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The Architecture, Engineering and Construction (AEC) Companies' Preferences on Digital Literacy among Fresh Graduates

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Abstract

Digital literacy refers to the understanding and use of information through digital technologies. In the Architecture, Engineering, and Construction (AEC) industry, digital advancements have been adopted later than in other sectors. However, Industry 4.0 is driving the AEC industry to embrace digitalization for improved efficiency and performance. Today, digital platforms are integral to most aspects of work, prompting companies to invest in human capital with proficient digital skills. This study aims to identify AEC companies' preferences for digital literacy among graduates and explore strategies to enhance these skills. Using a quantitative approach, over 100 questionnaires were distributed to AEC companies, yielding 83 valid responses. The key findings indicate significant differences in preferences for graduates' digital literacy, particularly in the areas of Critical Thinking and Problem Solving, across the three sectors. The study concludes that improving graduates' digital skills in these areas is essential to meet industry demands.

Keywords: Architecture, Engineering and Construction, AEC, digital literacy, graduates,

Introduction

Digital literacy is the knowledge and skills of users in utilizing digital media, such as communication tools, internet networks, and so on (Rachmadtullah et al., 2023; Reddy et al., 2020). AEC companies are finding it challenging to adjust to digitalization as a result of the rapid evolution of digital technologies in the sector. The AEC sector had a negative association with innovation adoption historically, which explains why digital advances have been adopted later than other industries (Dulaimi, 2022). This connection is linked to resistance to change, aversion to new ideas, and poor choices with unconventional methods (Durdyev et al., 2021).

However, the globally existing and fast-paced digitalisation in the context of Sector 4.0 or the digital revolution (García de Soto et al., 2019) is urging the construction sector to transform rationally for a more efficient performance (Hassan et al., 2021). Herewith, AEC graduates' and students who are proficient in these skills are in high demand in this decade. Through the adoption of cutting-edge technologies and inventive methodologies, Malaysia has the

potential to produce more intelligent and robust built environments, thereby augmenting the nation's overall economic growth and social welfare. (CIDB, 2022).

Hence, it is important to identify AEC companies' the most in demand preferred digital literacy among AEC graduates and ways to improve the skills in order to help these graduates preparing themselves before stepping into the construction field. Thus, the purpose of this study is to determine the AEC companies' preferences for digital literacy among AEC graduates and to identify strategies in enhancing digital literacy among AEC gradates.

Literature Review

Essential Elements of Digital Literacy (8C)

Digital literacy is shaped by the educational system, social and political norms, and cultural values. Doug Belshaw in 2014 (highlighted eight key components which are cultural, cognitive, constructive, communicative, confident, creative, critical, and civic in his groundbreaking book "The Essentials of Digital Literacies". The eight elements were split up into four skillsets and four mindsets. Cultural, Creative, Constructive, and Communicative are the skill sets while the four mindsets are Confident, Cognitive, Critical, and Civic (Panke, 2015).

Cultural

Mastering the cultural component of digital literacy involves immersion in diverse digital contexts, allowing individuals to navigate various environments, issues, and norms fluidly (Belshaw, 2014). Cultural literacy in the digital realm means understanding and appreciating different cultural perspectives online. It is essential to recognize and adapt to both similarities and differences when using digital tools for academic, personal, or professional purposes, as each setting comes with distinct cultural expectations (Sally, 2015). This ability to adjust communication patterns helps avoid misunderstandings and ensures that interactions are culturally sensitive, particularly in professional settings like construction, where technology adoption may be slower but still evolves steadily. As new technologies and management techniques emerge, the ability to transition smoothly between these advancements reflects the cultural aspect of digital literacy in industries like construction, which, despite its gradual pace, is far from stagnant (Miozzo & Ivory, 2000).

Cognitive

The cognitive component of digital literacy refers to the mental tools and operations needed to acquire, comprehend, and process information (Collins Dictionary, n.d.). Developing strong "habits of mind" through exposure to diverse perspectives on digital environments enhances critical thinking, problem-solving, and the ability to evaluate digital material (Belshaw, 2014). This cognitive aspect also involves mastering subject-specific and general digital tools, which are essential for efficiently processing and interpreting information. In the construction industry, a complex and uncertain sector that is key to Malaysia's economic growth (Al-Tmeemy et al., 2011), poor performance and delays are common (Abdullah, 2010), but the adoption of advanced practices has become necessary to enhance competitiveness. The success of construction projects heavily depends on the cognitive skills of project managers, whose decision-making and strategic planning are crucial for project success (Bandow, 2001; Esa et al., 2014; Gudienė et al., 2013). The cognitive element of digital literacy plays a vital role in supporting these managerial decisions, as mental models impact how managers process information and make decisions (George & Chattopadhyay, 2002).

