INTRODUCTION

This literature review is part of a wider study funded by the QAA Collaborative Enhancement Fund with the research question: How can higher education qualifications in STEM better integrate experiential learning to improve student experience and attainment? The study focuses on current experience of implementing experiential learning in STEM higher education, aiming to address a perceived gap in guidance and practice. The project has four key elements:

1. ***Literature Review:*** Establishing the current published experience and theory on Experiential Learning to inform later primary research.
2. ***Questionnaire:*** Establishing general use patterns and key experiences across a wide range of institutions.
3. ***Focus Groups and Interviews:*** Adding detail and depth of insight to the initial survey to develop a more rounded view of the issues.
4. ***Playbook and Vignette Development:*** Bringing together the previous 3 stages to develop guidance as to how institutions can integrate Experiential Learning into STEM education and to showcase specific examples of interesting practice related to the playbook.

BACKGROUND

Experiential Learning is certainly 'having a moment' (Peace 2023a); it seems to appear in most prospectuses and student experience strategies as well as being prominent in the educational discourse, particularly in STEM subjects. A subset of Active Learning (any instructional method that engages students beyond passive listening and note taking – Berkeley Center for Teaching and Learning (2024), Experiential Learning is rooted in constructivist learning theory which suggests humans learn by constructing knowledge through connecting new experiences and information to their existing understanding (Pellegrino, Bransford, and Donovan 1999). Experiential Learning has been a recognised part of engineering education since at least the mid 1950's (Evans 1990), and the 1975 World Congress on Educating Engineers for World Development emphasised the importance of experiential learning both within the United States and in the wider world. Higher Educational Institutions (HEIs) are still investing heavily in educational approaches which have a strong foundation in experiential learning (Tembrevilla, Phillion, and Zeadin 2024). However, the lack of consistency of implementation makes it difficult to effectively evaluate its impact (Jamison et al. 2022).

Additionally, there has long been a debate over the impact of experiential learning, and some argument as to whether the development of workplace skills is more effectively conducted purely in the workplace rather than as part of a higher education offering (Cranmer 2006).

The impact of experiential learning has principally been evaluated within the context of a single course and the learning outcomes for the intervention (Jamison et al. 2022) and this may have led to a less than complete integration of the concept into STEM Provision. Even while the current leader institutions are often engaging with Experiential Learning, they are often 'bolt-on activities' and are isolated within the curriculum (Graham 2018). Currently, there is a lack of contemporary sector-wide best practice information about how STEM disciplines can best embrace experiential learning; (Smith and Knapp 2011) suggest that the area is ‘experience-rich and theory-poor’. Furthermore, Jamison et al (2022), conducted a systematic review on Experiential Learning implementation in undergraduate engineering education and concluded that:

> *More research is needed to understand how Experiential Learning models can be used, and…*
>
> *Improving access to resources for faculty wishing to research the area may be necessary.*
>
> *Jamison et al (2022)*

This literature review will investigate the rationale for experiential learning, the forms it takes, potential benefits and how to integrate experiential learning into the curriculum with a view to building resources which might support effective practice in the area.

DEFINITION OF EXPERIENTIAL LEARNING AND EXPERIENTIAL EDUCATION

Experiential learning in the Higher Education sphere is a broad concept which encompasses two distinct ideas: Experiential Learning and Experiential Education. The terms are often used synonymously but there is a useful distinction to be made.

Many vague definitions of the two concepts exist, and often overlap (Itin 1999), but Experiential Learning might best be described as a high-level concept of ‘learning by doing’ (Jamison et al. 2022). This is an inclusive definition covering a wide range of pedagogies and activities, which is a strength in not being overly prescriptive, but provides little in the way of guidance for educational practitioners. Experiential Education can usefully be thought of as the formal structures and pedagogies which support and guide a student through an Experiential Learning process, and as such can provide a clearer way for scholars and practitioners to frame their choices and actions in the area. A good starting point in terms of a definition of Experiential Education can be found in Smith and Knapp (2011):

> *A philosophy and methodology in which educators purposely engage learners in direct experience and focused reflection in order to increase knowledge, develop skills and clarify values.*
>
> *Smith and Knapp (2011)*

Arguably there are a number of pedagogies and methodologies which might sit under the philosophy (AEE 2021) rather than a single approach. This is exemplified by the wide range of activities which fall under the broad definition of ‘Experiential Education’ as we will discuss later in this review.

