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Developing construction graduates fit for the 4th industrial revolution through fieldwork application of active learning

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ABSTRACT
The link between active learning and the development of graduate attributes has been cogently advocated in pedagogical research. Despite the extensive adoption of fieldwork in environmental and social sciences, enigmatically, there are no reported applications of fieldwork in construction and related engineering disciplines. This paper employs a case study approach to address this gap and exemplify the application of fieldwork in a postgraduate construction degree programme. It presents a robust design framework for assessed residential fieldwork that aids the scaffolding of a holistic set of graduate attributes. The framework promotes undertaking field-based experiential learning in international destinations in order to support the development of adaptable leadership and graduate future readiness for the fourth industrial revolution. After discussing its theoretical underpinnings, the paper presents the context for the case study, the design framework and stages of the fieldwork and concludes with an evaluation of its implementation, limitations and implications for practice.

Introduction
The Fourth Industrial Revolution (4IR) heralds to transform lives and bring unprecedented changes to the social, political, economic and cultural fabric of society globally (Schwab, 2017). It is characterised by rapid innovations in artificial intelligence, digitalisation, advanced robotics, automation and biotechnology which form the core of Science Technology Engineering and Mathematics (STEM) (Park, 2018).

Not only will the 4IR increase the demand for skills, it will also put further strain on the STEM pipeline by reshaping the labour market. STEM Learning (2018) estimates that 89% of businesses face difficulty recruiting STEM skilled workers and predicts that new roles in STEM will double in the next decade. Governments worldwide face increased calls to drive investment in STEM skills to battle the technological shock waves of the 4IR (World Economic Forum [WEF], 2018).

The National Audit Office [NAO], 2018 accepts that in education, STEM refers to the study of an exclusive subject or combined subjects, whilst in employment it concerns work in a particular industry, including the construction and built environment sector. Construction has great potential to power the 4IR by delivering critical transport infrastructure and smart
buildings (Hawksworth, Berriman, & Goel, 2018; World Economic Forum [WEF], 2016). It is the main premise of this paper that the role of construction in STEM education and employment should not be downplayed.

In higher education, graduate employability is not solely dependent on subject-specific technical knowledge, but a broader set of transferrable soft skills, qualities and behaviours broadly defined as ‘graduate attributes’ (Higher Education Academy [HEA], 2013). Whilst several studies examine pedagogical methods for designing graduate attributes into the curriculum (Kalfa & Takes, 2015; Kember, Hong, Yau, & Ho, 2017; Spencer, Riddle, & Knewstub, 2012), it is recognised that their effective development also requires their scaffolding into co-curricular activities and assessment strategies (Clarke, 2018; Hill, Walkington, & France, 2016; Oliver & Jorre de St Jorre, 2018).

Barrie (2007) correlates the attainment of graduate attributes with student-centred pedagogies which support deeper learning. Marvell, Simm, Schaal, and Harper (2013) reinforce this viewpoint and highlight fieldwork as a powerful form of active learning which provides immersive in-situ experiences. Applications of fieldwork in environmental sciences, bioscience, land surveying, agriculture, sports science, health and archaeology have proliferated recently (El-Mowafy, 2014; France et al., 2016; Mauchline, Peacock, & Park, 2013; Philips & Johns, 2012; Rydant, Shiplee, Smith, & Middlekauff, 2010; Scott et al., 2012; Welsh, Mauchline, Park, Whalley, & France, 2013). Although construction professions are inherently field based, there is a deficiency in reported fieldwork applications in this strand of STEM education in peer reviewed academic journals.

This paper presents a case study of fieldwork in a postgraduate construction degree programme. The remaining sections are organised as follows. Graduate attributes are discussed and attention is drawn to the framework adopted in this paper to map attributes, including adaptability and flexibility into the learning and assessment activities of the fieldwork. The theoretical grounding in active and experiential learning is explored, before positioning the fieldwork within its institutional context and discussing the rationale for selecting international destinations. The design and implementation framework for the fieldwork is presented next and the paper concludes with critical reflection on implementation issues and the implications for practice.