Constructive

The constructive element of digital literacy refers to the ability to create something new, which can include building upon the work of others rather than starting from scratch. Literacy traditionally involves reading and writing (Lankshear & Knobel, 2007), but in the digital age, being literate also means using digital technologies wisely to promote social action (Martin, 2006). Constructive creativity often involves repurposing or remixing existing content with proper attribution, as emphasized by the Creative Commons licenses (Creative Commons, 2023; Belshaw, 2014). Originality, in this context, means blending traditional ideas in new ways rather than inventing something entirely new (Shareef, 2018). In construction, this concept applies to incorporating new ideas into building designs while preserving valuable elements from previous ones (Abdelmonem, 2017). Additionally, project managers who introduce innovative techniques to improve productivity and the work environment are also demonstrating constructive thinking within their field.

Communicative

The communicative component of digital literacy is crucial, as it plays a role in nearly all aspects of literacy, connecting closely with other elements, particularly the constructive and cultural components (Belshaw, 2014). Communicative literacy involves understanding how communication technologies function, including network literacy, which focuses on how individuals interact within networks to access information and resources (jPodcaster, 2012). It also requires an understanding of online tools, verification, sharing, influence, and trust in digital environments (Sally, 2015). In the construction industry, effective communication is essential for project success, as multiple parties must collaborate (Gayeski, 1993). Communication across organizations depends on clear interpretation and distribution of information by individuals (Heath, 2020). Digital technologies help overcome barriers such as physical distance, enabling faster, more reliable information sharing, which is vital in the fragmented construction sector (Cheng et al., 2001).

Confident

The confident element of digital literacy involves recognizing the flexibility and experimental nature of digital tools, requiring a sense of familiarity and belonging to engage with technology comfortably (Sally, 2015). For those unfamiliar with the digital world, it can be intimidating, but confidence grows as individuals understand the differences between digital and manual processes (Belshaw, 2014). In industries like construction, confidence is essential when using industry-specific software and adapting to emerging technologies, such as augmented reality and drones, which enhance project efficiency. Familiarity, drawn from experience, increases comfort with using multiple digital tools to address issues, potentially adding significant business value (Scheuer, 2007). For instance, platforms that integrate computational design and BIM tools streamline the supply chain, enabling construction firms to optimize all phases of building development (Deloitte, 2019).

Creative

Creativity in digital literacy involves generating new, valuable ideas, solutions, or works, whether for problem-solving, interaction, or entertainment (Belshaw, 2014). In the digital age, where true originality is rare, the focus shifts to the value created within specific contexts. Creativity means using digital tools to do things that were previously impossible, encouraging individuals to become "problem-finders" rather than just "problem-solvers" (McIntosh, 2011).

It requires taking risks, being open to discovery, and finding relevant, novel solutions to challenges (Mumaw, 2013). The construction sector is deeply connected to creativity, as architecture and design engineering are inherently creative processes that produce original products through technological interventions (Wijesooriya & Wijesundara, 2012). Creativity and innovation are essential for the industry's survival, and it is recognized as one of the most important leadership qualities, especially in construction, where creative problem-solving and technological integration drive success (IBM Corporation, 2010).

Critical

The critical element of digital literacy involves examining assumptions and power dynamics within literacy practices, focusing on how communication and meaning are interpreted in various semiotic environments, such as text, visuals, and symbols (Digital Literacy Hub Africa, 2020). It encourages questioning who is included or excluded from these practices and reflecting on the decisions that shape them and their impact on others (Belshaw, 2014). This element also requires careful consideration of audience and diverse interpretations, alongside developing expertise in data management, authentication, and internet security (jPodcaster, 2012). Critical literacy entails evaluating the legitimacy of digital information, identifying inconsistencies or errors, and using computational thinking to solve problems. Moreover, it involves assessing new technologies for their relevance, advantages, and disadvantages before applying them to support well-informed project decisions..