The idea that Experiential Learning (as distinct from Experiential Education) is students ‘learning by contagion’ is critiqued by Peace (2023b) as he points out that:

> *Without an articulation of how transformation happens, we can neither assure that students have the tools to make the most of opportunities, nor be confident that benefits are experienced equally.*
>
> *Peace (2023b)*

Similarly, Tembrevilla, Phillion, and Zeadin (2024) suggest that Experiential Education and Experiential Learning share a methodology of ‘learning by doing’ but that the former encompasses a more holistic philosophy and scholarship.

In moving forward, we shall be considering the more intentional and pedagogically rigorous definition of Experiential Learning offered by notions of Experiential Education.

MODES OF EXPERIENTIAL LEARNING

As noted in the previous section, Experiential Learning in Higher Education could be said to include a wide range of approaches, or modes, such as project-based learning, challenge-based learning, service learning, work-based learning, internships, sandwich degrees, and Degree Apprenticeships.

Harrisberger, Heydinger, and Talburtt (1976) suggest that Experiential Learning is enacted in two ways:

- ***Authentic:*** Immersion of students in real situations with outcomes which are indeterminate at the time of exposure.
- ***Simulated:*** Designed, controlled and guided activities which mimic real situations but have known, or at least bounded, outcomes.

Both have their place in the educational armoury in STEM subjects, and both can be transformative for students, but they require different academic scaffolding, and make different demands of both staff and students. Arguably there is more of a continuum of authenticity rather than a toggling between two modes.

There are a number of activities which can be described as ‘context dependent’; whether they are ‘authentic’ or ‘simulated’ depends upon the details of how they are implemented. For example, Project Based Learning (PBL) can be conducted on industry derived projects with immersion in the industry context (authentic) or entirely within the University setting, although derived from real life issues and practices (simulated).

A list of potential Experiential Learning activities which is not necessarily exhaustive but covers many of the settings in which it is designed into the curriculum is given below in table 1.

Table 1. Settings for experiential learning (developed from Jamison et al. 2022; Tembrevilla, Phillion, and Zeadin 2024)

Authentic	***Simulated***	***Context Dependent***
Study abroad	Laboratory	Project Based Learning
In-company project	Simulation	Challenge Based Learning
Service Learning	Case study	Multi-disciplinary collaboration
Placements	Virtual and Augmented Reality	Design project
Internships	Visiting lecturers	Group projects
Site visits	Flipped classroom	Inquiry-based Learning
Field work	Self-directed learning	
	Games	

DRIVERS FOR EXPERIENTIAL LEARNING

As we can see, Experiential Learning has a long history, and is well embedded within the HEI community. It is worth examining why this is the case by looking at the key drivers of its adoption.

Employability and Industry Readiness

There is a long history of employers criticising the shortcomings of graduate engineers and, by implication, the academic system which produces them (e.g., Grinter 1955; Leonardi, Jackson, and Diwan 2009). An Institute for Engineering and Technology study (2017) found that 'more than half of employers surveyed say that recruits don't reach the expected standard and nearly two-thirds think skills gaps are a threat to their business' (Universities UK 2017) and the IET skills survey found that 41% of employers surveyed reported gaps in skills at a professional level, and 27% suggested that the most significant skills gap is in highly skilled roles – degree level or higher (IET 2021). Some Specific issues also came out which are pertinent to the expected benefits of experiential learning.

> *33% say that complex problem-solving skills specific to situations are a concern.*
>
> *49% of respondents who felt there was a 'soft' skills gap cited Team-working as an issue.*
>
> *52% said new entrants lack project management skills, and 50% that they lack business knowledge.*
>
> *IET (2021)*

The call from industry and government then, is for STEM graduates who are equipped with appropriate skills and can contribute to their employer immediately upon employment (Leonardi, Jackson, and Diwan 2009; Duffy and Bowe 2010).

This issue of workplace readiness is not confined to the employer perspective; a number of studies indicate that newly qualified graduates often feel 'incompetent' (e.g., Trevelyan 2019), and many researchers have identified the difficulty in transition into the workplace for graduate engineers (e.g., Anderson et al. 2010; Andrews, Clark, and Knowles 2019). This is unsurprising, given that some studies also indicate that there is little, if any, correlation between academic performance and success in the workplace (Gibbs and Simpson 2005). The authenticity of Experiential Learning offers the potential to bridge the learning and practice gap to deliver graduates which are 'oven ready'. A study by Perrenet, Bouhuijs, and Smits (2000), found that the particular characteristics of the subject that made Experiential Learning approaches easier to incorporate in the field of engineering education.

