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Enhancing workplace skills through work-based learning in engineering education.

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Enhancing Workplace Skills through Work-Based Learning in Engineering Education

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Abstract:- The industry's modern workplace is rapidly evolving due to the energy transition. This transformation focuses on advanced technology, and solutions to energy-related challenges. Aligning the skills taught in higher education with the demands of the workplace is a critical challenge for academia and industry. In today's job market, being innovative is a crucial skill for university graduates to enhance their employability. One effective approach to achieving this is through work-based learning (WBL) opportunities integrated into engineering education. WBL is essential for integrating education and workplace skills. Oil and gas companies are working with higher education institutions to develop an effective WBL framework that enhances competences. The paper introduces successful WBL pedagogical models integrated into engineering education to meet industry requirements. These models have utilised technology to expand Merrill's instructional principles and developed blended learning corporate programmes to enhance learning outcomes, engineering skills, innovativeness, and employability skills. WBL enables students to gain practical experience in a real-world work environment, applying the knowledge and skills acquired in the classroom to actual projects and challenges. This hands-on experience not only enhances students' technical skills but also helps them cultivate essential 4C soft skills (collaboration, creativity, critical thinking, and communication) and prepares them for future success. WBL is a valuable tool that enhances workplaces, increases productivity, and introduces innovative work methods. It equips engineering students for successful careers by enhancing their employability. Partner organisations have experienced enhanced technical and economic value by integrating WBL engineering education models into industry projects. This has led to innovative products, solutions to technical challenges, employee skill development, career advancement, and increased access to higher education opportunities.

Keywords:- *Higher Education, Principles of Instruction, Work-Based Learning, Soft Skills, Employability.*

I. INTRODUCTION

Employers are now looking for engineering graduates with a diverse skill set, making employability and innovation a top priority. Graduates should prioritise developing innovativeness, and soft skills such as problem-solving abilities, communication skills, and teamwork capabilities to meet these expectations. Soft skills are now widely recognised as essential for improving graduates' job prospects. These skills, which are not job-specific but are necessary for effective communication and teamwork within a company, are seen as a valuable addition to hard skills. They can improve the capacity to manage different tasks and scenarios. Soft skills are crucial for success in both personal and professional environments, making them essential for individuals looking for employment. Consequently, there is an increasing emphasis on enhancing students' preparedness for the evolving job market by key players in the education and employment sectors (Nisha and Rajasekaran, 2018).

Innovation is the process of generating new ideas and transforming them into new products, services, and procedures. It is widely acknowledged as a crucial driver of competitive advantage and organisational performance (Camisón and Villar-López, 2014; Crossan and Apaydin, 2010; Tuncdogan et al., 2017). Employers value individuals who can contribute to organisational innovation by creating and implementing creative ideas for new products, addressing external demands innovatively, and solving complex innovation challenges (Shalley and Gilson, 2004; Stierand, 2015; Yuan and Woodman, 2010). The World Economic Forum's report "The Future of Jobs" highlights the increasing demand for innovative skills in organisations across different industries (WEF, 2016) globally. Problem-solving and creativity will be essential skills. Higher education institutions (HEIs) are prioritising the development of these skills to improve graduate employability (Bridgstock Citation, 2009; Tomlinson Citation, 2012). They also need to acquire the necessary skills and attitudes for professional practice. In today's job market, being innovative is a crucial skill for university graduates to enhance their employability. Bridging the gap between the knowledge required in the workplace and what is taught in formal higher education is a pressing issue that concerns both the higher education sector and industry (Eraut, 2004; Brennan and Little, 2006; Stenstrom, 2006; Tynjala, Slotte, Nieminen, and Olkinoura, 2006; Piirto, 2011). Industries are facing challenges with graduates who lack the technical and soft skills needed to succeed in the workplace (Smith, Ferns, and Russell. 2016). Soft skills such as problem-solving, leadership, communication, critical thinking, and resource management are essential. It is crucial for students to develop both hard and soft skills. Educational institutions are now focusing on teaching methods that encourage active student engagement to nurture these soft skills. Integrating work-based learning (WBL) opportunities into engineering education is an effective method to enhance the practical skills and knowledge of students. WBL plays an important role in professional development and lifelong learning. WBL is a collaborative strategy employed by educational institutions and industry to educate and improve the skills of students or employees through hands-on experiences. It involves learning for, at, and through work, offering students valuable chances to acquire practical skills, explore job prospects, and enhance their future career opportunities. This method supports the cultivation of vital employability skills that are essential in the current competitive job market. WBL is an educational approach that involves applying theoretical knowledge in real-world work environments to enhance learning. This method, known as cognitive learning, helps students improve their understanding and knowledge (Balta, Coughlan, and Hobson 2012). Research has shown that learning in a work setting is an effective teaching strategy (Lee et al., 2010). Students who participate in structured work experience programmes often demonstrate improved academic performance in their future studies. The Fourth Industrial Revolution (IR 4.0) is accelerating the transformation of the workplace (Saari, et al., 2021), and employees need to learn new skills to keep up with the advancements in clean energy and technology. The Framework for Higher Education (HE) Qualifications states that degrees should provide outcomes that include transferable skills for employment to develop WBL initiatives (Broadbent, McCann, 2016). HEIs should prioritise graduate employability and consider implementing a Teaching Excellence Framework to recognise and reward effective teaching practices that enhance students' knowledge, skills, and career prospects. Integrating practical work experience into the curriculum is crucial for improving graduate employability, as students are increasingly focused on securing job opportunities after graduation. Research indicates that WBL approaches are essential for creating employment opportunities for graduates. Graduates with work experience are significantly more likely to secure full-time permanent employment compared to those without work experience during their academic studies (Pegg, Waldock., Hendy-Isaac., and Lawton 2012; Little and Collegues, 2006).