Civic

The civic element of digital literacy focuses on using technology to support civil society, which refers to groups outside of government that advocate for citizens' rights and serve as valuable information sources for both the public and government (Ingram, 2020). This element encourages the use of digital tools to self-organize and promote democracy, public participation, and global citizenship (Sally, 2015). Closely tied to the critical element, civic literacy involves reading and writing with a societal purpose in mind, fostering citizen-government relationships through digital platforms (Belshaw, 2014; Olivier & Wright, 2015). In the construction industry, engaging with local communities to ensure projects meet public needs, incorporating inclusive design, and using participatory approaches are vital for creating accessible and socially responsible infrastructure (Corbett & Le Dantec, 2019).

Digital Literacy Competence Area

A wide range of abilities and information are included in digital literacy, which is essential for thriving in the age of digitalisation. UNESCO (2018) categories the competence area as information and data literacy, communication and collaboration, safety, critical thinking and problem solving as well as adaptability and continuous learning. Whereas according to the other author, safety competence area was not mentioned in other past research. Hence, for the purpose of this study, the competence area to be discussed are only information and data literacy, communication and collaboration, critical thinking and problem solving as well as adaptability and continuous learning. Table 1 illustrates past research on digital literacy competence area

Table 1
Past Research Tabulation of Digital Literacy Competence Area

Digital Literacy Competence Area	Authors					
	1	2	3	4	5	6
Information and Data Literacy	✓	✓	✓	✓	✓	✓
Communication and Collaboration	✓	✓	✓	✓	✓	✓
Safety			✓			
Critical Thinking and Problem Solving	✓	✓	✓	✓	✓	✓
Adaptability and Continuous Learning	✓		✓		✓	

[1](Shariman et al., 2012); [2] (Spante et al., 2018); [3] (UNESCO Institute of Statistics, 2018); [4] (Martínez-Bravo et al., 2022); [5] (Cartelli, 2009); [6] (ISTE, 2007).

Information and Data Literacy

Data literacy is the ability to understand, work with, and communicate insights from data, allowing individuals and organizations to make informed decisions (Stedman, n.d.; Nehme & Crabtree, 2023). In the construction industry, this skill is crucial for using various information and communication technologies, such as BIM and CAD, to manage projects effectively. Professionals must retrieve, evaluate, and apply data ranging from material specifications to legal requirements. A high level of data literacy is increasingly valued, with 66% of companies in the US and UK willing to pay more for employees with these skills, including salary increases of up to 30% (DataCamp, 2023). Mastering data literacy reduces the risk of misunderstandings and miscommunications, leading to more accurate information exchanges and improved teamwork (Osment, 2023).

Communication and Collaboration

The communications and collaboration component of digital literacy involves participating in digital networks for learning and research (JISC, 2014), emphasizing effective idea-sharing, active listening, and teamwork. Communication focuses on exchanging knowledge to foster understanding, while collaboration builds on this by using shared data to improve collective output, with the two being deeply interconnected (O'Connor, 2015). In the construction industry, open and effective communication is crucial as all stakeholders—owners, architects, engineers, contractors, and suppliers—must share common information and goals. Collaboration ensures cohesive teamwork across disciplinary boundaries, essential for project success, with digital tools facilitating more efficient communication and collaboration (Karimzadeh, 2023).

Critical Thinking and Problem Solving

Critical thinking is a process that enhances the value of ideas through precise analysis, evaluation, and reconstruction (Partnership for 21st Century Skills, 2009). It involves independent and logical reasoning, closely linked to problem-solving, which focuses on identifying practical solutions to challenges (Master Builders, 2022). Effective critical thinking requires gathering necessary information, evaluating potential solutions, and seeking feedback before making decisions or taking action, ensuring that all options are considered based on rational assumptions and factual data (Skill IT, 2019). In situations where time is critical, individuals strive for the most efficient methods to achieve objectives, often seeking alternatives and working smarter, not harder.

Adaptability and Continuous Learning

Continuous learning, or lifelong learning, involves the ongoing acquisition of competencies, abilities, and knowledge throughout one's life, enabling individuals to adapt to changes and remain competitive in the modern workplace (FasterCapital, 2023). This mindset fosters adaptability in utilizing emerging technologies and encourages digital literacy by promoting awareness of technical advancements and a readiness to acquire new skills. Continuous learning initiatives are valuable, as they enhance productivity, encourage departmental collaboration, and motivate employees (Zhang, 2022). In the construction industry, staying updated on emerging trends, techniques, and technologies is crucial for improving project outcomes and implementing innovative practices that boost delivery and profitability. Furthermore, regular training and development opportunities equip staff with the necessary skills to succeed in their roles and adapt to the evolving demands of projects (Utilities One, 2023).

