# Digital-built Environment: Are Our Students Ready for the Next Challenge?

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**Abstract**: Today, the Industrial Revolution 4.0 (IR4.0) is producing immense uncertainty. Innovations transform our way of life and our methods of working. In this era of technological upheaval, employees and fresh graduates are aware of the skills gap and the importance of digital literacy due to pervasive change across all industries. Future graduates, especially from Built Environment, should incorporate the 4th Industrial Revolution and move toward a digital-built environment. Digital-built environment is the application of innovative digital engineering technologies, such as 3D printing, digital scanning, remote sensing, and building information modeling, to boost efficiency and performance in the construction industry. Today, digital inclusion significantly depends on skills than on technology availability. Students in the 21st century must be proficient in digital skills. Although Malaysia has adopted a digital learning environment, indicators are not established to gauge current digital competency standards for higher education graduates. Hence, this paper aims to investigate the digital competencies of built environment students based on the COBADI 2.0 (Basic Digital Competencies/Registered Trademark 2970648) questionnaire. The survey was conducted with final year students from built environment fields at Universiti Sains Malaysia. These future graduates demonstrated an upper-intermediate level of information and digital literacy, including communication and teamwork, but a lower-intermediate level of digital content creation. This research promotes digital competence in higher education and improves teaching and learning in built environment.

**Keywords**: Built environment, digital competencies, future skills, higher education, Malaysia

## Introduction

The core notion of IR4.0 is the trend of digitalization, automation, and increased use of Information and Communications Technology (ICT). The IR4.0 started early in the last decade, is defined as a combination of technologies and focalizing to reduce the gap between physical, biological, and digital skills (Schwab, 2017). The contribution of digital and smart technology such as artificial intelligence, internet of things (IoT), 3D and 4D printing, and robotics science to IR4.0 is widely dependent on the necessary critical thinking skills, creativity, complex problem-solving, and service orientation knowledge (Tsekeris, 2019, Maynard, 2015, Schwab, 2017). The current industrial revolution places a premium value on adaptability in critical thinking and learning, which means educational skill sets require updating their proficiencies to meet the needs of new industry technologies (Yusuf et al., 2020).

A long list of advantages has emerged from digitization through IR4.0. However, substantial changes also occurred in human resource management, such as in performance management techniques, essential skill sets, and context for training and education programs (Ozkan-Ozen & Kazancoglu, 2021). The constant changes across all industries worldwide make employees and fresh graduates seeking jobs aware of the skills gap and the importance of industry needs for digital literacy in this contemporary revolution era. In response to these needs, learning new digital skills, and accepting new approaches, including its challenges, will be essential (Gleason, 2018, Parry and Battista, 2019). Therefore, different skill sets and competencies will be required with digital capabilities for the future workforce's success (Mtshali & Ramaligela, 2020). The previous scholar indicates that various industrial sectors are developing in digital transformation (Parry & Battista, 2019, Aliu & Aigbavboa, 2019, Bakhshi et al., 2017, Bashay, 2020).

The construction sector has been slow to adapt to new technologies despite the rapid advancements in other industries (Alaloul et al., 2020). According to previous scholars, although Malaysia has introduced a digital learning environment in its education system (Khan et al., 2021), indicators are not established to measure the current demands for higher education graduates' digital competencies (Shuhidan et al., 2019, Grundke et al., 2018). Scholars and practitioners in the digital-built environment must focus on workforce management for IR4.0. This study contributes to introducing true digital competencies in the built environment and construction industry to have a novel approach to work effectively. The level determination of digital competence has been explained according to the DigCom 2.0 model monitoring students' evaluation of their digital skills in higher education studies in Malaysia, particularly in the built environment.

This study's aim is structured as follows. First, the theoretical background of keywords is reviewed. Then, the research method is explained to report data analysis. Lastly, this study's findings are intricately elaborated in the discussion part to discuss limitations and suggestions for future potential studies.

## Literature Review

### Digital Competencies

IR4.0 demands a broad and advanced set of digital competencies from its employees (Majumdar et al., 2021). Digital skills include engagement with modern interfaces and adaptability to new software and technology for workforce issues in IR4.0. To utilize IR4.0's full potential, employees must be equipped with the appropriate digital skills (Raj et al., 2019), where most organizations face challenges related to lack of IT/digital skills. The essential general skills and competencies IR4.0 are identified as follows: creativity, innovation, critical thinking and analysis, programming and technology design, complex problem solving, emotional intelligence, social influence and leadership, originality and initiative, reasoning and ideation, language and communication skills, empathy and corporation, and mathematics (Collet et al., 2015, Cotet et al., 2017, Bermúdez and Juárez, 2017, Hussin, 2018, Kamaruzaman et al., 2019, Anggraeni, 2018, Caruso, 2018). Various works of literature have stated that digital competencies can be recognized as the capacity to understand how to employ technology efficiently (Carretero et al., 2017, Rodríguez García et al., 2019).

The implementation of digital technologies has a significant impact on various spheres and facets of societal activities. For instance, it has the potential to transform employment opportunities, educational systems, and leisure activities, as well as the ways in which individuals are attracted to and participate in society. Digital competence, defined as the proficient utilization of information and communication technology (ICT) tools, plays a crucial role in enabling individuals to actively engage in contemporary socio-economic activities (Kuzminska et al., 2018). However, the concept of digital competencies has been explained as a collection of attitudes, skills, and expertise required when adopting digital media and ICTs to solve problems, accomplish tasks, manage information, and develop knowledge effectively (Ferrari, 2012, Janssen et al., 2013, Falloon, 2020). Thus, digital competency comprises technological skills that can explain multi-faceted terms in the digital world. Digital competence is the critical and confident use of technology, underpinned by basic ICT's skills in assessing, producing, retrieving, and exchanging information to participate and communicate in collaborative networks (Mirete et al., 2020). Thus, ICTs are likely to be considered as learning and teaching tools contributing to knowledge building. Given the growth of fast-changing digital technologies in developing countries like Malaysia, the education systems must consider all digital competencies and refresh their current skills to keep up with constant developments (Khan et al., 2021). As a result, the new educational system should promote critical thinking and equip students to deal with complexity, including enhancing digital skills by allowing them to interact with modern user interfaces.