II. STATEMENT OF THE PROBLEM

There is an increasing need for engineering degrees to be more practical and relevant to industry (Smith, Ferns, and Russell. 2016). The UK Royal Academy of Engineering highlights the significance of industry-university collaboration to create engineering programmes that meet industry standards and student needs (Broadbent and McCann, 2016a). Consequently, WBL programmes should be designed to produce graduates who are well-equipped for the industry and can thrive in a competitive environment (Arthur et al., 2008). Collaborative WBL approaches should be used to bridge the education and workplace skills gap in this evolving landscape by combining knowledge with experiential learning using technology. This practical approach emphasises skill development beyond traditional HE. This approach enhances essential employability skills (technical, soft, and digital skills) that are highly valued in today's job market.

III. OBJECTIVE OF THE RESEARCH

Many companies are partnering with the HE sectors to establish successful WBL models that bridge the innovation and employability skills gap. WBL involves collaboration between students, employers, and HEIs to enhance learning, workplace skills, student satisfaction, employability, and career guidance. It is crucial for lifelong learning and professional development. University-employer partnerships are enhancing the link between industry and education with sustainable WBL engineering programmes. The paper introduces successful WBL pedagogical models integrated into engineering education. These models use technology and expand Merrill's principles of instruction (MPI) to design blended learning programmes. WBL enhances workplace environments, productivity, and work practices. It prepares engineering students for successful careers and benefits companies through technical and economic growth, employee skill development, and expanded education opportunities.

➢ *Research Outcomes*

The partnership programmes improve learning through practical activities and assessments, reshaping workplaces and fostering engineering skills. Innovations in engineering education can benefit a variety of areas, including access, sustainability, education quality, health, well-being, inequality reduction, clean energy, and economic growth. These advancements are consistent with the Sustainable Development Goals (SDGs) 3, 4, 7, 9, 10, 11, 13, and 16 (Transforming our World, 2023).

IV. WBL CONCEPT AND CHARACTERISTICS

WBL integrates academic studies with practical workplace experience. It emphasises the role of the work environment in the learning process and provides structured opportunities for on-the-job training and off-the-job learning activities. Various models of WBL focus on learning for work, through work, and at work, offering different types of learning experiences such as work placements, projects, and in-house training (Seufert, 2000; and Gray, 2001). WBL is used in HEIs to enhance students' knowledge and skills by integrating theoretical knowledge with practical experiences. The goal is to align students' job requirements with their degree learning outcomes through a collaborative approach between HEIs and industries. WBL pathways and models in HEIs engage students and evaluate their progress, leading to academic recognition through accreditation of prior learning, work-experience placements, and employment-based learning programs. In 2001, Boud and Solomon outlined various types of WBL, such as collaboration between educational institutions and organisations to facilitate learning, learners negotiating learning plans during the design phase, courses developed based on workplace needs, learners undergoing competency recognition before determining their course of study, workplace assignments incorporating important learning components through projects, and educational institutions mapping assessments of learning outcomes against a standards framework. According to the WBL Guide (Morley, 2018), essential features of WBL

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courses and effective student preparation for successful transitions to the workplace include having a qualified leader coordinate the courses, designing the course to cater to learners' needs, a coordinator arranging on-the-job training experiences for learners, and ensuring evaluation activities are in place for educators to monitor their courses.