Methodology

The research methodology chosen for this study is a quantitative approach, as it effectively analyzes large populations and allows for the projection of findings from a study sample to broader populations (Swanson & Holton, 2005). This approach aims to understand the preferences of Architecture, Engineering, and Construction (AEC) companies, using statistical analysis to identify underlying trends and patterns across a larger demographic, thus enabling generalizable results (Sukamolson, 2007). Unlike qualitative methods, which focus on in-depth understanding, the quantitative method gathers substantial data to represent a wider group within the industry that did not participate in the survey. Additionally, quantitative techniques involve creating research instruments designed to transform qualitative events, such as preferences and strategies, into analyzable statistical data. For this study, a survey will be developed where participants rank a series of items on a scale from strongly disagree to strongly agree, assigning numerical values to their responses (e.g., 1 for significant disagreement and 5 for strong agreement), thereby facilitating the collection of numerical data for analysis. This rationale underpins the choice of a quantitative approach for this study.

Approach to Data Collection

Research instruments are instruments for gathering and analysing data. Selecting the appropriate research instrument can ease the process of data collection and yield more precise findings for the intended goal of the study. In this research, instrument development consists of Section A, Section B, and Section C. The demographics of the respondents are covered in Section A, along with the question of experience with digital technologies in the industry. Section B will include the instruments for digital literacies preferences while Section C contains the instruments for strategies. All items in the instruments need to be answered on the level of importance in the Likert scale (1-5).

Section A – Demographic

Section A will focus on respondents' demographic details such as genders, ages and their positions in a AEC company. Other than that, there will be a list of current technologies in construction industry and respondents have to choose the technologies they have encountered, have the knowledge of or have used in their lives.

Section B - Digital Literacy

In Section B, the goal is to achieve objective 1 which is to determine the AEC companies' preferences for digital literacy among AEC graduates. There are two (2) main category which are skillsets and mindsets with four (4) key elements under each category extracted from the literature review. Thus, three (3) items have been established to measure each construct, as shown in Table 3 to Table 6.

Table 2
Information and Data Literacy Construct

Dependent Variable	Construct	Code	Items
Information and Data Literacy	Cultural	ID1	Graduates who understand variations in information sources and data interpretation among different digital tools.
	Cognitive	ID2	Graduates who can process real life data into digital information effectively.
	Constructive	ID3	Graduates who contribute positively to discussions with informed information.
	Communicative	ID4	Graduates who can express ideas about information clearly using digital platforms.
	Confident	ID5	Graduates who feel confident in their ability to find and evaluate digital information.
	Creative	ID6	Graduates who can creatively use digital tools to find information.
	Critical	ID7	Graduates who can evaluate the reliability of digital sources critically.
	Civic	ID8	Graduates who understand digital information's role in civic engagement.

Table 3
Communication and Collaboration Construct

Dependent Variable	Construct	Code	Items
Communication and Collaboration	Cultural	CC1	Graduates who can easily switch into different digital instruments to communicate.
	Cognitive	CC2	Graduates who engage in effective online communication using digital tools.
	Constructive	CC3	Graduates who actively participate in constructive online collaborations.
	Communicative	CC4	Graduates who can adapt with communication styles to different digital platforms.
	Confident	CC5	Graduates who feel confident in expressing ideas through digital communication.
	Creative	CC6	Graduates who can creatively collaborate with others using digital tools.
	Critical	CC7	Graduates who can think critically in digital communication and collaboration.
	Civic	CC8	Graduates who recognize their role in digital collaboration.

Table 4
Critical Thinking and Problem Solving Construct

Dependent Variable	Construct	Code	Items
Critical Thinking and Problem Solving	Cultural	CP1	Graduates who can adapt to company's use of technology to solve problem.
	Cognitive	CP2	Graduates who can analyse digital information critically.
	Constructive	CP3	Graduates who approach challenges with a problem-solving mindset.
	Communicative	CP4	Graduates who use critical thinking in digital communication.
	Confident	CP5	Graduates who feel confident in facing digital challenges.
	Creative	CP6	Graduates who creatively solve problems in technology.
	Critical	CP7	Graduates who think critically to adapt to new digital tools.
	Civic	CP8	Graduates who recognize the challenges of technology with civic implications.