**Graduate Attributes (GA) frameworks**

The development of GA is on the top of the student employability agenda. The Quality Assurance Agency (QAA) Scotland and Higher Education Academy (HEA) agree that GA have profound effect on the students’ transition through education, career and life (Gunn, Bell, & Kafmann, 2010; Higher Education Academy [HEA], 2016). The Teaching Excellence Framework (TEF) introduced by the UK government, reinforced their importance. The acquisition of GA is the key determinant of student outcomes and learning gain, one of the three aspects of the student experience used in the TEF to measure excellence (Department for Education [DfE], 2017).

Early conceptions of GA had no epistemic foundation but were based on their perceived importance or popularity (Barrie, 2004). Donlevy (2012) proclaims their alignment with institutional values and employer requirements and reports disparities in those espoused by universities. GA frameworks have been the focus of pedagogical research and whilst some are generic (Bridgstock, 2009; Dacre Pool & Sewell, 2007), discipline-specific models are also reported (Coetzee, 2012; Mager & Spronken-Smith, 2014). Given their role in supplying skills to businesses, GA have also been considered in commercial research. A framework aligning 4IR skills to workforce readiness, soft skills, technical skills, entrepreneurship is proposed by Deloitte (2018).
The case for adaptability and flexibility

The UK government’s *Industrial Strategy* calls for investment on leadership development to boost the productivity of 5.7 million businesses (Business, Energy, Industrial Strategy [BEIS], 2018a). The Open University (2018) reveals that across sectors, 47% of businesses lack the adaptable and flexible leadership skills that can help them cope with rapid political, economic and technological change. Building leadership into the workforce is one of the targets of the *Construction Sector Deal* (Business, Energy, Industrial Strategy [BEIS], 2018b).

In the field of engineering, which is seen as related to construction, competency frameworks are driven by the Engineering Council UK, Royal Academy of Engineering (RAEng) and International Engineering Alliance. The development of the Engineering Habits of Mind (EHoM) (Royal Academy of Engineering [RAEng], 2014) is an expression of such an allied model and includes adaptability in its six attributes. Higher education courses in the construction segment of STEM considered in this paper, are accredited by professional bodies focusing on the built environment, rather than Professional Engineering Institutions (PEI) licensed by the Engineering Council UK. In contrast, their competency frameworks tend to be less unified.

Flexibility and adaptability are highly ranked in the GA literature (Osmani et al., 2015). Tomlinson (2017) presents adaptability as a component of the psychological capital that helps graduates navigate through career challenges. Student leadership development is advocated by Skalicky et al. (2018) as a strategic priority for higher education. This view is shared by Penprase (2018) who emphasises that to be fit for the 4IR, STEM curricula should equip graduates with leadership capability to oversee the ethical application of science and technology.

Independent sources of evidence converge on acclaining leadership as the golden thread that runs through graduate preparedness for the 4IR. Adaptability and flexibility are key attributes of situational leadership (Chapman, 2018; Northouse, 2009). This was introduced in the seminal work of Hersey (1984) and advanced by Hersey and Blanchard (1988). It is founded on the premise that there is no one-size-fits-all leadership, rather its effectiveness stems from the leader’s ability to diagnose situations and adapt to them.

Adaptability and flexibility are included in the 6-cluster GA model developed in research commissioned by Advance HE (Coonan & Pratt-Adams, 2018). Although leadership is not explicitly included in Figure 1, the model recognises that team working describes the ability to fluidly perform leader and member roles. The close connection of these 6 clusters to the imperatives of the *Industrial Strategy* and positioning in the context of the 4IR, formulated the rationale for adopting it to map GA into the fieldwork design and implementation framework presented in the respective section below.

Constructing knowledge through active learning and fieldwork

The increasing emphasis on measuring pedagogical efficacy provided a springboard for the evolution of learning theories (Pritchard, 2013). Merriam and Bierema (2014) classify constructivism among the most dominant orientations underpinning learning. In constructivism, the learner actively engages with experience to construct knowledge through exploration and reflection (Dawson, 2010).

