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Technical Notes and Reports

Evaluating Digital-Construction Maturity and Pedagogical Innovation through the QUB–BUE Transnational Education Collaboration

Ahmed O. Daoud[1*], Ahmed G. Mohamed[1], Faris Elghaish[2], Tara Brooks[2]

[1*] The British University in Egypt, Cairo, Egypt
[2] School of Natural and Built Environment, Queen's University Belfast, United Kingdom

Correspondence: ahmed.daoud@bue.edu.eg

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Abstract

This study examines the digital-construction maturity emerging through the QUB–BUE Transnational Education partnership, drawing on empirical evidence from 28 professionals and academics. Quantitative analysis reveals strong pedagogical endorsement for embedding AI (mean = 4.82), Digital Twins (mean = 4.50), and BIM (mean = 4.36) within higher-education curricula to enhance employability and digital competence, reflecting Egypt's growing alignment with global digital-engineering practices. Pedagogical findings confirm a dominant preference for experiential and case-based learning, while sustainability integration demonstrates advanced engagement with OneClick LCA, Power BI, and Python for low-carbon design analytics. Despite this progress, gaps remain in the systematic translation of digital awareness into operational learning workflows and standardised training frameworks. The partnership illustrates how Transnational Education (TNE) can bridge these gaps by embedding shared curricula, joint research, and industry collaboration that strengthen technical capacity and governance. The results position Digital-Construction TNE as an effective model for accelerating digital transformation and sustainable development in Egypt's construction sector.

Keywords: Digital Construction; BIM; AI; Transnational Education; Sustainability.

Highlights

- The QUB–BUE collaboration demonstrates how transnational education can advance sustainable and data-driven construction practice.
- Experiential and hands-on learning approaches are shown to be key drivers of digital competence and graduate employability.
- This study reveals strong adoption of BIM, AI, and Digital Twins, marking major progress in Egypt's digital-construction maturity.

Introduction

Transnational Education (TNE) can be defined as the "mobility of an educational program or higher education institution (HEI)/ provider between countries" (Knight, 2015). Where it works well, academics from two different jurisdictions and cultures share knowledge, compare approaches, and learn from each other. Through TNE, universities can work together to raise their standards and promulgate good practice, helping to project 'soft power' whilst increasing quality of education provision, building capacity and economic resilience (Universities UK, 2023). It has been shown that UK TNE can help increase exchange of culture and knowledge, widening access to higher education and contributing to the UN Sustainable Development Goals (British Council, 2023). Through exploratory projects with international tertiary education providers, UK universities can develop relationships from which research and teaching collaborations can be built.

The British Council's TNE strategy has been developed to help build capacity in tertiary education across the globe and to place the UK at the forefront of TNE partnerships (British Council, 2023). UK TNE is growing rapidly, with a growth of 12.7 percent in 2020 – 21 (British council, 2023); provision amongst Northern Irish providers increased at the fastest of all UK regions between 2021-22 and 2022-23, growing by 21.3% (Universities UK, 2023). Through the 'going global partnerships' programme, the British Council encourages a UK Higher Education Institute (HEI) to work with an international partner to align their goals, understand their respective priorities, and work together to remove barriers to TNE partnerships. The principles behind collaboration include developing a shared vision and mutual respect, co design of projects and curricula and promoting diversity and equality (British Council 2022).

The authors were part of a team undertaking a British Council funded collaboration between Queen's University, Belfast (QUB) and the British University in Egypt (BUE) based in Cairo, which was set up as an initial TNE knowledge exchange project to provide a platform for future collaboration. This paper aims to present findings from a questionnaire undertaken as part of the project.

Literature Review

1.1 Challenges to Successful TNE

In 2022, the British Council found that system level barriers to TNE included a lack of consistent regulatory approach, a lack of guidelines for TNE implementation and a lack of recognition of degree or qualification recognition. Institution level challenges included a lack of experience in setting up TNEs and a lack of resources for the same. Lack of financial resource and low English proficiency were highlighted at student level challenges (British Council, 2022). In Egypt, barriers to TNE include lengthy and complicated process for approval by local authorities and a requirement for UK HEIs to develop a deep understanding of the complexities of the Egyptian higher education sector (British Council, 2022).