Table 5
Adaptability and Continuous Learning Construct

Dependent Variable	Construct	Code	Items
Adaptability and Continuous Learning	Cultural	AC1	Graduates who make effort to adjust to company's use of tools/software.
	Cognitive	AC2	Graduates who can apply cognitive skills to new digital tools.
	Constructive	AC3	Graduates who keep trying to learn new tools and use it to company's benefit.
	Communicative	AC4	Graduates who try to seek familiarity in technology to communicate effectively.
	Confident	AC5	Graduates who feel confident to adapt to new technologies.
	Creative	AC6	Graduates who can learn creatively in the digital space.
	Critical	AC7	Graduates who continue to learn to make critical decision making.
	Civic	AC8	Graduates who engage in civic participation to adapt and learn continuously.

Population and Sampling

The study's intended audience consisted of construction staff who had worked or still working in AEC companies. They are Project Managers, Site Supervisors and Administrator/HR in Malaysia who have experiences in interviewing new employees such as graduates. This is carried out to find out how they would like new hires to be digitally literate and what approaches they think might improve digital literacy. The convenience sampling approach was

the sample technique employed in this study. It is a common method of random sampling used to examine large populations, the researcher may select participants based on factors such as willingness to engage, availability at a specific time, or physical closeness. Convenience sampling can offer an affordable data collection option when budgetary or time constraints are present (Simkus, 2023). It is because there are three targeted categories of audience which are the Architects, Engineers and Construction personnel.

Data Analysis

Quantitative data is presented and examined using statistical techniques. There are two (2) method of data analysis for quantitative analysis which are descriptive statistics and inferential statistics. However, the method of analysis for this research is descriptive statistics where frequency and mean will be the instrument. Descriptive analysis describes the characteristics of a variable. It is used to make a conclusion about a variable based on numerical data and a valid quantification necessitates that the measuring process follow predetermined standards and processes for data collection and analysis (Kemp et al., 2018).

Reliability Test

One of the most crucial and essential areas in evaluating any measuring technique for data collecting in a quality study is the reliability test. It is about how well a measuring instrument controls random error and how accurate the results collected are (Ahmed and Ishtiaq, 2021). There are various kinds of reliability indexes. The repeatability of a measure is determined by its internal reliability, which is quantified by Cronbach's alpha as shown in tables below. the reliability test result for this study is 0.812 indicating a good level of consistency between items on the scale and that shows stronger relationship between the items.

Normality Test

The results of a normality test indicate whether or not the sample data came from a population that was normally distributed. It is typically carried out to confirm that the research's data have a normal distribution. Regardless of sample size, the assumption of normalcy must be adhered to in order to draw relevant results (Gupta et al., 2019). A normality test was adopted in this study to assess the distribution of data from both research goals. In order to determine the study's normalcy, a Shapiro-Wilk test was used as all Shapiro Wilk Sig. Data is more than 0.50. Therefore, the data is normally distributed.

Relative Importance Index (RII)

Relative index analysis was chosen in this study to rank the preference and strategies according to their relative importance. Relative relevance index analysis is a useful approach for prioritizing indicators scored on Likert-type scales and for determining the majority of significant criteria based on participant replies. Researchers in construction and facilities management frequently employ the non-parametric Relative Importance Index (RII) method to analyze structured questionnaire answers for information related to ordinal measurement such as opinions and attitudes.

Relative Importance Index (RII) method is used because in this study, the researcher wants to determine the relative importance of quality factors involved. For this study specifically, the rank of importance between each statement in the research instrument is analysed. For

example, out of all the listed preference, which one is the most important for companies in the AEC industry or which strategy is the most essential to enhance graduates' digital literacy.

The RII value has a range of 0 to 1, where 0 is not included. It demonstrates that the construct element was more significant the higher the RII value, and vice versa. Akadiri (2011) proposed measuring the comparison of RII with the equivalent importance level using the transformation matrix. According to him, derived importance levels from RII are as follows.