Among the strongest expressions of constructivism are active learning (Bonwell & Eison, 1991) and the Experiential Learning Theory (ELT) introduced by Kolb, which regards learning as ‘the process whereby knowledge is created through the transformation of experience’ (1984, p. 41). The ELT as schematically depicted in Figure 2, comprises an axis with Concrete Experience (CE) and
Abstract Conceptualisation (AC) as the two dialectical modes of the ‘grasping experience’ continuum. An intersecting axis represents the ‘transforming experience’ continuum and related modes of Reflective Observation (RO) and Active Experimentation (AE).

In the ELT, learners can start the process from any stage (mode), but need to follow the remaining stages sequentially. The four quadrants of the model are associated with the diverging, assimilating, converging and accommodating learning styles. Learners with preference to any of these, have the dialectic modes of the respective quadrant(s) as dominant learning abilities (Kolb & Kolb, 2005, 2009).

Andres (2019) promotes active/experiential learning as a major paradigm shift from instructional and passive learning models. Experiential learning and ‘learning by doing’ are used interchangeably by Shephard (2008). The prominence of experiential learning has grown, owing to its alignment and association with other constructivist models including problem-based learning (Michel, Cater, & Varela, 2009), Gibbs’ work-based learning and Revan’s action learning (MacVaugh & Norton, 2012).

In the engineering strand of STEM, active learning through fieldwork features in reports commissioned by national engineering academies (RAEng, 2014), projects delivered by not-for-
profit organisations e.g. the Useful Simple Trust (https://www.usefulsimple.co.uk/) and articles by PEI, such as the Institution of Civil Engineers (ICE) (Bell, 2018). Whilst these and similar publications highlight the role of fieldwork in providing industry-focused education and creating employment-ready graduates, their emphasis is hardly on the matter of fieldwork design examined in this paper. Aspects of engineering fieldwork including for instance, safety (Liu & Gambatese, 2018) and community service-learning (Birzer & Hamilton, 2019) are examined in peer-reviewed academic journals, nonetheless again, fieldwork design aligned to experiential learning theories is scarcely the focus.

A commonly adopted form of fieldwork bridging construction and engineering skills is Constructionarium (https://www.constructionarium.co.uk/), an initiative aimed at providing students in built environment higher education courses with hands-on learning. In Constructionarium, students engage in the construction of scaled-down replicas of built structures, supported by academics and industrial partners. The fieldwork takes place in a controlled environment designed to safely emulate real-life projects. The fundamental difference with the fieldwork presented in this paper is that it stretches the students’ adaptability and resilience by facilitating fieldwork in unfamiliar international construction settings in the real world.

**Applications of experiential learning in fieldwork**

The Universities Safety and Health Association (Universities Safety and Health Association [UHSA], 2018, p. 8) defines fieldwork as ‘any work carried out by staff or students for the purposes of teaching, research or other activities while representing the institution off-site’. International fieldwork promoted in the context of this paper is endorsed for enabling
students to own their learning whilst analysing contextual differences and adapting their knowledge to unfamiliar settings (Glass, 2014; Marvell et al., 2013).

Munge, Thomas, and Heck (2018) stress that the future of biology, archaeology, environmental sciences and geosciences depends on fieldwork with foundation in experiential learning. The role of early residential fieldwork in promoting student engagement in geography, biology, tourism and sports science is evaluated by Walsh, Larsen, and Parry (2014). Tonts (2011) incorporates problem-based learning in geography fieldwork and asserts that its core elements e.g. observation and reflection are closely aligned with Kolb’s experiential learning. A model integrating affective, experiential and critical learning constructs with human geography fieldwork is presented by Golubchikov (2015).

Three types of geography fieldwork are designed by Krakowka (2012) utilising Kolb’s ELT. Dunphy and Spellman (2009) investigate the effect of Kolb’s learning styles on the value of geography fieldwork. Kolb’s theory is also considered by Lamm et al. (2011) who analyse the fieldwork journals of agricultural students in order to examine emerging reflection patterns and their link to learning styles.

Dummer, Cook, Parker, Barrett, and Hull (2008) underline the prevalence of Kolb’s experiential learning by suggesting that it is implicitly present in fieldwork, even when it is not explicitly included in its design. Another key finding presented by Cassady, Kozlowski, and Kommann (2008) is that, integrating classroom activities to prepare students for fieldwork, optimises the learning that emerges from it. The design of the international construction fieldwork presented in the following sections reflects these two viewpoints.