1.2 Digital Construction in the UK and Egypt

Construction technology and tools are developing rapidly in the era of Industry 4.0. In the UK, BIM has been mandated for publicly funded projects since 2016, acting as a catalyst for wider uptake of digital construction. In the 2021 NBS BIM Report, only 8% of survey respondents had not started their digital transformation journey, with 46% on the journey and 19% well on the way or having completed the transformation process. By the time of the 2025 report, 72.3% of construction professionals had adopted BIM with an increasing sophistication in its use with widespread cloud computing and exploration of AI adoption (NBS Digital Construction Report 2025). However, digital technology uptake in the UK is highly fragmented. Ibrahim and Aliu (2025) found a lack of workforce skills in digital construction and high implementation costs to be key factors constraining digital construction deployment in the UK; with investment in training and industry wide collaboration as recommendations to increase its use.

Alshafei, et al. (2025) found awareness of advanced digital construction technology in Egypt to be high, with low uptake. They found barriers to advanced technology in Egypt include cost and a shortage of people skilled in their use, suggesting that training would aid implementation. At the same time, there is a widespread appetite for digital construction in Egypt, demonstrated though events like the Egypt Digital Twin event in 2025 and Digital Construction Week Egypt in 2024.

Methodology and Results

The data collection was undertaken by the authors during workshops and presentations at the host university in Egypt. Following a presentation of the digital construction programmes from both partner institutions, a multiple choice anonymous survey was circulated to participants who comprised academic faculty, professionals, digital construction specialists and students. The analysis synthesises both quantitative and qualitative evidence gathered from the twenty-eight participants.

The findings offer an integrated empirical understanding of how stakeholders perceive digital transformation, curriculum alignment, pedagogical reform, and international collaboration in Egypt's construction sector. The responses provide an informed reflection on the readiness of the Egyptian construction ecosystem and the role of the QUB–BUE Transnational Education (TNE) partnership in bridging identified capability gaps.

1.3 Industry Context and Respondent Profile

The respondents represented a diverse mix of academics and industry practitioners from consultancies, contractors, and digital-technology firms. Nearly half of the participants were academics involved in curriculum design or teaching digital construction, while the remainder were professionals from private-sector organisations of various scales. The majority had between five and fifteen years of professional experience, ensuring that opinions were grounded in both pedagogical and practical realities. This balance between academic and industrial perspectives adds analytical robustness to the dataset, as it allows the results to reflect both policy-driven and implementation-level insights.

Table 1 summarises the profile data and shows that representation from both educational institutions and private firms provided a comprehensive perspective on the intersection of learning and industry needs. The combination of experienced practitioners and teaching academics provided nuanced insights into how construction education could evolve to meet market demands.

Table 1: Respondent profile by role, experience, organisation size, and sector representation.

Category	Variable	Frequency (n)	Percentage (%)
Professional Role	Academic (Lecturer/Professor)	14	50.0
	Industry Professional (Engineer/Manager/Consultant)	10	35.7
	Researcher / Student / Other	4	14.3
Years of Professional Experience	Less than 5 years	6	21.4
	5–10 years	7	25.0
	11–15 years	5	17.9
	More than 15 years	10	35.7
Organisation Size	Small / Medium Enterprise	11	39.3
	Large / Multinational	17	60.7
Sector Representation	Academia & Research	13	46.4
	Construction / Contracting	9	32.1
	Consultancy / Design / Technology	6	21.5

1.4 Digital Technologies and Curriculum Relevance

Respondents displayed a high degree of familiarity with digital technologies that underpin modern construction practice. Mean scores ranged from 4.1 to 4.8 on the five-point scale. AI-related items

recorded the highest mean (4.82), followed by Digital Twins (4.50) and BIM (4.36), confirming that these technologies are recognised as key enablers for enhancing digital-construction education and employability. Approximately 86 % of participants rated BIM integration ≥ 4, illustrating strong conceptual alignment with global digital-construction trends. However, the item concerning current graduate skill readiness yielded the lowest mean (3.1), highlighting a persistent gap between technological awareness and applied competence. Figure 1 visualises this divergence between high awareness and moderate perceptions of graduate capability.