Research Findings

The survey was distributed through online platform. For instance, through Email, LinkedIn as well as other social media such as Facebook post, and Whatsapp group. The researcher also met some respondents in person physically but the questionnaire was still answered online by scanning a QR code that brought the respondents to the survey. The targeted respondents are any personnel in the AEC industry who has experiences with the use of technology. The survey was distributed to over a hundred potential respondents but only 84 had completed the survey.

The AEC Companies Preferences for Digital Literacy among AEC Graduates

Section B is focusing on obtaining the findings for objective 1 which is to determine AEC companies' preference of AEC graduates' digital literacy. Digital literacy competence area which are Information and Data Literacy, Communication and Collaboration, Critical Thinking and Problem Solving as well as Adaptability and Continuous Learning together with the essential elements of digital literacy that consist of Cultural, Cognitive, Constructive, Communicative, Confident, Creative, Critical and Civic are both extracted from literature review were analysed.

Information and Data Literacy

The first competence area that will be discussed is Information and Data Literacy. All of the 8C essential elements of digital literacy become the items of the competence area. The table presents the total weightage and RII values for each construct element, all based on the same sample size and highest weight. Construct item code ID3 ranks highest with an RII value of 0.913, indicating high importance, followed closely by ID7, ID6, ID2, ID4, and ID5, which all maintain high importance classifications but have slightly lower RII values (0.863 to 0.812). ID8 and ID1 are ranked lower at 0.720 and 0.704, respectively, categorized as medium-high importance. Overall, AEC companies prefer graduates who positively contribute informed insights and critically evaluate digital sources, while they show moderate preference for graduates understanding digital information's role in civic engagement and variations in data interpretation.

Table 6
Information and Data Literacy RII Value

Code	Items	Total Weightage	RII Value	Ranks
ID3	Graduates who contribute positively to discussions with informed information.	**∑w** = 379	0.913	1
ID7	Graduates who can evaluate the reliability of digital sources critically.	**∑w** = 358	0.863	2
ID6	Graduates who can creatively use digital tools to find information.	**∑w** = 355	0.855	3
ID2	Graduates who can process real life data into digital information effectively.	**∑w** = 345	0.831	4
ID4	Graduates who can express ideas about information clearly using digital platforms.	**∑w** = 342	0.824	5
ID5	Graduates who feel confident in their ability to find and evaluate digital information.	**∑w** = 337	0.812	6
ID8	Graduates who understand digital information's role in civic engagement.	**∑w** = 299	0.720	7
ID1	Graduates who understand variations in information sources and data interpretation among different digital tools.	**∑w** = 292	0.704	8
		Average RII Value	**0.815**	

Communication and Collaboration

Competence area that will be discussed next is Communication and Collaboration. All of the 8C essential elements of digital literacy also become the items of the competence area. According to the Table 7 below, item code CC2 has the highest RII value which is 0.889, followed by item code CC7 and CC3 close behind with 0.860 and 0.851 RII value respectively at rank 2 and 3. All of these item ranked 1 to 3 have a High importance classification together with item code CC4 and CC5 that share the same RII value which is 0.824. Other than those items, item code CC6 and CC1 belong to another importance classification which is a Medium-High level with 0.701 and 0.655 RII value individually. Last but not least, code item CC8 received a Medium level with only 0.545 RII value and a lot of respondents think that graduates who recognize their role in digital collaboration has a low importance.

Thus, we can conclude that AEC companies highly prefer graduates who engage effectively in online communication using technology, graduates who can think critically in digital communication and collaboration and graduates who actively participate in constructive online collaboration. AEC companies also highly prefer graduates who can adapt with different digital platforms' communication styles as well as graduates who feel confident in expressing ideas digitally. On the other hand, AEC companies prefer graduates who can creatively collaborate using digital tools, graduates who can easily switch into different digital instruments to communicate and graduates who recognize their role in digital collaboration fairly-high but not as much as the ones mentioned before.