**Organisational and historical context for the case study**

The case study relates to fieldwork undertaken by postgraduate construction students in the Faculty of Science, Engineering and Computing (SEC) at Kingston University London. The University is at the forefront of widening participation and inclusive curriculum delivery. Active learning is a central tenet of the University’s strategy for enriching the student experience and enhancing employability outcomes. In the last two years, SEC performed an overhaul of its course portfolio by integrating novel pedagogies marked by flipped classroom and problem-based learning with learner-centred assessments.

The course resides in the school responsible for engineering, construction and environmental sciences. Residential fieldwork to long-haul international destinations is solely offered in the construction and environmental sciences programmes. The design of fieldwork tends to be ad-hoc; its theoretical foundations and design principles differ across courses.

The fieldwork considered in this case study is embedded in the MSc Quantity Surveying (QS). It is integral to its design, with the programme specification stating that ‘the use of residential fieldwork in a major international city reinforces the students’ understanding of international practice and supports the ambition of the programme to produce rounded graduates who have a strong theoretical and technical base and can apply this to real life situations … Furthermore, the aim is to provide a vehicle for the development and application of interpersonal skills and enable students to take a pro-active, self-critical and reflective approach in their subsequent careers’.

The course complies with the Subject Benchmark Statement: Land, Construction, Real Estate and Surveying (Quality Assurance Agency [QAA], 2016) and is accredited by the Royal Institution of Chartered Surveyors (RICS) and Chartered Institute of Building (CIOB). Their accreditation frameworks require programmes to incorporate learning outcomes which promote
an understanding of construction management within the global context and furthermore field activities that support the students’ transition from education to professional practice (Chartered Institute of Building [CIOB], 2010; Royal Institution of Chartered Surveyors [RICS], 2019).

A distinctive feature of the programme is that it is a conversion Masters, aimed at non-cognate graduates. The demographic makeup of the student body is diverse with a good proportion of female students historically. The QS profession has its origins in the UK, where it is mainly recognised. For this reason, the majority of students have home fee status. There is invariably a fair balance between full/part-time students, with most part-time students working in construction in the UK.

The case study considers fieldwork in Dubai, UAE. Other locations in Europe were used in previous years. Dubai was selected for its unparalleled scale and speed of construction, which raise the bar for what the students are expected to achieve during the fieldwork and provide them with a unique learning experience.

Fieldwork design and implementation framework

Students undertake the fieldwork in the last stage of the programme in the context of CE7404 Management Consultancy. This module comprises two courseworks. The first is individual coursework weighted at 40% and designed to test project management knowledge and skills reflected in two of the module’s Learning Outcomes (LO). The second coursework centres on the fieldwork and involves a group capstone project accounting for 60% of the module mark. This tests the following:

- **LO1.** Develop and implement a client consultancy strategy and innovate as part of the client’s business development.
- **LO2.** Develop original and authoritative work through the medium of a group project, be able to progress into a practice environment and act as an effective team member in complex project situations.
- **LO3.** Analyse academic and professional issues relating to the commercial QS practice in the international context.
- **LO4.** Develop technical and interpersonal skills to respond to and embrace new trends in professional practice and technology.

The capstone project enables students to pull together knowledge and skills from across the programme and apply these during fieldwork. Students take the role of consultants commissioned by a client (an actual developer) to produce a business case for the appraisal of investment options. In this multifaceted project, students perform economic and market analysis, sector benchmarking, cost planning and residual valuation calculations and combine these with procurement, contract and programming advice to provide an added value service to their client.

In recent years, the consultancy project and fieldwork centred on the hospitality sector of Dubai (Figure 3 presents selected fieldwork photographs). The client is a hotel chain developer, owner and operator. The coursework brief outlines the client’s profile, vision, corporate values and goals which include their expansion in the UK and Middle East.
Project and fieldwork stages

The project evolves in phases which mirror Kolb’s experiential learning stages. The illustration in Table 1 associates the stages with learning and assessment activities categorised as classroom/field-based and also maps the development of graduate attributes (GA) from the model in Figure 1. From these, the only GA not mapped are working remotely from a team and developing optimised emotional intelligence. However, it can be argued that there is subtle difference between working independently and remotely from a team. Furthermore, emotional intelligence is developed through other mapped attributes e.g. self-awareness and reflection.