Table 2: Awareness and familiarity with core digital-construction technologies.

Question	Mean	Std Dev	%≥4
The integration of Building Information Modelling (BIM) into BUE's sustainability programme would be beneficial	4.36	0.81	85.7
Introducing Artificial Intelligence (AI) and data analytics would improve graduate employability	4.82	0.38	100
Adding Digital Twins technology to the BUE curriculum would significantly enhance learning outcomes	4.5	0.68	89.3
Practical lab sessions with AI and analytics software should become a component of teaching at BUE	4.75	0.57	92.9
Advanced modules in AI-driven project management would enhance the BUE programme	4.7	0.53	92.9
Integrating advanced digital tools would enhance the Sustainability modules at BUE	4.46	0.68	89.3
Including Low-carbon Digital Construction technologies is important to educate future sustainability experts	4.25	0.87	78.6
Hand on training in BIM-specific software (Revit, Navisworks, Synchro, Solibri)	4.54	0.73	85.7
Hands-on AI skills (Python, Azure ML)	4.61	0.77	89.3
Real-time monitoring techniques using digital twins	4.36	0.81	78.6
Ethical use of AI, including privacy and responsibility	4.82	0.47	96.4
Data analytics and cost control with AI	4.67	0.54	92.9
Implementation of Digital Twin with BIM for monitoring, facility management and energy efficiency	4.39	0.82	85.7
Use of Dynamo for automated data management in BIM environments	4.21	1.15	75
Teaching sustainability using practical digital tools improves understanding and application	4.63	0.67	85.7
Advanced digital modules should be introduced into BUE's sustainability curriculum	4.68	0.54	96.4
I would recommend prospective students to enrol in a programme enhanced with AI, BIM, and digital twins	4.64	0.61	92.9

These findings demonstrate that the Egyptian construction community is conceptually aligned with global digital trends. AI and Digital Twin technologies emerged as the most highly rated areas of awareness, while BIM remains recognised as the backbone of information management and a prerequisite for data integration. The emphasis on these domains highlights a growing readiness for curricula that extend beyond traditional modelling toward data-driven and predictive learning frameworks.

Software-specific responses further demonstrate the direction of skill demand. Revit, Navisworks, and Synchro were consistently prioritised (mean ≈ 4.7), confirming that BIM competencies remain foundational. However, emerging analytical tools also ranked highly: Python and Azure ML achieved means above 4.5, while Power BI reached 4.6. These findings signify a paradigm shift from model-based proficiency to data-interpretation capability, reflecting the convergence between design, analytics, and sustainability

Respondents were equally clear about the need to embed such technologies within higher-education programmes. Items related to introducing AI and data analytics to enhance employability, integrating Digital Twins for experiential learning, and embedding BIM into sustainability modules recorded mean scores between 4.5 and 4.8. More than ninety per cent of participants agreed that practical laboratory sessions using analytics software should form a core component of future teaching. However, the

statement concerning whether current graduates possess adequate digital-construction skills produced the lowest mean score (3.1) (check figure1), confirming a significant skills gap between academic instruction and industry expectations. This disparity highlights a maturity paradox: awareness of technology is strong, yet institutional readiness to teach and apply it effectively remains limited. Figure 1 visualises this divergence, where high awareness levels contrast with modest perceptions of graduate capability.

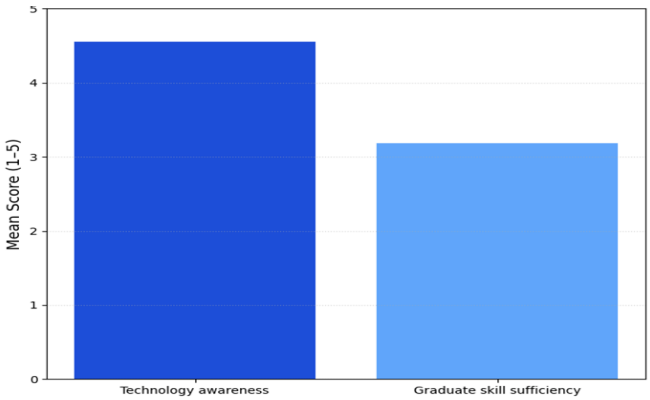

Figure 1: Awareness levels of digital-construction technologies.