The idea of developing a professional identity is another crucial aspect in understanding the drive for Experiential Learning. Figure 1 shows the concept of Engineering Habits of Mind (Lucas and Hanson 2016) which builds upon Shulman's broader seminal work on 'Signature Pedagogies' (e.g., Shulman 2005) which seeks to understand the linkage between identity development and the way fledgling professionals are taught about how to 'think, perform and act with integrity'.

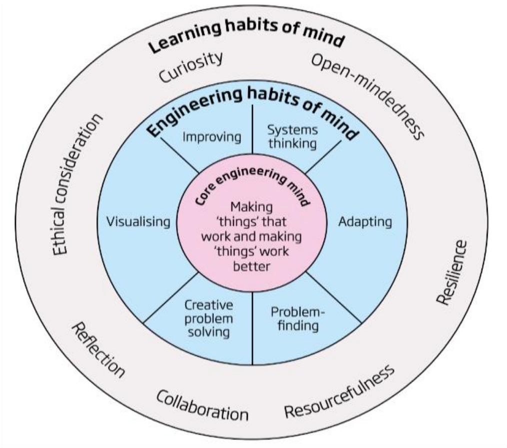

Figure 1. Engineering Habits of Mind: Lucas and Hanson (2016)

It is argued that part of the purpose of the HEI is to facilitate the development of a professional identity, which requires the contextualisation provided by Experiential Learning in one of its forms.

Student Engagement, Retention and Learning Gain

Active learning processes and ways of engaging students are adopted by many different universities on a global scale (Hernández-de-Menéndez, Vallejo Guevara, and Morales-Menendez 2019). They argue that although reasons for this globally might differ, one of the main facets is that the learner is positioned directly within the space that allows the student to learn from tasks that facilitate the development of critical thinking skills as well as performing meaningful tasks. Active learning is seen as a way to improve the learning of students beyond that attained by the passive receipt of information (e.g., Chi and Wylie 2014). Active learning is defined by Bonwell and Eison (1991) as 'engaging cognitively and meaningfully with the learning materials.

Chi and Wylie (2014) built on this when they validated their 'ICAP' model of engagement (figure 2) with student engagement and learning increasing from the bottom to the top of the diagram:

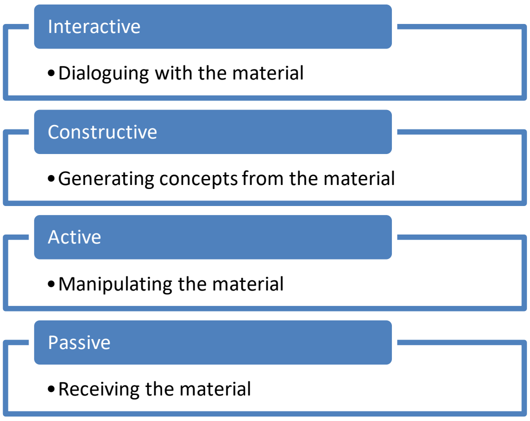

Figure 2. ICAP Model Chi and Wylie (2014)

Chi and Wylie (2014) cite the effects of engagement in active learning as being motivational, but also being associated with higher levels of Bloom's taxonomy in terms of mastering complex skills and ideas. The specific relationship between practice and learning is at the centre of Laurillard's Conversational Learning Framework (2013). The model recognises that learner's concepts and practice evolve in a co-dependent fashion, putting concepts into practice and drawing on practical experience to develop more robust concepts – the essence of Experiential Learning.