**Digital Competencies in Built Environment Studies**

There has been a surge in economic importance and innovation policy for other industries (e.g., the creative industries), but the built environment has been seeing a slow process of digital innovation, which includes design and construction. Several sorts of innovations exist, such as products (e.g., new materials) and processes (e.g., novel workflows and digital technologies). Importing technology from other industries is common in the built environment. Notably, other industries are doing better than construction in harnessing "the digital thread" - a continuous data stream from design through production (Oraee et al., 2019).

However, the study of the built environment is characterized as a multidisciplinary and interdisciplinary approach in higher education teaching students the skills they need for environmental design (Conte, 2016). The pursuit of improved outcomes in the construction industry and built environment activities have resulted in technological creativity and technical complexities, which increases the demands for skilled graduates (Aliu & Aigbavboa, 2019). Meanwhile, anticipating the traditional educational approaches have massive requirements for the bigger picture of the industry's future (Yusuf et al., 2020). The teaching quality in the academic system is important to enhance the students' skills required to adapt to the needs of the construction industry after graduation (Aliu & Aigbavboa, 2021). Hence, considerable policy and academic attention has recently emphasized that young employees' lives are mediated by technology and digital skills (Peña-López, 2016). The broadband statistics update in OECD countries by the end of 2020 shows data usage and internet access are increasing rapidly. In IR4.0, technologies enter the education system to reshape the future industry through innovations (Redden et al., 2017). Digital competencies and ability to use digital technology strategically increase the importance of ensuring universities' graduates full industrial and societal participation (Iordache et al., 2017). According to Chowdhury et al.'s (2019) findings, going digital is a solution that can improve productivity in the construction industry with the need to upscale the advanced technologies adoption. Most existing literature investigated how digital competencies and new technologies can be adopted to reshape the industry for better construction safety, and productivity enhancement with high quality (Shibeika & Harty, 2015, Loosemore, 2014, Omar & Nehdi, 2016, Beatty, 2017, Kaufmann et al., 2018). Notably, the built environment study enters the digital age while the industry-related workforce is still confused about the changes. However, some researchers argued that the construction industry, as a part of the built environment, has a delay in technological advancement (Alaloul et al., 2018, Osunsanmi et al., 2018) due to the lack of investment in developing in this sector (Oesterreich and Teuteberg, 2016). Eventually, skills development remains a considerable topic in the current revolution. Besides, digital skills and technologies are considered opportunities regarding cost efficiency and offer differentiation with experienced workforces (Kaufmann et al., 2018, Jin et al., 2019).

Employability-related research over the years addressed that the employers in the industry are not only looking for academic graduates but also seeking a range of skills to experience industry activities, communications skills, and critical thinking (Succi & Canovi, 2020, Aliu & Aigbavboa, 2019, Aliu & Aigbavboa, 2021). Regardless of the academic achievement, built environment graduates must dominate personal values, which enhances their productivity in the industry (Aliu & Aigbavboa, 2019). Thus, the built environment and construction industry constantly seek to employ graduates with the appropriate skills to fulfill global expectation (Ahn et al., 2012). Transforming educational curriculum improvement is impossible without infrastructure and advanced technology (Gleason, 2018, Richert et al., 2016). The existing literature supports various transformative technologies such as 3D printing (Camacho et al., 2018, Wu et al., 2016), ANN (Brady et al., 2018, El-Gohary et al., 2017), Cloud computing (Palos-Sánchez et al., 2019), Software applications: 3D, 4D, 5D, CAD (Lu & Lee, 2017), and how the industry can benefit from these kinds of technologies

(Chowdhury et al., 2019). Therefore, current digital construction processes are not similar with the old-fashioned method (Kaufmann et al., 2018).

**Higher Education and Digital Competencies**

"*The rapidly developing digital economy is boosting the demand for highly qualified technical personnel and digital business skills*," according to Malaysian Youth and Sports Minister, Khairy Jamaluddin. Regardless of the difficulty of finding work for the local workforce, the unemployment rate for Malaysia's graduates reached 10.7% in 2015, over three times the national unemployment average of 3.1% (Dian Hikmah & Mohd Zaidi, 2017). Programs offered are not coordinated with the market need, a contributing factor to this problem. It has become increasingly difficult to find jobs for recent Malaysian graduates, attributing to educational institutions' inability to provide the necessary training (Khan et al., 2021).

There is a discrepancy between what universities teach and what employers demand. In their view, present university curricula do not adequately prepare students to meet today's job market needs. Also, employers mentioned the absence of students in the workforce as another issue. People without soft skills are having difficulty finding work, according to a recent poll by Talent Corp Malaysia (Khan et al., 2021). Some studies show that students lack mastery of certain soft skills important in ensuring job employability after graduating (Mat Saat et al., 2021). Educators are typically shown as providing information and wisdom to their students. However, this is out of step with the common educational aims of the 21st century. Currently, students have more opportunities to expand their knowledge and acquire new abilities. Therefore, reframing the responsibilities of the lecturers is necessary. As a result, the focus may shift to helping young people grow into contributing members of society rather than simply providing services. (Nadia Sullivan, 2020).