The project has two major outputs. The first concerns the development of new brand prototypes to facilitate the client’s expansion strategy. The prototypes are developed initially for the client’s portfolio in London. The learning outcomes tested are LO1, LO2 and LO4. This output is presented in written reports by the groups. Students are then expected to produce modified prototypes with adaptations for hotels in Dubai. These constitute the second output delivered orally via group presentations. The assessed learning outcomes are LO3 and LO4.

The prototypes combine the interior and exterior concept design and cost model for new hotels with different star ratings. The brief stresses the expectation for prototypes to outline enterprising solutions that increase the lettable space and thus revenue from rooms and other hotel functions, optimise operational efficiencies and drive sustainable performance in line with the client’s strategic objectives.

Concrete Experience (CE) stage

The project is initiated by releasing the coursework and briefing the students about the fieldwork stages and outputs. This stage takes place in London and culminates in the production of the new prototypes. Students are exposed to an intricate scenario and this concrete experience starts the learning-by-doing process. There are no taught sessions, as the project builds on knowledge developed in other parts of the programme.

A series of scheduled tutorials facilitate this stage. These simulate team meetings providing students (working as consultants) with the context to analyse the requirements of the brief, develop a problem statement and debate solutions from different viewpoints. In simulated client meetings supervised by the course team, students are able to ask penetrating questions about the client’s requirements and adapt their proposals accordingly.

The client’s sector is unfamiliar territory, explored by collecting data and interpreting market trends and performance indicators. The design and cost constituent parts of the prototypes require the manipulation of space planning and cost data but also the justification of assumptions where datasets are incomplete. Students demonstrate entrepreneurial thinking by incorporating technological innovations in the design to streamline the hotel’s operations and enhance the travellers’ experience, in turn strengthening brand identity and market positioning.

Students work in teams and independently to develop their proposals. They negotiate their team roles and responsibilities, set-up communication protocols and take responsibility for facilitating group meetings. Their professional communication skills are demonstrated in the simulated client meetings and written reports presenting the prototypes.
Reflective Observation (RO) stage
In RO students receive feedback on their prototypes and take time out from doing to reflect on their experience. They engage in self-evaluation which enhances their self-awareness and critically appraise their individual and collective performance in group discussions (project review meetings). In these, students practice their communication skills by verbalising their experiences, asking questions and actively listening to peers. The feedback helps students build their resilience by celebrating success and setting goals for the next key stage.

Abstract Conceptualisation (AC) stage
AC and the remainder of the project encompass the fieldwork. Acting as consultants, students fly to Dubai for a week in order to adapt their prototypes. Their mission is largely fact-finding and whist in Dubai, students attend professional meetings with central and local government
Table 1. Project stages including fieldwork and mapping of graduate attributes.

| Kolb’s experiential learning stage | Project activities (classroom or field based) | Mapped graduate attributes from Figure 1 (those not mapped shown in grey) |
|-----------------------------------|-----------------------------------------------|-----------------------------------------------------------------------|
| Location: Concrete Experience (CE) | • working on prototype development independently and as part of a team  
• simulated team meetings (students as consultants)  
• simulated client meetings (students with course team)  
◆ assessed group report presenting prototypes | Problem formulation; problem solving; arguing from different viewpoints; asking the right questions; systemic understanding (Cluster 1). Using data creatively; dealing with incomplete datasets; working with rich data (Cluster 2). Acting as facilitator; managing diverse stakeholders; communicating well and confidently; effective listening; being able to work in teams; optimising emotional intelligence; understanding oneself in relation to others and to work (Cluster 3). Being able to work both in a team and remotely; being able to work both in a team and independently; developing and responding to change; being flexible and adaptable; adapting to new environments; demonstrating good learning and research skills (Cluster 4). Understanding the big picture; seeing the big picture but also dealing with detail; being entrepreneurial and enterprising (Cluster 5). Being creative; being professional; being resilient in many forms; demonstrating capability to reflect; taking responsibility for decisions; feeling comfortable with dealing with complexity; considering learning as a lifelong journey; being self-aware (Cluster 6). |
| Reflective Observation (RO) | • self-evaluation and reflection  
• team meetings (students as consultants) simulating project review and lessons learned analysis | Problem formulation; problem solving; arguing from different viewpoints; asking the right questions; systemic understanding (Cluster 1). Using data creatively; dealing with incomplete datasets; working with rich data (Cluster 2). Acting as facilitator; managing diverse stakeholders; communicating well and confidently; effective listening; being able to work in teams; optimising emotional intelligence; understanding oneself in relation to others and to work (Cluster 3). Being able to work both in a team and remotely; being able to work both in a team and independently; developing and responding to change; being flexible and adaptable; adapting to new environments; demonstrating good learning and research skills (Cluster 4). Understanding the big picture; seeing the big picture but also dealing with detail; being entrepreneurial and enterprising (Cluster 5). Being creative; being professional; being resilient in many forms; demonstrating capability to reflect; taking responsibility for decisions; feeling comfortable with dealing with complexity; considering learning as a lifelong journey; being self-aware (Cluster 6). |