Table 7
Communication and Collaboration RII Value

Code	Items	Total Weightage	RII Value	Ranks
CC2	Graduates who engage in effective online communication using digital tools.	**∑w** = 369	0.889	1
CC7	Graduates who can think critically in digital communication and collaboration.	**∑w** = 357	0.860	2
CC3	Graduates who actively participate in constructive online collaborations.	**∑w** = 353	0.851	3
CC4	Graduates who can adapt with communication styles to different digital platforms.	**∑w** = 342	0.824	4
CC5	Graduates who feel confident in expressing ideas through digital communication.	**∑w** = 342	0.824	4
CC6	Graduates who can creatively collaborate with others using digital tools.	**∑w** = 291	0.701	5
CC1	Graduates who can easily switch into different digital instruments to communicate.	**∑w** = 272	0.655	6
CC8	Graduates who recognize their role in digital collaboration.	**∑w** = 226	0.545	7
		Average RII value	**0.769**	

Critical Thinking and Problem Solving
The third competence area to be analysed is Critical Thinking and Problem Solving. Similar as the other ones, the total frequency of each item are shown in the table 8 below. The ranking of the items starts with item code CP1 with RII value of 0.889, then CP7 with RII value of 0.884 and CP3 with 0.870 RII value. Overall, most respondents of the respondents think that it is very important to have graduates who can adapt to company's use of technology to solve problem. Item code CP6 followed not so far behind with RII value of 0.829. Therefore, CP1, CP7, CP3 and CP6 topping the rank with a High importance classification. At the same time, CP4 with 0.798, CP2 with 0.793 and CP5 with 0.651 RII value are at a Medium-High level and finally CP8 has a Medium importance classification with only 0.528 RII value.

All in all, AEC companies truly prefer graduates who can adapt to company's use of technology to solve problem, graduates who think critically to adapt to new digital tools and graduates who approach challenges with a problem-solving mindset. Those companies also still highly prefer graduates who creatively solve problems in technology and graduates who use critical thinking in digital communication. Additionally, AEC companies moderately prefer graduates who can analyse digital information critically and graduates who feel confident in facing digital challenges. Inversely, companies in the AEC industry prefer graduates who recognize the challenges of technology with civic implications to a smaller extent.

Table 8
Critical Thinking and Problem Solving RII Value

Code	Items	Total Weightage	RII Value	Ranks
CP1	Graduates who can adapt to company's use of technology to solve problem.	**∑w** = 369	0.889	1
CP7	Graduates who think critically to adapt to new digital tools.	**∑w** = 367	0.884	2
CP3	Graduates who approach challenges with a problem-solving mindset.	**∑w** = 361	0.870	3
CP6	Graduates who creatively solve problems in technology.	**∑w** = 344	0.829	4
CP4	Graduates who use critical thinking in digital communication.	**∑w** = 331	0.798	5
CP2	Graduates who can analyse digital information critically.	**∑w** = 329	0.793	6
CP5	Graduates who feel confident in facing digital challenges.	**∑w** = 270	0.651	7
CP8	Graduates who recognize the challenges of technology with civic implications.	**∑w** = 219	0.528	8
		Average RII value	**0.780**	

Adaptability and Continuous Learning

The last competence area that need to be analysed in this study is Adaptability and Continuous Learning. For this competence area, a large number of items are ranked “Important” compared to “Very Important”. Some of them are item code AC2, AC3, AC4, AC5, AC6 and AC8. Only item code AC1 and AC7 that most respondents agreed for it to be a “Very Important” for graduates to have. There are also some items that a few respondents think the items are “Not at all Important” which are item code AC6 and AC8 while item code AC3 has the most “Low Importance” votes. According to the RII value of Adaptability and Continuous Learning competence area above, majority of the items has High important classification. The items are AC1 with 0.901 which is the highest RII value for this area, followed by AC7 and AC4 with RII value of 0.875 and 0.853 individually. Then, the rest of items with also High level of importance are AC2 with 0.839, AC5 together AC6 sharing the same RII value at 0.824. Apart from those items, there are two other items with Medium-High importance level with 0.687 and 0.614 RII value. The two items are AC8 and AC3.

In short, AEC companies immensely prefer graduates who make effort to adjust to company's use of tools/software and graduates who continue to learn to make critical decision making. Furthermore, AEC companies also highly prefer graduates who try to seek familiarity in technology to communicate effectively, graduates who can apply cognitive skills to new digital tools and not drastically less, also highly prefer graduates who feel confident to adapt to new technologies as well as graduates who can learn creatively in the digital space. Nonetheless, AEC companies less prefer graduates who engage in civic participation to adapt and learn continuously and graduates who keep trying to learn new tools and use it to company's benefit, than the rest of the statements.