Hence, for the modernization of higher education, including developing of important competencies, such as ICTs are essential. One of the most repeated talents in the models is mastery of digital technologies. Hence, as the OECD (2018) points out, today's students must put their knowledge to use in rapidly evolving digital contexts and under previously unanticipated conditions, necessitating specialized digital training. In higher education, access to new technology and digital information positively impacts students' learning and performance. The new educational process intends to address IR4.0's potential needs (Almeida & Simoes, 2019). As such, the current expectation and transformation in higher education revealed the importance of qualified and skilled graduates for the professional labor market (Chea et al., 2019). According to Ferrari (2012), literacy and digital competence have different meanings, depending on who uses the terminology and when. Ferrari (2012) mentioned that pupils can be considered digitally literate when they can access, assess, and handle digital content. They could get information from various sources and know how to tell if they are trustworthy (Sánchez-Caballé et al., 2021).

Recent development in higher education has formed the way digital learning and skills (Pagani et al., 2016) distinguished between two concepts of digital literacy. First are the operational dimensions, such as the ability to operate the system using computers. Second, the content-related dimensions evaluate digital data and available information on the internet. Operational digital skills are discussed in the literature as a fundamental and important set of competencies that could be considered to predict positive outcomes (Hurwitz & Schmitt, 2020, Marsh, 2016, Cabello-Hutt et al., 2018).

In some developed countries accessing digital technology is a common practice, starting from school to higher education (Gudmundsdottir & Hatlevik, 2018). Therefore, the higher education sector has shown growth in demand for well-trained and highly qualified future employees and workers (Claro et al., 2018). Meanwhile, in response to the globalization demands, higher education institutes prepare their students with competencies for the workplace, which require essential and fundamental changes in teaching practices and curriculum (Lai, 2011). The new generation in higher education studies is surrounded by technologies in their daily activities and is growing up with digital technologies. The ability to use technology and process digital skills effectively influences academic performance (Hurwitz & Schmitt, 2020). According to Dunwill (2016), the technology advancement keeps transforming and changing the setting of the learning and teaching process, such as employing online class portals and learning management systems. Hence, the higher education system must update its graduands to confront digitalization besides changing their mindset to adapt to the challenges of IR4.0. Furthermore, the availability of computers and the internet in many developed countries is increasing, while the ability to adopt digital technology rather than accessibility represents crucial determinants of digital capability in some developing counties. Thus, boosting digital skills is one of the considerable priorities in Malaysian higher education studies. As education gives insight and aids in developing of skills and competencies such as creativity, critical analysis of established practice, and comprehension of theoretical concepts, especially those pertaining to new technology, education is essential (Ahn et al., 2020). For this, education must emphasize on the ability to perform effectively (Musonda & Okoro, 2021).

### Future Skills

The IR4.0 necessitates a contemporary style of thinking and a willingness to adapt to the digital world. Data mining and automation in complex projects are setting the pace. A granular skill-cluster level of change is needed to upgrade key digital capabilities and provide the right education for the future needs of the digital world (WEF, 2016). To break free from the old teaching mindset in the built environment education and learning process, the educational system must enable new possibilities and potential of digital knowledge. Due to the requirements for more appropriate skills and digital competencies, higher education graduates are typically facing challenges in new markets for the next years (Yap et al., 2021). Moreover, due to unforeseen circumstances of the COVID-19 pandemic, the construction industry and operational conditions are temporarily disrupted. Therefore, policymakers within the construction industry and higher education studies must perform new digital strategies to deliver more profitability in the post-pandemic era (Antonopoulou et al., 2021, Bashay, 2020, Bergson-Shilcock, 2020).

In 2019, the Construction Leadership Council (CLC) Skills Workstream reported fundamental changes are required to support the new skilled professionals and develop smart construction competencies in the future (Reynolds et al., 2019, CLC, 2019). Thus, digital literacy and skills will be vital for all professionals, managers, and newly hired with appropriate training and constantly updated competencies. Nevertheless, future work in a built environment and skill requirements will be more digitally-focused and adaptive (Yap et al., 2021, Bakhshi et al., 2017).

## Materials and Methods

A few frameworks to define digital competencies level have typically been implemented by European countries for ICT professionals (Kuzminska et al., 2018). The Digital Competence for Citizen (DigComp) was proposed by European Commission (Pérez-Escoda & Fernández-Villavicencio, 2016). Since 2013, the DigComp has been adopted to help policymakers to support digital competence building, identify key areas of digital competencies, and plan education (Vuorikari et al., 2016). Since early 2015, the European Union introduced a new and developed DigComp 2.0 framework to identify the five components of digital competency area, summarized as follows: (1) data and information literacy, (2) Communication and collaboration, (3) Digital content creation, (4) Safety and being legal online, and (5) Problem-solving (Vuorikari et al., 2016, Van Deursen et al., 2014). The upgrade competency components described in DigComp 2.0 was selected for this research to identify the strategic challenges in higher education-built environment studies aiming a sustainable digitalization in the Malaysian university.

The target population of this study focused on higher education students undertaking the field of built environment studies to evaluate their ICTs use skills, interpersonal skills in using ICTs in the university context, and the virtual social communication tools of the university. Following the industrial reports and academic research in the digital competency context, the competencies' professional level, ICTs usage, and access to relevant tools were considered. These measurements have been undertaken in other research relevant to the built environment and digital skills in higher education. This study design is a descriptive quantitative survey allowing the collected data to be generalized to a wider population (Mirete et al., 2020). The standardized survey questionnaires, covering a range of digital competencies components at different professional levels, are based on COBADI 2.0 (Basic Digital Competencies/Registered Trademark 2970648) questionnaire.