1.5 Pedagogical Innovation and Experiential Learning

The results revealed a clear pedagogical consensus favouring experiential, practice-based learning as the most effective pathway for developing digital competence. Statements related to hands-on laboratory work, case-study integration, and technology-driven assignments achieved mean scores between 4.6 and 4.7 (≈ 93 %), as shown in Table III. The highest overall agreement (mean = 4.75; 100 % ≥ 4) was recorded for the statement that universities in Egypt should collaborate more closely with industry in shaping curricula. A similarly high level of support (mean = 4.75; ≈ 93 % ≥ 4) was observed for the inclusion of practical lab sessions with AI and analytics software as a core teaching component.

Table 3: Pedagogical innovation and experiential learning preferences.

Question	Mean	StdDev	%≥4
Universities in Egypt should collaborate more closely with industry in shaping curricula	4.75	0.43	100
Adding Digital Twins technology to the BUE curriculum would significantly enhance learning outcomes	4.5	0.68	89.3
Practical lab sessions with AI and analytics software should become a component of teaching at BUE	4.75	0.57	92.9
Experiential learning and practical labs enhance learning outcomes significantly	4.54	0.75	78.6
Universities in Egypt should adopt more case study-driven project work	4.63	0.67	85.7
Integrating technology-driven assignments improves student engagement	4.63	0.67	85.7
Teaching sustainability using practical digital tools improves understanding and application	4.63	0.67	85.7

Open-ended responses reinforced these quantitative findings. Phrases such as “hands-on training,” “industry engagement,” and “digital transformation in Egypt” occurred frequently, indicating a widespread belief that theoretical teaching alone cannot deliver the required competencies. Several respondents proposed joint dissertation supervision by QUB and BUE academics to connect theoretical instruction with live industrial data. Others advocated embedding industry placements within the academic calendar to allow students to apply digital tools in real projects. Figure 2, which visualises the distribution of pedagogical preferences, clearly demonstrates that experiential and case-based approaches dominate stakeholder expectations.