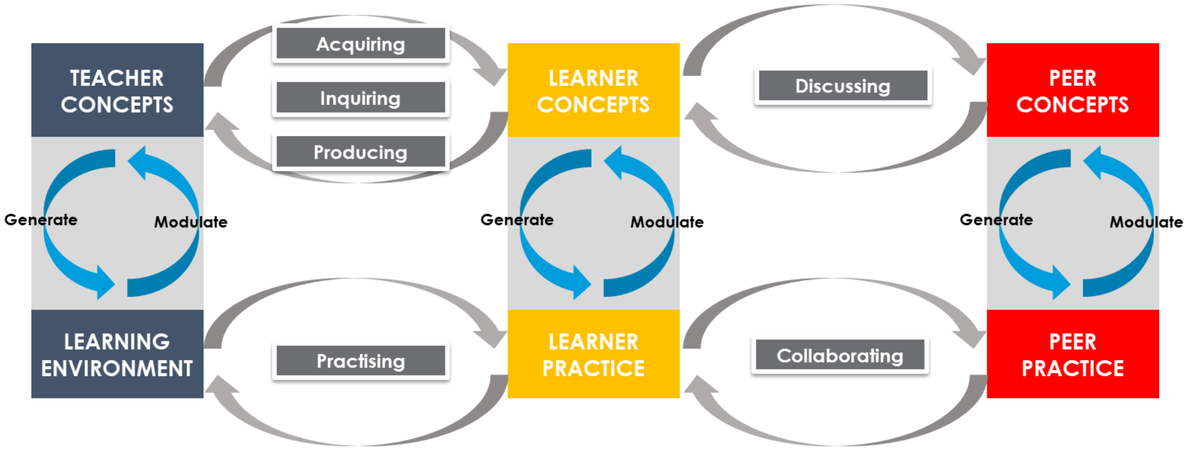

Figure 3. Laurillard's Conversational Framework (2013)

We can further see that this internal learner development is enhanced by the interactions with the teacher concepts and learning environment stimulating development of their concepts and practice and engaging with peers on a conceptual or a practical level.

There has been a concentration of Experiential Learning in the first year of courses in an attempt to address the problem of attrition in Engineering schools (Ambrose and Amon 1997) by linking students to the reason they embarked on their studies in the first place.

BENEFITS OF EXPERIENTIAL LEARNING

Having considered the drivers for the emergence of Experiential Learning it is now incumbent upon us to consider the impact of these efforts upon the key stakeholders. It is worth noting that a number of authors make the point that there are insufficient, and particularly insufficient academically rigorous evaluations of the impact of Experiential Learning, so that the evidence for the benefits suggested may require bolstering for increased confidence (e.g., Tembrevilla, Phillion, and Zeadin 2024; Jamison et al. 2022). Agwa-Ejon and Pradhan (2017), argue that Work Integrated Learning (analogous here to Experiential Learning) is a process by which work practices are ingrained into academic programmes that are mutually beneficial to both students and their employers. It can be seen that as these are two major 'customers' of educational institutions that there will, necessarily, be associated beneficial effects for those institutions themselves. We will consider each of these stakeholders in turn.

Students

In a study conducted in Thailand, data suggested that by using structural equation modelling, lifelong learning skills in engineering and skill self-efficacy, Experiential Learning had a positive impact upon learning outcomes. The practice of learning in the workplace was an important factor in building engineering skill self-efficacy and lifelong learning habits (Khampirat 2021). Similar effects have been observed across a range of other studies: For example, Duchatelet, Cornelissen, and Volman (2024) suggest that specific learning outcomes fostered by Experiential Learning included the cognitive, affective, meta-cognitive and socio-communicative domains, with specific learning outcomes in confidence, communication skills, team-working and problem-solving. Also, Chidwick, Kapiriri, and Chen (2024) looked at the experiences of students, educators and organizations finding that students felt that the approach was more effective in achieving their learning outcomes. Increasing knowledge retention, increased motivation and reduced drop-out rates were identified as benefits of Experiential Learning by Strobel and Van Barneveld (2009). Arrambide-Leal et al. (2019) show that it allows students to construct a 'network of knowledge' and take ownership of their learning.

Hernández-de-Menéndez, Vallejo Guevara, and Morales-Menendez (2019) argue that Experiential Learning approaches allow students to acquire and practice different technical skills under supervision and have led to increased retention rates and improved student performance. Cantor (1997) show that Experiential Learning has a positive impact on improving career placement and also has a positive impact on the recruitment and retention of under-represented student populations.

Experiential Learning has been shown to help bridge the gap between engineering education and engineering work and developing professional competencies (Kolmos and Koretke 2017). Karim, Campbell, and Hasan (2019) found that student engagement with such modes of learning and experience was very high, giving rise of high levels of confidence, leading to conclusions that postgraduate students were able to have transformative experiences, apply theoretical knowledge correctly and that this practice developed their capabilities for wider industry led ventures. Agwa-Ejon and Pradhan (2017), conducted a study on selected Operational Management Engineering students that explored the experiential impact on teaching and learning for engineering students, who reported they enjoyed the work and became aware of the developing skills to improve their overall employability.