The questionnaire was distributed to the 212 final-year students in built environment studies, specifically to the School of Housing, Building and Planning in Universiti Sains Malaysia (USM), as respondents due to the pandemic restrictions, the survey has been administrated and distributed online and electronically.

The questionnaire consists of two parts: the descriptive part (demographic information, internet access, and time of using digital devices) and the evaluative part (measuring the digital competencies). In the questionnaire, according to the DigComp 2.0, the evaluative part was comprised of 15 items which were divided into three main blocks. The first block was called "Competences in the use of ICTs for the search and processing of information" comprising 8 items on a 4-point Likert scale (1 = I feel totally incapable to 4 = I feel totally in control). The block measures individual competence using of various technological tools. The items are as follows:

ICT 1: I can surf the internet with different browsers (E.g., Mozilla, Explorer, etc.)
ICT 2: I am able to use different search engines (E.g., google, yahoo,bing, etc.)
ICT 3: I can work the documents online (Google Drive, One Drive)
ICT 4: I can organize, analyze and synthesize information with conceptual maps using social software tools (E.g., Smartdraw, Microsoft Visio, etc...)
ICT 5: I can use programs to disseminate interactive presentations online (E.g., Prezi, SlideShare, Scribd, etc.)
ICT 6: I can handle images using tools and/or social software applications (E.g., iMovie, loom)
ICT 7: I feel capable of using podcasting and video casts (E.g., flicks, Youtube, etc.)
ICT 8: I use QR codes to disseminate information

In the second block "Interpersonal skills in the use of ICTs in the university context" were designed in the following items intended to measure student ability to interact through effective listening and communication:

IS 1: I consult the lecturer
IS 2: I look for tutorials online and try to fix it on my own
IS 3: I talk with a colleague to see if we can solve it together
IS 4: I wait and request a face-to-face tutoring

In the third block, three items were adapted to measure ICT use as a virtual and social communication tool in the university context as detailed below:

VSCI 1: I use the university's e-mail service
VSCI 2: I use the university's virtual-learning platform (E.g., E-Learn, Microsoft Teams)
VSCI 3: I am active/participate on the university's social networks (E.g., Facebook, Instagram)

The respondents were selected by Quota sampling method and distributed online to the final-year students in built environment fields in USM during the second semester of the academic year 2021. In this study, data were analyzed using SPSS 24.0 due to the descriptive nature of the study.

## Results and Discussion

The following results present the main findings of this study. Table 1 shows the demographic background of the students participating in this research. Out of 212 final-year students, only 182 in the field of built environment study responded to the questionnaires with an 85% response rate. The respondents are 64.3% female and 35.7% male. Most of the respondents were between 21 to 25 years old (95%).

**Table 1.** Summary of Demographic Profile of Respondents (N = 182)

| Demographic Variables | Frequency | Percentage (%) |
|---|---|---|
| Gender | | |
| Male | 65 | 35.7% |
| Female | 117 | 64.3% |
| Age | | |
| 21–25 years old | 177 | 97.3% |
| 26–30 years old | 3 | 1.6% |
| Above 30 | 2 | 1.1% |
| Citizenship | | |
| Local | 166 | 91.2% |
| International | 16 | 8.8% |
| How many hours do you use the computer/laptop a week (academic purpose)? | | |
| An hour or less | 0 | 0.0% |
| More than one hour and up to 5 hours | 15 | 8.2% |
| More than 5 hour and up to 20 hours | 83 | 45.6% |
| More than 20 hours | 84 | 46.2% |
| What type of training have you received in the use/management of computers? | | |
| None | 13 | 7.0% |
| Basic computer knowledge (turn on / off, how to open programs) | 80 | 43.9% |
| Use of programs (word processing, spreadsheets) | 33 | 18.1% |
| Learning software specific to my area of study | 56 | 30.8% |
| Evaluate your degree of training or experience in the use of ICT | | |
| Self-taught (by myself) | 159 | 86.1% |
| University | 16 | 8.7% |
| Training courses | 4 | 2.2% |
| Other | 3 | 3.0% |

According to the results, all the respondents own a laptop or personal computer while only 1.1% of them do not have internet access at their current accommodations. The findings in **Table 1** also reveal that most students in this study were using computers for more than 20 hours a week for academic purposes. Besides, most of the final-year students have received at least one type of training, such as basic computer knowledge (43.9%) or learning software (30.8%). Most students (86.1%) have evaluated their degree of training and experience in ICT by self-taught.

The reliability test was utilized. The overall Cronbach's Alpha for each variable shows a reliability level above 0.75 and is ideal to proceed for further analysis. Kaiser-Meyer-Olkin (KMO) test was conducted on items for respondents yielding a score of 0.84, considered an excellent result with exceeded 0.5. Bartlett's test is significant at the p of 0.000 < 0.05 that represents the appropriate factor model (Table 2).

**Table 2.** Kaiser-Meyer-Olkin and Bartlett's Test

| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | | .834 |
|---|---|---|
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1,091.241 |
| | Degrees of freedom | 105 |
| | Significance | .000 |

According to Table 3, a summary of descriptive analysis illustrates that the average mean rating on digital competencies of respondents rated their digital and ICT skills as a mixed level of competence. The Standard Deviation also indicates that the value in the data set is close to the mean and average.