V. METHODOLOGY

Although there are many existing frameworks and guidelines for WBL in the literature (Achtemeier, Morris, and Finnegan, 2003; McInnis & Devlin, 2002; Merrill, 2002), none fully capture the specific type of blended learning that combines formal and informal learning through technology and reinforces work-based activities. Existing frameworks often assume that instruction is either face-to-face or online. To address this gap, flexible and distinctive blended learning WBL programmes were developed to establish a strong relationship between educational institutes and the industry (Skills Development Scotland, 2017; Edmunds, 2007). These programmes aim to offer WBL degrees, enhance graduate-level skills, foster innovation, and strengthen industry-education collaborations. The focus is on WBL centered around business innovation and employability skills, aligned with real-world workplace tasks, to enrich student learning and produce globally competitive graduates. The term "development of WBL models" refers to the various types of WBL models designed and the principles applied to integrate theory and practice. The WBL learning components are coordinated and integrated with the curriculum and assessment system in both the classroom and workplace. Successful implementation of petroleum engineering WBL models has been developed and utilised in courses at the Robert Gordon University School of Engineering. This research focuses on the creation of WBL models, which involves designing various models and implementing principles to effectively combine theory and practice. WBL components are smoothly integrated into the curriculum and assessment systems in both classroom and workplace settings. These models combine formal learning with workplace tasks, leveraging technology and workplace resources. The WBL engineering framework is consistent with MPI (Dgv, 2002), aiming to foster partnerships between universities and employers for blended learning. MPI is a framework that integrates five essential learning principles for effective, efficient, and engaging instructional design adopted in blended learning programmes (task-centered, activation, demonstration, application, and integration). Students develop knowledge and skills through solving real-world problems. Workplace supervisors, subject-matter experts, and academic leaders provide guidance to bridge theory and practice. WBL offers a structured experience that emphasises critical reflection to enhance employability skills and academic learning. Collaboration among learners, universities, and companies in the construction of WBL improves competence, confidence, graduate employability, and meets business requirements. Figure 1 illustrates the interconnected relationships between HEIs, employers, and students in the context of WBL. It showcases the training, education, and knowledge exchange components of the framework, emphasising the interactions between students and employers, students and HEIs, and employers and HEIs.

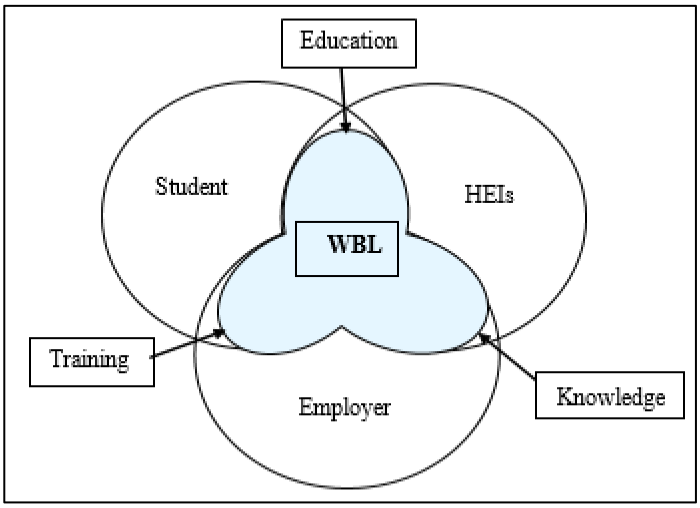

Fig 1. Relationship between Students, Employers, and HIs

The School of Engineering has effectively integrated the following WBL models into its oil and gas engineering programmes.

- *Model One*

WBL provides learners with the knowledge and skills needed to develop and market energy-related innovations, such as the MSc Oil and Gas Innovation programme. This initiative is a collaboration among five Scottish universities.

- *Model Two*

WBL incorporates relevant practical work experience with HEI programmes to prepare students for their future careers. An example is in-house programmes and the Sonatrach corporate blended learning programmes in Algeria, which include theoretical training at the company's facilities.

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➢ *Model Three*

WBL is a full-time employee study strategy supported by HEIs such as MSc Shell corporate programmes.

VII. RESULTS AND DISCUSSIONS

➢ *Model One*

The WBL programme, such as the MSc Oil and Gas Innovation Partnership, prepares learners to develop and commercialise innovative technologies in the energy sector. This project-based master's programme, developed in collaboration with five universities in Scotland and the Oil & Gas Innovation Centre, is designed for graduates, industry professionals, and innovators with new ideas. Leaners study energy-related technologies related to well lifecycle processes. The curriculum includes business and innovation modules delivered through a mix of online and in-person sessions. The Oil and Gas industry project, comprising 75% of the programme, allows students to apply their knowledge through innovative practical projects. Assessment includes formal testing and a report (thesis) on the industry project, which is crucial for determining the final grade (Figure 2).