(Continued)
### Table 1. (Continued).

| Kolb’s experiential learning stage | Project activities (classroom or field based) | Mapped graduate attributes from Figure 1 (those not mapped shown in grey) |
|-----------------------------------|-----------------------------------------------|-------------------------------------------------------------------------|
| **Location:** Dubai Abstract Conceptualisation (AC) | • working on prototype adaptations independently and as part of a team  
• simulated meetings with project stakeholders (students with government and industry officials)  
• visits to construction sites and appraisal | Problem formulation; problem solving; arguing from different viewpoints; asking the right questions; systemic understanding (Cluster 1). Using data creatively; dealing with incomplete datasets; working with rich data (Cluster 2). Acting as facilitator; managing diverse stakeholders; communicating well and confidently; effective listening; being able to work in teams; optimising emotional intelligence; understanding oneself in relation to others and to work (Cluster 3). Being able to work both in a team and remotely; being able to work both in a team and independently; developing and responding to change; being flexible and adaptable; adapting to new environments; demonstrating good learning and research skills (Cluster 4). Understanding the big picture; seeing the big picture but also dealing with detail; being entrepreneurial and enterprising (Cluster 5). Being creative; being professional; being resilient in many forms; demonstrating capability to reflect; taking responsibility for decisions; feeling comfortable with dealing with complexity; considering learning as a lifelong journey; being self-aware (Cluster 6). |
| **Active Experimentation (AE)** | • working on oral presentation independently and as part of the team  
• simulated oral presentations to client board (course team and industry officials)  
• simulated project debriefing meetings (students and course team) | Problem formulation; problem solving; arguing from different viewpoints; asking the right questions; systemic understanding (Cluster 1). Using data creatively; dealing with incomplete datasets; working with rich data (Cluster 2). Acting as facilitator; managing diverse stakeholders; communicating well and confidently; effective listening; being able to work in teams; optimising emotional intelligence; understanding oneself in relation to others and to work (Cluster 3). Being able to work both in a team and remotely; being able to work both in a team and independently; developing and responding to change; being flexible and adaptable; adapting to new environments; demonstrating good learning and research skills (Cluster 4). Understanding the big picture; seeing the big picture but also dealing with detail; being entrepreneurial and enterprising (Cluster 5). Being creative; being professional; being resilient in many forms; demonstrating capability to reflect; taking responsibility for decisions; feeling comfortable with dealing with complexity; considering learning as a lifelong journey; being self-aware (Cluster 6). |
officials as well as the client (the developer) and other stakeholders (architects, cost managers, project managers).

These meetings aim to enable students to analyse economic, technological, legislative, environmental, cultural etc. issues pertaining to Dubai and use these to inform adaptations to their prototypes. For instance, students appreciate that typical ground conditions in Dubai (related to the type of soil and water table), increase the cost and lead time of substructure works. This finding necessitates the replacement of basement car parks in their original proposals, with raised podium car parks in the bespoke prototypes for Dubai.