**Table 3.** Summary of Descriptive Analysis

| | Mean | Std. Deviation | Analysis N |
|---|---|---|---|
| ICT1 | 1.45 | 1.049 | 182 |
| ICT2 | 2.58 | 1.162 | 182 |
| ICT3 | 1.48 | 1.060 | 182 |
| ICT4 | 2.62 | 1.263 | 182 |
| ICT5 | 3.19 | 1.295 | 182 |
| ICT6 | 2.49 | 1.333 | 182 |
| ICT7 | 2.11 | 1.321 | 182 |
| ICT8 | 2.43 | 1.297 | 182 |
| IS1 | 3.51 | .785 | 182 |
| IS2 | 1.52 | .553 | 182 |
| IS3 | 1.75 | .673 | 182 |
| IS4 | 2.97 | .966 | 182 |
| VSC1 | 2.06 | 1.253 | 182 |
| VSC2 | 1.53 | 1.086 | 182 |
| VSC3 | 2.49 | 1.337 | 182 |

**Table 4.** Summary of Descriptive Analysis

| Literacies and Competencies | Mean | Std. Deviation | Analysis N |
|---|---|---|---|
| ICT use skills | 2.93 | 1.219 | 182 |
| Interpersonal skills | 3.66 | 0.744 | 182 |
| Virtual and social communication | 2.03 | 1.225 | 182 |

As will be discussed further, based on the characteristics of all items in this study, we can easily recognize the different levels of perceived competencies by the 182 final-year students in built environment studies.

Today's academic sector and higher education require digital competencies. Thus, students must adopt digital technology on sufficient and functional levels besides the ability to solve the problem they may face when using these technologies. The findings described how final-year students perceive their competence level before graduation, posing them with a better employability chance. According to the results, all students have basic computer knowledge and ICT skills. The importance depends on how they would become skillful in each competence level in a future professional environment. The finding of this study is consistent with previous literature confirming the demand for advancing digital competencies in higher education and enhancing the teaching and learning activities in the built environment field (Aliu & Aigbavboa, 2021, Rodríguez García et al., 2019, Reynolds et al., 2019, Khan et al., 2021). The frequency result (Appendix 1) shows the high percentage of students' capability in ICT usage to process information and research. Final-year students demonstrated improvement in their digital competencies, such as using different browsers and search engines with almost 80% capability. However, they are somewhat incapable of synthesizing information using social software tools such as Smart draw or interactive online presentations such as SlideShare, Prezi, etc. This finding is not surprising because it has been reported that college students usually struggle to analyze and synthesize different pieces of information (Howard, Serviss, & Rodrigue, 2010). This indicates that more emphasis must be placed on this skill in the teaching process.

Following interpersonal use of ICTs in the university, students reported that they mostly try to fix the problem independently (50.0%) or often talk with a classmate or colleague (48.9%). However, these students rarely consulted with the lectures due to problem-solving (67.0%) (Appendix 2). Most students preferred using virtual communication tools provided by the university, such as e-mail service (54.4%), virtual learning platform (78.6%), and university social networks (39.0%) (Appendix 3). These results are consistent with other scholars, confirming that students believe in themselves and feel competent in using digital skills and also solving their problems related to information and communication (Porln & Snchez, 2016).

Future operation models for the construction project will need fully automated manufactured instruments and interactive building information modelling. In response, the industry should employ graduates from higher education with enhanced digital skills (Needs, 2020). Investigating the digital competencies of the graduates-built environment in Malaysia will lead to future growth, especially IT and sustainable construction areas, while still not meeting current market expectations. Meanwhile, the role of ICTs as an extensive form of IT for future sustainable digital education models in the higher education context is inevitable (González-Zamar et al., 2020).

In this present study, data were collected during the COVID-19 pandemic. Therefore, any changes in learning style and mass use of technologies could be noticeable. Accordingly, in the post-pandemic, some digital skills may be more considerable to cope with the new working norm such as work-from-home. Due to the competitive job markets, future graduates must perfectly display their employability skills and digital competencies to succeed in work challenges.

## Conclusion

To fulfill the current and future needs of the construction industry, innovations, such as the IR4.0, must identify new and emerging skill requirements to ensure that the industry stays relevant and could contribute to national and global economic needs. Skills development projects should include access to education and innovation systems to meet the diverse needs in the construction industry and produce highly trained workers. This will improve employment opportunities. This study intends to describe the students' evaluation of their digital competencies in built environment of higher education, as measured by the DigComp questionnaire and illustrate how digital skills and competence may change in the areas of competencies, as explained by DigComp 2.0 components. The findings indicate that these future graduates had a mixed level of competence in information and data literacy, communication and collaboration, and digital content creation. The School of Housing, Building and Planning comprises seven (7) different programs and each program focuses on different skill sets which can be grouped into design, technical, and management. The emphasis on digital competence varies depending on the needs of the program. As such, further investigation is needed to explore how each program embeds digital skills into the curriculum and how these skills equip students for future interdisciplinary careers. Addressing digital skills should no longer be optional in built environment education. There must be more effective and efficient ways to measure students' digital skills which would support the quality of the teaching and learning experience in built-environment education.

## Suggestions for Future Research

This research intends to measure digital competence among university students, as few studies have been undertaken in Malaysia about digital competence, particularly in the context of the built environment in Malaysian public institutions. Although this study's findings were generated from a robust quantitative analysis, some limitations exist. First, the quantitative analysis should be supplemented with a qualitative analysis comprising open-ended questions that will allow for more in-depth results regarding the type of activities conducted on the internet, the level of competence derived from some of these activities, and the impact of these activities on developing academic competencies. Future research could include participants from other public and private universities in Malaysia to provide robust information on developing digital competencies by graduates.

**Co-Authors' Contribution**

The authors confirmed that there is no conflict of interest in this article. Author 1 and Author 4 prepared the literature review and prepared the interpretation of the results. Author 2 carried out the field work and wrote the research methodology. Author 3 proofread the manuscript.

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## References

Ahn, Y. H., Annie, R. P. & Kwon, H. (2012). "Key competencies for us construction graduates: Industry perspective". *Journal of Professional Issues in Engineering Education and Practice,* 138. pp. 123-130.