In a study conducted on educational methodology at the Technical University of Madrid by de Los Rios et al. (2010), based upon the final years of an undergraduate programme, the methodology gave rise to three main advantages:

(1) It facilitates training in technical, personal, and contextual competences
(2) Real problems in the professional sphere are dealt with
(3) Collaborative learning is facilitated through the integration of teaching and research.

One less researched area is the development of a professional identity, which aligns well with the signature pedagogy movement. By undertaking authentic tasks it is argued that student personas can be developed into professional personas. Mann et al. (2021) argue that Experiential Learning gives rise to an experience of 'becoming' for the students and can provide the impetus of applying this new knowledge elsewhere.

Overall, these findings correlate well with the drivers of the adoption of Experiential Learning discussed previously.

Employers

There appears to be little direct research on the direct benefits to employers from the Experiential Learning approach, but it seems reasonable to infer that they will indirectly benefit from the improvements in knowledge retention, employability attributes and soft skills noted in the previous section.

The second benefit to employers is the movement on the agenda of alignment of Higher Education principles and practice with the needs of industry (as discussed in the background section). In discussing the structure of the educational system in incorporating practice-based learning, Rouvrais, Remaud, and Saveuse (2020) argue, in the 1990s in France, there was a compulsory internship period. From this national experience, emerged the recognition of the need to match the needs of industry with the 'competency expectations of future engineers', (ibid., 2018).

Institutions

Similarly to employers, the research on benefits to institutions is rather scant. And similarly we can infer indirect benefits in terms of more engaged students, improved employability and enhanced attainment for employing Experiential Education. Cantor's (1997) findings in respect of improved attraction and retention of under-represented educational groups is perhaps the most direct evidence of a benefit.

Another benefit is the improvement (both in actuality and in a reputational sense) of the design of their courses. For example, the focus of Strobel et al.'s (2013) study, a systematic literature review, is on the notion of 'authenticity' within engineering education literature, with specific attention on mainly undergraduate students. They suggest the use of different types of authenticity to provide more appropriate and promising principles for better design of engineering curricula and standards for curriculum developers (ibid 2013). According to Litzinger et al. (2011), engineering education needs to encompass 'a set of learning experiences that allow students to construct deep conceptual knowledge, to develop the ability to apply key technical and professional skills fluently, and to engage in a number of authentic engineering projects' and argue that the current formulation of such curricula do not match these needs for students and indeed, current curricula needs to be developed in this fashion.

PEDAGOGY AND LEARNING MODELS

Experiential Learning as a concept was first developed by John Dewey (Jamison et al. 2022). A number of models with similar elements have been developed by subsequent authors (Itin 1999) with perhaps the most commonly cited being Kolb's Experiential Learning Cycle (Kolb 2014), figure 4, below.

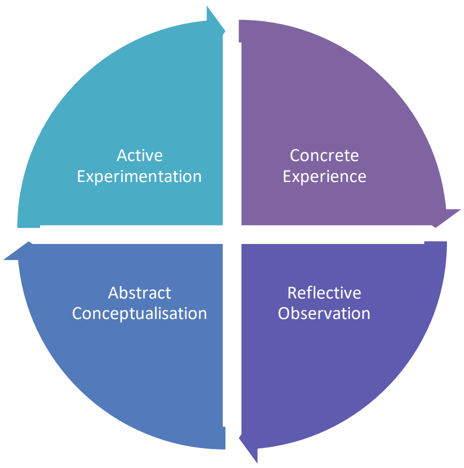

Figure 4. Kolb's Experiential Learning Model (adapted from Kolb, 1984)

Kolb developed his model to incorporate the foundational work of several key scholars (Lewin, Dewey, Piaget) into a framework (Kolb, 2014), which is perhaps why it is probably the most applied and cited model of Experiential Learning.