Table 22
Adaptability and Continuous Learning RII Value

Code	Items	Total Weightage	RII Value	Ranks
AC1	Graduates who make effort to adjust to company's use of tools/software.	∑w = 374	0.901	1
AC7	Graduates who continue to learn to make critical decision making.	∑w = 363	0.875	2
AC4	Graduates who try to seek familiarity in technology to communicate effectively.	∑w = 354	0.853	3
AC2	Graduates who can apply cognitive skills to new digital tools.	∑w = 345	0.831	4
AC5	Graduates who feel confident to adapt to new technologies.	∑w = 342	0.824	5
AC6	Graduates who can learn creatively in the digital space.	∑w = 342	0.824	5
AC8	Graduates who engage in civic participation to adapt and learn continuously.	∑w = 285	0.687	6
AC3	Graduates who keep trying to learn new tools and use it to company's benefit.	∑w = 255	0.614	7
Average RII value			0.801	

Discussion

Findings from the Relative Importance Index (RII) analysis as summarized in Table 28 shows that all of the construct have either High, Medium-High and Medium importance level overall. To conclude, AEC companies have a high preference on graduates who master digital information and data literacy as well as someone who have high technology adaptability level and willing to learn continuously because both have High importance classification. While graduates who is professional in communication and collaboration in the digital context with critical mindset to solve problems are still important but not as much as the formers because both have Medium-High level of importance.

Table 28
Ranking of Average RII Value of the Competence Area

Competence Area	Average RII	Importance Classification	Rank
Information and Data Literacy	0.815	High	1
Communication and Collaboration	0.769	Medium-High	4
Critical Thinking and Problem Solving	0.780	Medium-High	3
Adaptability and Continuous Learning	0.801	High	2

Due to its Sign. value that is below 0.05, only one of the competency areas from the data collection and analysis shows a significant difference between the three groups which is Critical Thinking and Problem Solving. In contrast with the other competence area that have

no notable difference because of the Sig. values are above 0.05. It illustrates that the three groups are not significantly different from one another in terms of Information and Data Literacy, Communication and Collaboration as well as in the Adaptability and Continuous Learning competence area. This is a result of the shared preferences that AEC companies have for those certain areas.

In addition, for the overall ranking overview using Relative Importance Index (RII) method, Information and data literacy is the most critical digital literacy preferences for AEC graduates. Extracted from the literature review, this competence area helps individuals and organizations to make better informed decisions based on data (Nehme & Crabtree, 2023). It is not surprising for companies to look out for this competence area among AEC graduates because it is particularly relevant in the AEC sector, where data-driven decisions have a big influence on the performance of a project, efficiency, and final outcomes. Information and Data Literacy require graduates to be familiar with a range of data sources such as IoT devices, BIM (Building Information Modeling) systems, and other tools frequently utilized in AEC projects. Graduates are expected to know how to gather accurate data from various sources.

Meanwhile, Adaptability and Continuous Learning is the second most critical digital literacy preferred competence area. The AEC industry adopts new technology fairly slowly in general. Adoption reluctance stems from the fact that technology drives change rather than facilitates it (Davis and Songer, 2002). In accordance with this, AEC firms highly regard graduates who exhibit great adaptability and continuous learning competencies. AEC companies could be looking for Graduates who are willing to explore company's use of technology and next can improve project results and efficiency. Additionally, the AEC sector respects graduates who are dedicated to lifelong learning and who improve their knowledge and abilities to stay up to date with technology developments and be able to seamlessly switch from conventional approaches to digital solutions.

Conclusion

The study analyzed four competence areas and eight essential elements of digital literacy to reveal AEC companies' preferences for graduates' digital literacy. By calculating the Relative Importance Index (RII) for each element, the average RII value for each competence area was obtained. Information and Data Literacy ranked highest with an RII of 0.815, followed by Adaptability and Continuous Learning with 0.801, both classified as highly important. In contrast, Critical Thinking and Problem-Solving ranked third with an RII of 0.780, and Communication and Collaboration ranked fourth with 0.769. Significant differences in preferences were observed for Critical Thinking and Problem-Solving between AEC companies and among construction companies of different grades, as well as for Communication and Collaboration. The study highlights the AEC industry's slower adoption of digital literacy compared to other sectors and aims to inform strategies to improve graduates' digital skills. These findings can help graduates better prepare for the industry and guide employers in developing initiatives to enhance digital literacy.

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