Ahn et al. (2020). "Improving effectiveness of safety training at construction worksite using 3D BIM simulation", 12.

Alaloul, W. S., Liew, M. S., Zawawi, N. A. W. A., & Kennedy, I. B. (2020). Industrial Revolution 4.0 in the construction industry: Challenges and opportunities for stakeholders. *Ain Shams Engineering Journal*, **11**(**1**), 225–230. doi:10.1016/j.asej.2019.08.010

Aliu, J. & Aigbavboa, C. (2021). "Key generic skills for employability of built environment graduates". *International Journal of Construction Management,* pp. 1-19.

Aliu, J. & Aigbavboa, C. O. (2019). "Employers' perception of employability skills among built-environment graduates". *Journal of Engineering, Design and Technology,*

Anggraeni, C. W. (2018). "Promoting education 4.0 in english for survival class: What are the challenges?". *Metathesis: journal of English language, literature, and teaching,* 2. pp. 12-24.

Antonopoulou, H., Halkiopoulos, C., Barlou, O. & Beligiannis, G. N. (2021). "Transformational leadership and digital skills in higher education institutes: During the covid-19 pandemic". *Emerging Science Journal,* 5. pp. 1-15.

Bakhshi, H., Downing, J. M., Osborne, M. A. & Schneider, P. (2017) *The future of skills: Employment in 2030,* Pearson.

Bashay, M. (2020). "Digital skills for an equitable recovery: Policy recommendations to address the digital skill needs of workers most vulnerable to displacement". *National Skills Coalition,*

Beatty, B. (2017). "Innovation 2050: A digital future for the infrastructure industry". *London: Balfour Beatty plc,*

Bergson-Shilcock, A. (2020). "The new landscape of digital literacy: How workers' uneven digital skills affect economic mobility and business competitiveness, and what policymakers can do about it". *National Skills Coalition,*

Bermúdez, M. D. & Juárez, B. F. (Year) Published. "Competencies to adopt industry 4.0 for operations management personnel at automotive parts suppliers in nuevo leon". Proc. of the International Conference on Industrial Engineering and Operations Management (25–26th of Oct., 2017, Bogota). Bogota, 2017. 736-747.

Brady, D. A., Tzortzopoulos, P., Rooke, J., Formoso, C. T. & Tezel, A. (2018). "Improving transparency in construction management: A visual planning and control model". *Engineering, Construction and Architectural Management,*

Cabello-Hutt, T., Cabello, P. & Claro, M. (2018). "Online opportunities and risks for children and adolescents: The role of digital skills, age, gender and parental mediation in brazil". *new media & society,* 20. pp. 2411-2431.

Camacho, D. D., Clayton, P., O'brien, W. J., Seepersad, C., Juenger, M., Ferron, R. & Salamone, S. (2018). "Applications of additive manufacturing in the construction industry–a forward-looking review". *Automation in construction,* 89. pp. 110-119.

Carretero, S., Vuorikari, R. & Punie, Y. (2017). Digcomp 2.1: The digital competence framework for citizens with eight proficiency levels and examples of use. Joint Research Centre (Seville site).

Caruso, L. (2018). "Digital innovation and the fourth industrial revolution: Epochal social changes?". *Ai & Society,* 33. pp. 379-392.

Chowdhury, T., Adafin, J. & Wilkinson, S. (2019). "Review of digital technologies to improve productivity of new zealand construction industry".

Claro, M., Salinas, Á., Cabello-Hutt, T., San Martín, E., Preiss, D. D., Valenzuela, S. & Jara, I. (2018). "Teaching in a digital environment (tide): Defining and measuring teachers' capacity to develop students' digital information and communication skills". *Computers & Education,* 121. pp. 162-174.

Future skills report. (2019). Available at: http://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2019/06/CLC-Skills-Workstream_Future-Skills-Report_June-2019_A4-Print-Version.pdf [Accessed: 10 July 2021].

Collet, C., Hine, D. & Du Plessis, K. (2015). "Employability skills: Perspectives from a knowledge-intensive industry". *Education+ Training,*

Conte, E. (2016). "Sustainability and built environment: The role of higher education in architecture and building engineering". *European Journal of Sustainable Development,* 5. pp. 1-1.

Cotet, G. B., Balgiu, B. A. & Zaleschi, V. C. (Year) Published. "Assessment procedure for the soft skills requested by industry 4.0". MATEC web of conferences, 2017. EDP Sciences, 07005.

Dunwill, E. (2016). "Changes that will shape the classroom of the future: Making education fully technological". *E-Learning Industry. https://elearningindustry. com/4-changes-will-shapeclassroom-of-the-future-making-education-fully-technological,*

El-Gohary, K. M., Aziz, R. F. & Abdel-Khalek, H. A. (2017). "Engineering approach using ann to improve and predict construction labor productivity under different influences". *Journal of Construction Engineering and Management,* 143. p. 04017045.

Falloon, G. (2020). "From digital literacy to digital competence: The teacher digital competency (tdc) framework". *Educational Technology Research and Development,* 68. pp. 2449-2472.

Ferrari, A. (2012). "Digital competence in practice: An analysis of frameworks". *Sevilla: JRC IPTS.(DOI: 10.2791/82116),*

Gleason, N. W. (2018) *Higher education in the era of the fourth industrial revolution,* Springer Nature.

Grundke, R., Marcolin, L. & Squicciarini, M. (2018). "Which skills for the digital era?: Returns to skills analysis".

Gudmundsdottir, G. B. & Hatlevik, O. E. (2018). "Newly qualified teachers' professional digital competence: Implications for teacher education". *European Journal of Teacher Education,* 41. pp. 214-231.