Abstract conceptualisation draws upon the experiences and reflections from preceding stages to interpret new stimuli, perform comparisons and conceptualise new models applicable to a new environment. The students work individually and in groups to modify their prototypes for specific development sites in Dubai. Site appraisal is facilitated by planned visits to a selection of live construction sites, occupied sites marked for redevelopment and vacant land.

**Active Experimentation (AE) stage**

The complexity, speed and intensity of fieldwork in this new environment put the students’ flexibility, adaptability, resilience and leadership to the ultimate test. The demonstration of these skills starts from the AC stage but reaches a climax in this final stage. Students experiment with various solutions to optimise their prototypes and present them orally to the client’s board.

The board comprises the course team and client’s representatives. Defending their proposals to industry experts from Dubai, enables students to take responsibility for their decisions and demonstrate professional and competent communication. Debriefing meetings with the course team, provide the opportunity for reflection in the context of the students’ continuing professional development.

**Practical dimensions of fieldwork**

Organising international residential fieldwork is a major undertaking involving months of coordination. For this to be a truly rewarding experience for students, the course team needs to work passionately to produce a rich itinerary and forge relationships with international industry networks, which provide access to live construction sites as well as their design and construction teams who offer collaborative insight to the students’ project.

The transient nature of construction means that visits to live construction sites that took place in one year may not be possible next year. Consequently, planning for the fieldwork tends to start from a blank canvas every academic year and require a robust risk assessment, which focuses on hazards and control measures for the specific activities planned each year.

The fieldwork logistics and travel requirements need to be explained to the students early in the course and reinforced in subsequent briefings. There may be a small percentage of students not able to partake in international fieldwork due to extenuating circumstances. An alternative UK-based project built around the same principle of undertaking fieldwork linked to actual construction projects in the real world is available to offer them a comparable learning experience.

The course team should take concrete steps to ensure students are familiar with local customs, traditions and laws in the hosting country. This is key for their safety
and welfare and importantly professional conduct throughout the fieldwork. Students should be encouraged to act as ambassadors for their university. Not only does this serve well the employability aim of the fieldwork, it also cultivates sectorial relationships ensuring fieldwork can be sustained to enrich the learning of future students.

**valuation, implications for practice and limitations**

Despite the large number of studies considering fieldwork design and graduate attributes development frameworks in various disciplines, particularly in the environmental sciences, the examination of these key matters in other field-based STEM professions, including construction that this paper has concentrated on, remains unexplored. A case study approach has been adopted to address this gap. The main contribution of the paper is that it proposes a coherent framework to aid higher education institutions design and implement construction fieldwork which has strong theoretical underpinnings and supports the development of a comprehensive set of graduate attributes.

The paper argues that to cope with rapid change brought by the Fourth Industrial Revolution (4IR), STEM graduates need to be equipped with adaptable and flexible leadership skills. Two design pillars of the proposed framework, which enable students to develop these attributes are the utilisation of real-world, as opposed to, simulated safe settings and its international dimension. These design principles can be adopted in fieldwork applications across STEM to support transformational learning.

The fieldwork design was found to enhance student learning as evidenced by consistently strong performance in this assessment element (mark average in the upper quartile, low standard deviation and almost 100% pass rate at first attempt) and has contributed to employment levels for the respective course that consistently exceeded the sector benchmark.

In addition to outstanding feedback recorded in module evaluation reviews and all forms of regulated student feedback, the fieldwork is continuously praised by the external examiners and accrediting professional bodies. Its pedagogic impact was showcased along with other teaching and learning innovation projects in the University’s civic reception of parliamentarians and the local community in June 2018, by presenting videos from the fieldwork, exemplars from the students’ work and testimonials.

Although the framework had several refinements over the years, it is not without limitations. The fieldwork is grounded on Kolb’s experiential learning theory and relies heavily on learners taking responsibility for self-directed, collaborative and reflective learning. The framework has been applied to a postgraduate degree programme, so testing in undergraduate courses can shed light on its effectiveness for students who are developing their autonomy. Further research can evaluate the integration of fieldwork with other active learning models and graduate attributes sets. Finally, extending the framework to multidisciplinary fieldwork can foster a collaborative mindset critical for STEM in the 4IR.
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