Kolb's framework has been successfully applied in many disciplinary areas and many Experiential Learning settings (Kolb, 2014). However, it has been criticised by some for the lack of clarity of the terms (especially 'concrete experience') and the need for more guidance on how to support the learning process (Morris 2020). Having conducted research to understand how Kolb's cycle was understood and operationalised Morris (2020) suggested some adjustments to the terms used (in italics):

- *Contextually rich* concrete experience
- *Critical* reflective observation
- *Context specific* abstract conceptualisation
- *Pragmatic* active experimentation

Together, these additions imply that educators need to be more focused and controlled in their application of Experiential Learning in order to maximise the benefit of the approach – moving us closer to a useful definition of an Experiential Education pedagogy. This also helps to address Peace's (2023b) criticism of Experiential Learning as often appearing to be 'learning by contagion'. The importance of this is bolstered by the work of Kirschner, Sweller, and Clark (2006) which drew on concepts of human cognitive architecture, expert-novice differences and cognitive load to demonstrate that minimally guided instruction (including constructivist, discovery, problem-based, experiential and inquiry-based teaching) is much less effective than more guidance-dense approaches.

Fink (2013) argues that combining academic and engineering problem solving is necessary for an effective education. They further argue that understanding how this works provides the basis for further development to incorporate learning that is work based with that which academic engineering education. Problem Based Learning and Challenge Based Learning are particular applications of Experiential Learning which seek to address and utilise this nexus. In these approaches the role of educator moves from source of knowledge to designer of challenges; facilitator of the learning process; promoter of critical thinking; and creator of collaborative learning environments (Galdames-Calderón, Stavnskær Pedersen, and Rodriguez-Gomez 2024). Pedagogically this is indistinguishable from Experiential Education, although a little more designed and robust than Experiential Learning. Table 2 shows the teaching practices for the pedagogical approaches.

Teaching Practices	***Description and conceptualization***
Shifting from instructor to facilitator	Teachers' roles evolve to focus on learning facilitation and support rather than direct instruction and shifting from a traditional teaching role to that of a coach or facilitator
Facilitating the learning process	Teachers guide students through CBL, fostering autonomy in learning, nurturing entrepreneurial skills, and enhancing critical thinking abilities, thereby shaping proactive and dedicated community members
Creating collaborative learning environments	Teachers enhance collaborative learning by establishing positive classrooms that promote teamwork and guide problem-solving while also supporting student autonomy through valuing their feelings and choices and creating an open environment for expression and decision-making
Promoting critical thinking and innovation	Teachers promote critical thinking and innovation through holistic methodologies, enhancing the practical application of theoretical knowledge beyond the confines of the classroom and involving students in taking action and developing innovative solutions for sustainable development
Guiding research questions and problem-solving	Educators guide students through a multifaceted process in CBL, where they assist in navigating complex questions and solving problems by immersing students in a mix of conceptual, procedural, and attitudinal learning. This approach includes an iterative cycle of three phases of CBL framework: "engage", "investigate", and "act" and the related processes, such as analysis, diagnosis, observation, research, strategy development, decision-making, design, evaluating feasibility and environmental impact, implementation, and assessment. Consequently, it cultivates essential skills in research, analysis, and information management among students
Encouraging active learning	The teacher's role encompasses empowering students to become self-directed learners co-responsible for the creation of knowledge who take ownership of their education, preparing them to master the skill of learning to learn and fulfilling meaningful and lifelong learning through active learning or learning by doing.
Designing challenges	By connecting students with real-world problems observed in their communities, teachers create engaging and motivating challenges with global importance based

	on students' interests, integrating adaptable difficulty levels to cater to diverse abilities and ensuring personalized and inclusive learning experiences

Table 2. Teaching practices in CBL pedagogy (Galdames-Calderón, Stavnskær Pedersen, and Rodriguez-Gomez 2024)

Another facet that proves important is both the theoretical and applied perspectives that focus on competency-based learning that can be and are implemented in engineering education according to Henri, Johnson, and Nepal (2017), who also argues that there are gaps in the literature on structuring courses and how they should be assessed.

BARRIERS & ENABLERS TO EMBEDDING/IMPLEMENTING EXPERIENTIAL LEARNING

There is clearly a strong rationale for the consistent and embedded implementation of Experiential Learning. This section will consider what might help or hinder this adoption.

Institutional

Institutional barriers or enablers relate to institutional culture, processes and behaviours. The discipline/department-based structure of many engineering schools and universities is a problem for innovation in educational approaches (Graham 2018). As Hadgraft and Kolmos (2020) note, high prestige Universities are naturally conservative in nature, and embedding Experiential Learning requires a very significant change in both culture and practice. It is also worth noting that effective Experiential learning has significant expense attached to it, and that this may constrain the integrated implementation Experiential Learning as it will compete with other institutional priorities for funding. Splitt (2003) takes into account the overall infrastructure of universities (such as financial pressures) when thinking about and deciding the future of problem-based courses such as engineering and insist that there is no 'one size fits all' when thinking about the challenge to change to such programmes; indeed, institutions should adapt learning objectives for their students, institutions and faculty and proceed from there.