Howard, R. M., Serviss, T., & Rodrigue, T. K. (2010). Writing from sources, writing from sentences. Writing & Pedagogy, 2(2), 177-192. doi: 10.1558/wap.v2i2.177.

Hurwitz, L. B. & Schmitt, K. L. (2020). "Can children benefit from early internet exposure? Short-and long-term links between internet use, digital skill, and academic performance". *Computers & Education,* 146. p. 103750.

Hussin, A. A. (2018). "Education 4.0 made simple: Ideas for teaching". *International Journal of Education and Literacy Studies,* 6. pp. 92-98.

Iordache, C., Mariën, I. & Baelden, D. (2017). "Developing digital skills and competences: A quick-scan analysis of 13 digital literacy models". *Italian Journal of Sociology of Education,* 9.

Janssen, J., Stoyanov, S., Ferrari, A., Punie, Y., Pannekeet, K. & Sloep, P. (2013). "Experts' views on digital competence: Commonalities and differences". *Computers & Education,* 68. pp. 473-481.

Kamaruzaman, F. M., Hamid, R., Mutalib, A. A. & Rasul, M. S. (2019). "Conceptual framework for the development of 4ir skills for engineering graduates". *Global Journal of Engineering Education,* 21. pp. 54-61.

Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D. & Buckley, N. (2015). "Strategy, not technology, drives digital transformation". *MIT Sloan Management Review and Deloitte University Press,* 14.

Kaufmann, D., Ruaux, X. & Jacob, M. (2018). "Digitalization of the construction industry: The revolution is underway". *Oliver Wyman,*

Khan, N., Khan, S., Tan, B. & Loon, C. (Year) Published. "Driving digital competency model towards ir 4.0 in malaysia". Journal of Physics: Conference Series, 2021. IOP Publishing, 012049.

Kuzminska, O., Mazorchuk, M., Morze, N., Pavlenko, V. & Prokhorov, A. (Year) Published. "Digital competency of the students and teachers in ukraine: Measurement, analysis, development prospects". ICTERI Workshops, 2018. 366-379.

Lai, K.-W. (2011). "Digital technology and the culture of teaching and learning in higher education". *Australasian Journal of Educational Technology,* 27.

Loosemore, M. (2014). "Improving construction productivity: A subcontractor's perspective". *Engineering, Construction and Architectural Management,*

López-Meneses, E., Sirignano, F. M., Vázquez-Cano, E. & Ramírez-Hurtado, J. M. (2020). "University students' digital competence in three areas of the digcom 2.1 model: A comparative study at three european universities". *Australasian Journal of Educational Technology,* 36. pp. 69-88.

Lu, Q. & Lee, S. (2017). "Image-based technologies for constructing as-is building information models for existing buildings". *Journal of Computing in Civil Engineering,* 31. p. 04017005.

Marsh, J. (2016). "The digital literacy skills and competences of children of pre-school age". *Media education,* 7. pp. 178-195.

Mat Saat, Mohd Zaidi and Saripin, Muhammed Soffiq and Musa, Noor Dalila and Ridzuan, Arifi (2021) Factors influencing students' employability skills in Pahang. *Gading Journal for Social Sciences, 24* (4), 82-85.

Maynard, A. D. (2015). "Navigating the fourth industrial revolution". *Nature nanotechnology,* 10. pp. 1005-1006.

Mirete, A. B., Maquilón, J. J., Mirete, L. & Rodríguez, R. A. (2020). "Digital competence and university teachers' conceptions about teaching. A structural causal model". *Sustainability,* 12. p. 4842.

Mtshali, T. I. & Ramaligela, S. M. (2020). "Contemporary employability skills needed for learners to succeed in the civil technology field in the 4ir era". *Journal of Technical Education and Training,* 12. pp. 29-40.

Musonda, I., & Okoro, C. (2021). Assessment of current and future critical skills in the South African construction industry. *Higher Education, Skills and Work-Based Learning*, **11**(**5**), 1055–1067. doi:10.1108/HESWBL-08-2020-0177

Nadia Sullivan. (2020, October 12). Going Digital: A new normal in Higher Education. *MyForesight*. Retrieved from https://www.myforesight.my/going-digital-a-new-normal-in-higher-education/

Needs, E. G. O. F. S. (2020). "Building future skills: The demand for skills in ireland's built environment sector to 2030".

Oesterreich, T. D. & Teuteberg, F. (2016). "Understanding the implications of digitisation and automation in the context of industry 4.0: A triangulation approach and elements of a research agenda for the construction industry". *Computers in industry,* 83. pp. 121-139.

Omar, T. & Nehdi, M. L. (2016). "Data acquisition technologies for construction progress tracking". *Automation in Construction,* 70. pp. 143-155.

Osunsanmi, T. O., Aigbavboa, C. & Oke, A. (2018). "Construction 4.0: The future of the construction industry in south africa". *Int J Civ Environ Eng,* 12. pp. 206-212.

Ozkan-Ozen, Y. D., & Kazancoglu, Y. (2021). Analysing workforce development challenges in the Industry 4.0. *International Journal of Manpower*. doi:10.1108/IJM-03-2021-0167

Pagani, L., Argentin, G., Gui, M. & Stanca, L. (2016). "The impact of digital skills on educational outcomes: Evidence from performance tests". *Educational studies,* 42. pp. 137-162.

Palos-Sanchez, P. R., Robina-Ramirez, R. & Velicia-Martin, F. (2019). "What role does corporate governance play in the intention to use cloud computing technology?". *Symmetry,* 11. p. 1253.

Parry, E. & Battista, V. (2019). "The impact of emerging technologies on work: A review of the evidence and implications for the human resource function". *Emerald Open Research,* 1. p. 5.