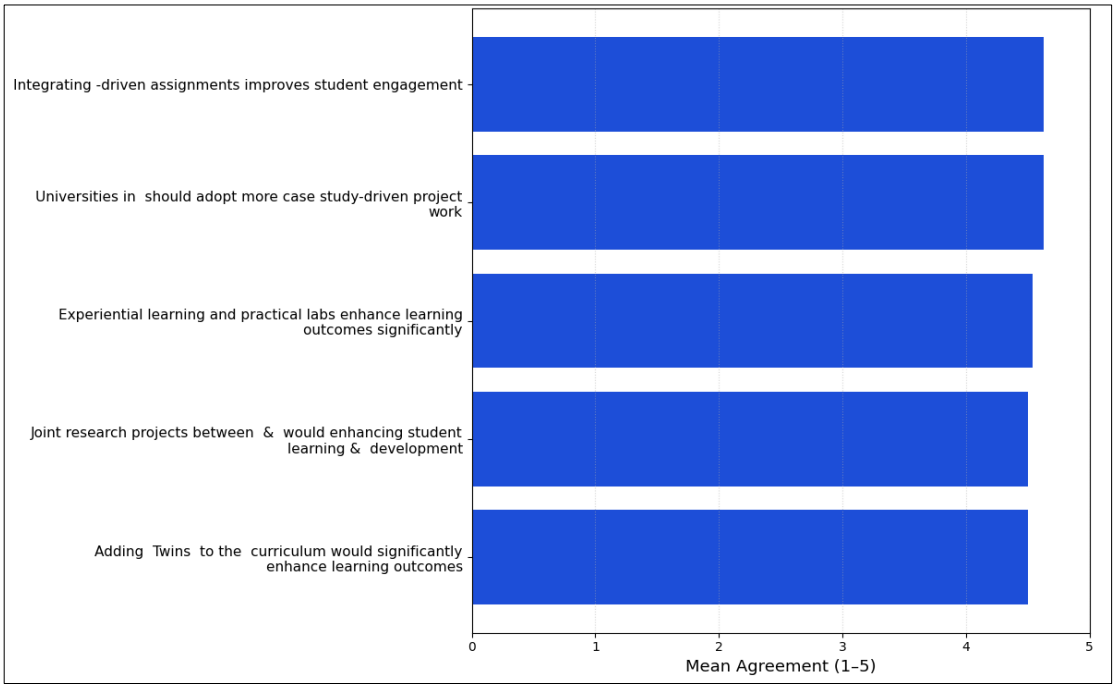

Figure 2: Distribution of pedagogical preferences showing dominance of experiential and case-based learning.

These results confirm that the Egyptian sector is seeking a shift from passive instruction to active learning models similar to those already established at QUB. Modules such as BIM in Practice and Technical BIM Implementation provide relevant templates, integrating Revit, Synchro, and Power BI for simulation and data analytics. Adapting such models to BUE's context would enhance both engagement and employability outcomes.

1.6 Sustainability, Digital Tools and Applied Skills

The integration of sustainability and digital skills emerged as a central theme across responses. Most participants agreed that sustainability education should be technologically driven, with a mean score of 4.25 for the statement that low-carbon digital-construction technologies are essential for developing future sustainability experts. Respondents emphasised a transition from theoretical discussions of environmental responsibility toward quantitative, simulation-based approaches. Table IV summarises these results and shows that tools such as OneClick LCA and Carbon Life Cycle Calculator were highly valued (mean = 4.14), as they enable measurable links between design decisions and carbon outcomes.

Table 4: Integration of sustainability and digital-tool competencies.

Question	Mean	StdDev	%≥4
The integration of Building Information Modelling (BIM) into BUE's sustainability programme would be beneficial	4.36	0.81	85.7
Integrating advanced digital tools would enhance the Sustainability modules at BUE	4.46	0.68	89.3
Including Low-carbon Digital Construction technologies is important to educate future sustainability experts	4.25	0.87	78.6
Using tools such as OneClick LCA and Carbon Life Calculator to calculate whole-life carbon.	4.14	1.09	71.4
Teaching sustainability using practical digital tools improves understanding and application	4.63	0.67	85.7
Advanced digital modules should be introduced into BUE's sustainability curriculum	4.68	0.54	96.4

1.7 Collaboration and Transnational Education Development

Collaboration emerged as the most positively rated domain. Respondents showed strong consensus that structured cooperation between QUB and BUE would strengthen both educational and research

outcomes. Joint research projects achieved a mean = 4.50 (SD = 0.78; 91.7 % ≥ 4), followed closely by a formal student-exchange programme (mean = 4.46; SD = 0.72; 95.8 % ≥ 4) and dual-degree options (mean = 4.54; SD = 0.78; 91.7 % ≥ 4). The industrial-focused dissertation initiative also attracted strong agreement (mean = 4.35; SD = 0.63; 92.3 % ≥ 4). These findings confirm a consistently high level of support across all collaborative dimensions, underscoring the perceived value of joint educational and research engagement between both institutions.

Table 5: Collaboration and transnational-education (TNE) partnership indicators.

Question	Mean	StdDev	%≥4
An industrial focussed 4-month dissertation would enhance the BUE programme	4.35	0.62	92.3
Joint research projects between QUB & BUE would enhancing student learning & programme development	4.5	0.76	91.7
QUB & BUE should develop a formal student exchange programme	4.46	0.71	95.8
The collaboration between QUB & BUE should include dual degree programmes	4.54	0.76	91.7

Participants viewed the TNE partnership not merely as an academic exercise but as a mechanism for systemic reform and knowledge transfer. Several comments emphasised that QUB's expertise in AI-enabled project analytics, predictive maintenance, and digital-twin applications could serve as a model for BUE's curriculum modernisation. Conversely, BUE's strengths in sustainability-oriented teaching were considered valuable contributions to QUB's global pedagogical portfolio. This reciprocity suggests that the collaboration is mutually enriching, enabling both institutions to extend their influence beyond their national boundaries.