The cultural and practical change required of staff to move to the pedagogies and teaching practices of Experiential Learning as identified by, for example, Galdames-Calderón, Stavnskær Pedersen, and Rodriguez-Gomez (2024) (see table 2) should not be underestimated. Add to this the need to engage with industrial partners when many institutional staff have never left the University environment. There is no clear evidence in the literature of significant attempts to address this in a systematic way. This is further emphasised by the fact that faculty support, commitment and enthusiasm are seen as crucial to student success in Experiential Learning (Teller and Gates 2001).

Pedagogic Design and Learning Structure

Whilst Tembrevilla, Phillion, and Zeadin (2024) noted that the majority (159 out of 220 papers reviewed) of Experiential Learning papers, and hence interventions did not 'meaningfully connect their proposed Experiential Learning with underlying theory' there is evidence that the pedagogy plays an important part in the successful application of the techniques. Mann et al. (2021) argue that the traditional educational structures restrict the engineer's ability to solve complex problems as they focus on particular aspects whilst constraining others; they present a framework with three elements for success:

1) The context of an authentic engineering practice
2) Supporting learners' agency in the process of becoming professionals

3) Opportunities to work and learn simultaneously' (ibid.).

This, they argue, gives rise to an experience of 'becoming' for the students and can provide the impetus of applying this new knowledge elsewhere. There are strong parallel's here with more general research on motivation. For example, Pink's (2011) three elements of motivation:

- Autonomy: Control of your own work and the ability to contribute with a degree of independence.
- Mastery: The opportunity to learn, develop or hone new skills and to grow in your role.
- Purpose: The sense that you are making a difference and contributing to something bigger and worthwhile.

The first two are an almost exact match, but the 'authentic engineering context' perhaps falls a little short of a true 'purpose'. It may be that for a student feeling like they are really contributing to an engineering enterprise fulfils the notion of purpose, but Peace (2023a) asks some questions which might bridge the gap:

- *How do we make learning contexts that are meaningful and rich?*
- *What scaffolds might nurture learning in inclusive and effective ways?*

He suggests that making learning meaningful is about attaching learning to something beyond the immediate, whether that be societal impact, previous experience or to wider contexts beyond the immediate learning environment. Reflection obviously has a part to play here, with this being a critical part of Kolb's Experiential Learning Cycle and a fundamental of most models of Experiential Learning, as do 'Grand Challenges' which are framed around big societal issues. However, Peace (2023a) suggests that scaffolding is even more crucial if we are to avoid placing an unreasonable burden of sense-making on students:

- ***Preparatory Scaffolds:*** Are what students need to engage effectively with the Experiential Learning – perhaps initial theory, skills and knowledge to work in the environment of the activity.
- ***Context-Embedded Scaffold:*** Interventions which invite the application of particular tools, or which disrupt established patterns of thought.
- ***Interpersonal Scaffolds:*** Educator interventions to direct focus, mediate scope and allow students to gain traction on important learning.

The rationale for this approach is supported by Kirschner, Sweller, and Clark (2006) who conclude that due to human cognitive architecture the basis of constructivist, minimal guidance approaches is flawed. Other studies have also corroborated the importance of scaffolding (e.g., Teller and Gates 2001; Aglan and Ali 1996). There is clearly a fine line to be trodden between effective scaffolding which allows increased mastery and the stifling of student autonomy, but this is the province of the educator. It is also worth noting that some studies also suggested that assessment processes which were multi-stage and multi-dimensional in order to capture the complexity of the student experience (e.g., Aloul et al. 2015; Bright and Phillips 1999).

At its heart, Experiential Learning is a pedagogy of reflection and sense-making, if we return to Smith and Knapp's (2011) definition of Experiential Education with added emphasis we can see that it is a fundamental part of the model. "*A philosophy and methodology in which educators purposely engage learners in direct experience and focused reflection in order to increase knowledge, develop skills and clarify values*".

