the digital natives and the digital immigrants (Akcayir et al 2016, Lu et al 2016). Strong connection was seen between the nationality and language background of the students, and the applications that they used, e.g. WeChat, Weibo, QQ and QZone which were used almost solely by the international and ESL students. Forbush and Foucault-Welles (2016) discuss the limitations imposed by strict censorship laws in China, which make it difficult for many Chinese students to freely access social media of their choosing. This directs the students to certain applications such as Weibo (Forbush & Foucault-Welles 2016).

For creating content, the most commonly used software was a word editing software, otherwise content creation was uncommon. These findings are similar to others in the literature such as Lu et al (2016). Most students used a word editing software daily, some weekly and two students monthly. The younger the students were, the less frequent the use was. This had no correlation with other demographic factors.

4.3 Use of construction-specific digital technology prior to the course

All students, except two, who left this question unanswered, had used some construction-specific technology before, either on previous courses on the programme, when studying for their previous qualification or at work. Earlier degree courses at level 5 and 6 introduce Solibri and SketchUp, level 7 courses on the Construction Economics major introduce Cost-X, and level 7 courses on the Construction Management major introduce Navisworks Manage and Vico Office. However, the level 7 courses are not pre-requisites for the Advanced BIM in Construction course and therefore some of the students had exposure only to Solibri and SketchUp. The one student with a degree in architecture and some construction industry experience (1 year) had the widest experience in the use of software applications: ArchiCAD, AutoCAD, BIM360, Navisworks Freedom, Navisworks Manage, Revit, SketchUp, Solibri, Tekla BIMsight and Trimble Connect. AutoCAD skills were common with engineering graduates and the ones who had been longer (4+ years) in the industry.

4.4 Experiences with construction-specific digital technology

Unsurprisingly, students who had used Revit or Navisworks prior to the course, found the use of the applications on average easier than those ones who had no previous exposure to the applications (Table 1). The extent of previous use was not investigated, however the students' background (previous studies and work experience) provided some insights. The student who

found the use of Revit very easy, had a Master's in Engineering and 4+ years work experience in the industry. Similarly, another student who found both Revit and Navisworks easy to use, had a Bachelor's degree in Engineering and 4+ years work experience in the industry. Surprisingly, neither the previous use of other construction-specific software such as AutoCad, Cost-X, SketchUp or Solibri nor the students' age group had any impact on the perceived difficulty of Revit or Navisworks Manage. Most students found the software applications difficult or somewhat difficult to use. Students who had construction industry experience were more comfortable with the use of software, regardless of their age (Table 1). When students were asked to compare the software use with applications that they were used to i.e. office and social media applications, they commented "not developed to be user friendly", "very hard compared to social media applications", "requires frequent use and proper training", "social media is fun, BIM applications are boring" and "difficult to navigate". Most students felt that Revit and Navisworks were on a different level compared to other construction-specific software such as MS Project, SketchUp or Solibri when it came to difficulty. Literature, such as Kiroff and Puolitaival (2021) and Sarkar et al (2017) argue that digital natives are technologically savvy. However, the difference between those studies and this research is in the complexity of the technology. As an example, Kiroff and Puolitaival (2021) investigated the use of construction-specific freeware applications, not full professional desktop applications. It can be argued that freeware applications are closer to social media applications in terms of ease of use than full professional desktop applications are, and students are therefore more comfortable in using them.

Table 1. Correlation between previous exposure to software or construction industry experience, and the perceived difficulty of the software (scale: 1 very easy, 2 easy, 3 moderate, 4 difficult, 5 very difficult).

	Perceived difficulty of the software	
	Revit	**Navisworks Manage**
Previous experience in using the application	2.0	2.8
No previous exposure to the application	3.4	3.0
Construction industry experience	2.9	2.7
No construction industry experience	3.6	3.6

Online tutorials were preferred over lecturer demonstrations as learning methods. Similarly, Prensky (2001) and Kiroff and Puolitaival (2021) reported students having low tolerance for traditional lecturing, step-by-step guides and detailed instructions. Learning by intuition was strongly connected with the feeling that the software application was easy to use. The ones who found the software applications difficult to use and therefore did not receive instant gratification (Akçayır et al 2016) in the form of an achievement, engaged poorly with the formative tasks.

5 Conclusions

In the context of using professional software applications in education, this research indicates that: first, general digital fluency does not necessarily translate into fluency in the use of professional software applications, and second, the gap between the different generations of students is marginal or non-existent. More important than the age of the students was work experience. This suggests that understanding the construction management context is a more important factor in learning how to use a construction management specific software application than being a 'digital native'. It is therefore imperative that there are no compromises how the foundation knowledge, understanding of construction management itself, is addressed in the curriculum. This can be further reinforced by encouraging and supporting the accumulation of work experience before and during studies. Full professional applications should not be introduced without ensuring first that the students have the necessary understanding of the context where they are being used.

On the other hand, this implies, that introducing new professional applications to industry professionals can be somewhat challenging, although achievable, as they have a wide and deep understanding of the context itself.

The limitations of this research are around the small sample size and the focus on a single construction discipline. However, it should be noted that the study captured the whole class or all the students enrolled in the course in semester 2, 2019. The findings of this study could be viewed as an exploratory research on the topic, with the potential to inform further research involving larger samples with wider age brackets and across diverse cultural contexts to minimise the impact of various local factors. Exploring other disciplines, such as architecture, architectural and construction engineering first, and then maybe expanding to other engineering areas and business, could provide useful insights into students' digital technology competences in general, and not just in one discipline context.

The gaps between the use of social media applications, construction-specific freeware and full professional applications require further investigation. Existing research, including this research, is unable to explain those differences in detail and more importantly how to address them in education to ensure that the graduates are able to critically evaluate content, create content, problem-solve, and adequately communicate and collaborate via digital means in a broader professional context.

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