Peña-López, I. (2016). "Innovating education and educating for innovation. The power of digital technologies and skills".

Pérez-Escoda, A. & Fernández-Villavicencio, N. G. (Year) Published. "Digital competence in use: From digcomp 1 to digcomp 2". Proceedings of the Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality, 2016. 619-624.

Porln, I. G. & Snchez, J. S. (2016). "Evaluation and development of digital competence in future primary school teachers at the university of murcia". *Journal of New Approaches in Educational Research (NAER Journal),* 5. pp. 51-56.

Redden, L., Collins, W. & Kim, J. (2017). "Integration of construction mobile technologies into construction management curriculum: A case study". *Procedia engineering,* 196. pp. 535-542.

Reynolds, L., Henderson, D. & Roche, N. (2019). "Digital technologies and future opportunities for the construction industry in wales".

Richert, A., Shehadeh, M., Plumanns, L., Groß, K., Schuster, K. & Jeschke, S. (Year) Published. "Educating engineers for industry 4.0: Virtual worlds and human-robot-teams: Empirical studies towards a new educational age". 2016 IEEE Global Engineering Education Conference (EDUCON), 2016. Ieee, 142-149.

Rodríguez García, A. M., Raso Sánchez, F. & Ruiz Palmero, J. (2019). "Competencia digital, educación superior y formación del profesorado: Un estudio de meta-análisis en la web of science". *Pixel-Bit: Revista de Medios y Educación, 54, 65-81.,*

Sánchez-Caballé, A., Gisbert-Cervera, M., & Esteve-Món, F. (2021). Integrating digital competence in higher education curricula: An institutional analysis. *Educar*, **57**(**1**), 241–258. doi:10.5565/REV/EDUCAR.1174

Schwab, K. (2017) *The fourth industrial revolution*, Currency.

Shibeika, A. & Harty, C. (2015). "Diffusion of digital innovation in construction: A case study of a uk engineering firm". *Construction management and economics,* 33. pp. 453-466.

Shuhidan, S. M., Yahaya, W. a. W., Hashim, H., Shuhidan, S. M. & Abd Hakim, A. A. (2019). "Malaysian research students encounter with information seeking process for academic purposes". *Journal of e-Learning and Higher Education,* pp. 1-10.

Solis, B. (2016). "The six stages of digital transformation maturity". *Teaneck, New Jersey: Altimeter Group on behalf of Cognizant. Accessed March,* 17. p. 2019.

Succi, C. & Canovi, M. (2020). "Soft skills to enhance graduate employability: Comparing students and employers' perceptions". *Studies in Higher Education,* 45. pp. 1834-1847.

Tsekeris, C. (2019). "Surviving and thriving in the fourth industrial revolution: Digital skills for education and society". *Homo Virtualis,* 2. pp. 34-42.

Van Deursen, A. J., Helsper, E. J. & Eynon, R. (2014). "Measuring digital skills. From digital skills to tangible outcomes project report".

Vuorikari, R., Punie, Y., Gomez, S. C. & Van Den Brande, G. (2016). Digcomp 2.0: The digital competence framework for citizens. Update phase 1: The conceptual reference model. Joint Research Centre (Seville site).

WEF. (2016). Shaping the Future of Construction A Breakthrough in Mindset and Technology. Retrieved from www.weforum.org

Wu, P., Wang, J. & Wang, X. (2016). "A critical review of the use of 3-d printing in the construction industry". *Automation in Construction,* 68. pp. 21-31.

Yap, J. B. H., Skitmore, M., Lim, Y. W., Loo, S.-C. & Gray, J. (2021). "Assessing the expected current and future competencies of quantity surveyors in the malaysian built environment". *Engineering, Construction and Architectural Management,*

Yusuf, B., Walters, L. M. & Sailin, S. N. (2020). "Restructuring educational institutions for growth in the fourth industrial revolution (4ir): A systematic review". *International Journal of Emerging Technologies in Learning,* 15.

# Appendices

**Appendix 1**

| | **ICT1** | **ICT2** | **ICT3** | **ICT4** | **ICT5** | **ICT6** | **ICT7** | **ICT8** |
|---|---|---|---|---|---|---|---|---|
| Capable | 82.4% | 76.4% | 80.2% | 32.4% | 48.9% | 30.9% | 54.4% | 39.0% |
| NA | 1.1% | 2.7% | 2.7% | 3.3% | 2.7% | 3.3 | 1.6% | 4.9% |
| Somewhat Capable | 9.3% | 11.5% | 10.4% | 39.0% | 31.3% | 33.0% | 28.6% | 36.8% |
| Somewhat Incapable | 3.3% | 4.4% | 2.2% | 20.3% | 12.1% | 18.7% | 9.3% | 12.6% |
| Totally Incapable | 3.8% | 4.9% | 4.4% | 4.9% | 4.4% | 6.0% | 6.0% | 6.6% |

**Appendix 2**

| | **IS1** | **IS2** | **IS3** | **IS4** |
|---|---|---|---|---|
| Every time | 2.2% | 50.0% | 37.9% | 2.7% |
| Often | 19.2% | 46.7% | 48.9% | 15.4% |
| Rarely | 67.0% | 2.7% | 13.2% | 42.3% |
| Never | 11.5% | 0.0% | 0.0% | 39.6% |

**Appendix 3**

| | VSC1 | VSC2 | VSC3 |
|---|---|---|---|
| Capable | 54.4% | 78.6% | 39.0% |
| NA | 2.2% | 1.1% | 2.7% |
| Somewhat Capable | 30.2% | 13.2% | 36.3% |
| Somewhat Incapable | 9.3% | 3.3% | 14.3% |
| Totally Incapable | 3.8% | 3.8% | 7.7% |