> *A philosophy and methodology in which educators purposely engage learners in direct experience and focused reflection in order to increase knowledge, develop skills and clarify values.*
>
> *Smith and Knapp (2011)*

Reflection has been shown to enhance engineer's identity and to establish the importance of emotion in the discipline (Clark and Dickerson 2018). It has also been shown that meaningful reflections sustained throughout the experience enhanced innovation, critical thinking, and professionalism.

Reflection requires, an individual's active participation so attention must be paid to motivating reflection in-action and on-action (Radović, Hummel, and Vermeulen 2021) and for-action where reflection is used to plan for the future (King 2002). Further, sharing reflections and comments within a learning community can improve understanding. Several studies have noted that interaction with knowledgeable peers (Harford and MacRuairc 2008), communities of practice (Yang 2009), teachers (Hramiak, Boulton, and Irwin 2009), assist in improving reflective practice for students. This can be seen to link back to Laurillard's Conversational Framework which involves peers and teachers in the learning of the individual student and recognises the role of theory and practice in that learning.

External

One of the key issues identified in the literature for an effective Experiential Learning activity is the need for authenticity (e.g., Radović, Hummel, and Vermeulen 2021; Hadgraft and Kolmos 2020). This can be hard to achieve, especially in company-based interventions where the locus of control is not entirely with the academic team. There is a need to ensure that the connection between academic and practical aspects of learning and this can be undermined by a lack of effective facilitation of learning in the workplace (e.g., Henriksen 2013).

Student

There are a number of aspects of the student experience of Experiential Learning which need careful attention if maximum benefit is to be derived from this approach.

Active engagement is an important element of effective Experiential Learning; being argued not only to stimulate learning but also improves the transfer between practice and knowledge (e.g., Radović, Hummel, and Vermeulen 2021). One of the issues raised by Peace (2023b) is the issue of student diversity, suggesting that without careful scaffolding and interventions the benefits of Experiential Learning are likely to be disproportionately felt by students who are already advantaged by 'confidence, demographic or social positioning'. This is an important issue which is very much under-investigated.

Level of study can be important in designing Experiential Learning; Karim, Campbell, and Hasan (2019) suggest that for the postgraduate experience, 'there is an intersection between project-based learning and work integrated learning which may provide a pathway for broader student–industry engagement, scaffolding the development of professional networks and practices for students already within an engineering workplace, and allowing students to transform their practice and improve workplace capabilities'.

Brunhaver et al. (2017) conducted a qualitative study that interviewed engineering students and those who had already qualified as new engineers to compare skills and knowledge to compare those undergoing academic training with those who were active in industry. They found that 'while engineering practice requires the integration of several kinds of knowledge and skills, engineering education focuses mainly on the technical side. Engineers learn most professional and organizational knowledge and skills only after entering the workforce'. Brunhaver et al. (2017) argue that students are exposed to only one facet of engineering and are thus may not see the profession in its' entirety. Thus, they argue, there are deficiencies within the current engineering educational model that potentially impact the effectiveness of graduates.

Students need support in experiential learning, this includes the scaffolding mentioned earlier, but also developmental interventions to help them develop skills which they find more difficult, such as reflection (Radović, Hummel, and Vermeulen 2021; Chi 2013). Critical reflection is a complex blend of self-awareness, connection to theory and careful observation of practice. It would appear to be relatively rare that students are given comprehensive training or development in these critical skills.

CONCLUSIONS

This literature review has highlighted the significant and growing importance of Experiential Learning in STEM education. There are many different forms of Experiential Learning, both authentic and simulated; each has a similar pedagogy and ideal supporting structure but are subtly different in the demands on staff and students and their benefits.

The broad purpose of Experiential Learning is for students to develop conceptual knowledge coupled with an ability to apply technical knowledge and skills in industry and to engage in real-life projects. Done right, Experiential Learning offers advantages in terms of student retention, engagement, learning and personal and professional development. The skills of critical reflection and self-directed learning are also a sound basis for the lifelong learning journey upon which today's STEM graduates must embark. Focus on scaffolding, assessing and developing these skills needs to be a fundamental part of an Experiential Learning journey. This must be bolstered with support from university tutors, mentors and supervisors in industry to allow the broadening and deepening of student understanding and hence capability. Without careful pedagogic engagement and effective design Experiential Learning (or Experiential Education is perhaps a better fit in this context) can be reduced to an osmotic effect and rendered ineffective except for those students who, by fortune have the social and intellectual capital to take best advantage.

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