Qualitative insights further demonstrated strong interest in developing joint industry-linked research projects that could yield tangible outputs, such as demonstrator models for AI-based construction monitoring or carbon-efficient design. Such initiatives would transform the TNE collaboration into a catalyst for real-world innovation.

Discussion

Across the five integrated domains—industry context, digital technologies, pedagogy, sustainability, and collaboration—the overall pattern reflects high conceptual maturity but moderate operational readiness. The mean values across most categories exceeded 4.5, indicating strong enthusiasm and alignment with international best practice. Only the item measuring perceived graduate skill sufficiency remained moderate at 3.1, confirming that the human-capital gap persists despite strategic awareness. These asymmetries are characteristic of construction sectors in transitional economies. Participants display high aspirational alignment with global trends but encounter limitations in local resources, institutional capacity, and faculty development. The results therefore underscore the importance of aligning curriculum reform with infrastructure and staff training, ensuring that technological ambition is supported by implementation capacity.

From a strategic standpoint, the survey positions the QUB–BUE partnership as an ideal mechanism for overcoming these challenges. The integration of advanced technologies such as AI and Digital Twins within an applied sustainability framework provides a coherent direction for the forthcoming MSc programmes. The combination of high stakeholder endorsement, strong industry demand, and cross-institutional expertise offers a solid foundation for sustained collaboration. The results also reaffirm the centrality of experiential learning in achieving digital competence. By embedding hands-on laboratories, case-study projects, and industrial placements into the curriculum, both institutions can bridge the gap between theory and practice. The emphasis on sustainability demonstrates an understanding of digital construction as a driver of both economic and environmental value.

Taken collectively, the results confirm that Egypt's construction-education ecosystem stands at a pivotal stage in its digital evolution. The sector exhibits high awareness of technologies such as BIM, AI, and Digital Twins, strong consensus on the need for applied and sustainable learning, and remarkable

enthusiasm for international partnership. The only persistent weakness is the skills deficit, which the proposed TNE initiative is well positioned to address.

The convergence of findings across quantitative and qualitative dimensions suggests that the success of this collaboration will depend on a triad of interconnected strategies. First, curriculum modernisation should ensure that digital technologies are embedded not as isolated subjects but as integrative tools across modules. Second, faculty capacity building must accompany curricular reform through targeted training in analytics and programming. Third, collaboration must move from conceptual agreement to structured implementation, including joint research, co-supervision of dissertations, and shared access to digital laboratories. By operationalising these strategies, the QUB–BUE partnership can establish a benchmark for digital-construction education within the Global South.

Conclusions

The results provide an evidence-based foundation for decision-makers in higher education and industry seeking to accelerate Egypt's digital-construction transformation. The study demonstrates that while awareness of BIM, AI, and Digital Twins is high, operational implementation remains inconsistent, signalling the need for policies that prioritise workforce development, infrastructure investment, and curriculum modernisation. For university leaders, the outcomes highlight the strategic value of integrating experiential and data-driven pedagogy into engineering and management programmes. Embedding laboratory simulations, digital-twin applications, and sustainability analytics can directly enhance graduate employability and institutional competitiveness.

For policymakers and professional bodies, the findings outline a clear roadmap for aligning national digital-construction standards with global benchmarks. The QUB–BUE Transnational Education model offers a replicable framework through which knowledge transfer, staff training, and joint research can drive digital-maturity progression across the region. By uniting academic excellence with industry relevance, the partnership demonstrates how international collaboration can translate digital ambition into measurable educational and economic impact. Ultimately, the study positions Digital-Construction TNE as a strategic instrument for shaping evidence-informed decision-making and cultivating a skilled workforce capable of delivering data-driven, low-carbon, and resilient built environments.

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Ethical Approval Declaration
The study was conducted in accordance with established standards for research integrity and ethics.

Data Availability Statement
Data used in this study is not held in a publicly archived dataset due to privacy and ethical restrictions.

Conflicts of Interest
The authors declare no conflict of interest.

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