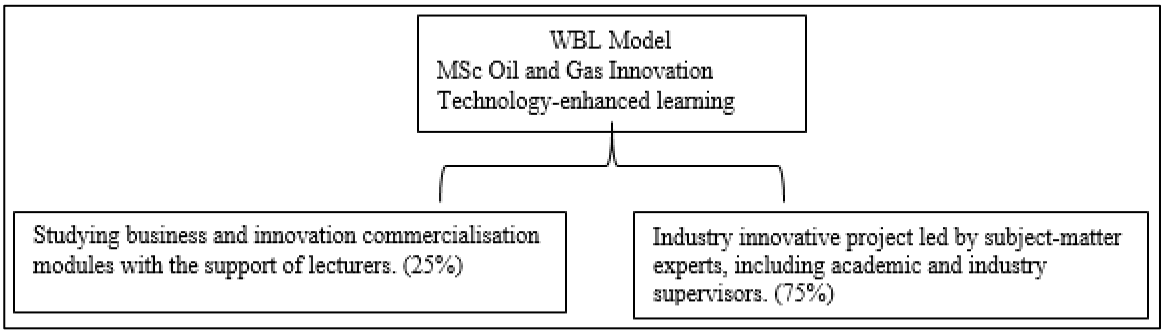

Fig 2. WBL Model One (innovation corporate programme)

➢ *Model Two*

The in-house programmes offer high-quality, energy industry-focused education to prepare students for careers as independent, industry-ready engineers in the energy sector. The programmes include a range of hands-on activities such as industry visits, geology trips, lab projects, drilling advanced simulator, industry software applications, group projects, work placements, industry-based projects, and formal presentations (Figure 3). Fossil fuels such as oil and natural gas continue to play a vital role in the energy sector, alongside cleaner energy sources. The programmes are designed using pedagogy-based solutions supported by technology with a focus on energy and environmental sustainability, artificial intelligence, and machine learning applications (Amish and Etta-Agbor, 2023; Mahdi, Amish, and Oluyemi, 2023; and Khodja, Debih, Lebtahi, and Amish, 2022). One of the key benefits is the development of skilled engineers who can address the "Energy Trilemma" - ensuring energy security, sustainability, and affordability to support the economy and society in line with the SDGs. Students are encouraged to have knowledge of various energy sources beyond just oil and gas. The programmes are aligned with the energy transition by incorporating workshops, new modules and topics such as sustainability and innovation (developing new technologies in the oil and gas industry to achieve low carbon and NetZero goals), decarbonisation, energy storage, and geothermal energy, including carbon dioxide capture. One of the learning methods used is to encourage students to attend industry events and organise networking events between employers and students. This helps students build their skills, expand their networks, and enhance their prospects for future employment. These strategies have enhanced students' digital, technical, and soft skills, enabling them to generate innovative ideas to address the SDGs. Consequently, they are better positioned to compete in the job market. The project-based learning approach has improved learning quality, engagement, and empathy by combining traditional and technology-based methods. Students can apply academic concepts practically, gain advanced knowledge, and develop digital and 4C soft skills. Notably, creative, and critical thinking skills have improved, along with time management, communication, and interpersonal skills. In a problem-based learning environment, students collaborate, share knowledge, and connect over shared goals. The blended learning platform offers diverse communication tools and enriches course material, enhancing student engagement and learning outcomes in engineering subjects (Adebakin, Ajadi, and Subair, 2015).

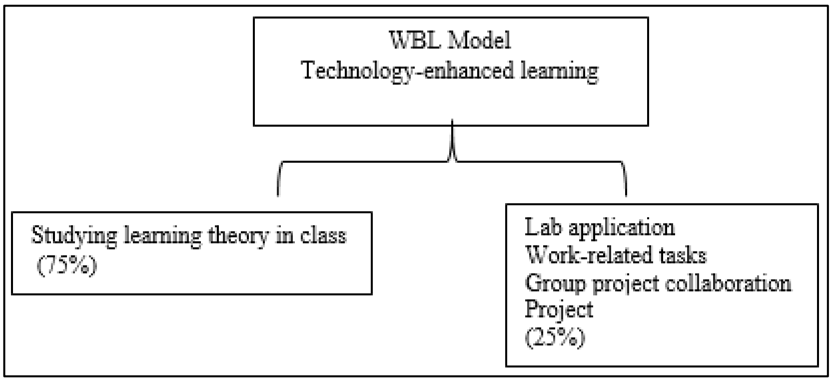

Fig 3. WBL Model Two (in-house programmes)

Sonatrach's partnership programmes in Algeria utilised a blended learning approach that combines informal on-the-job activities with formal classroom instruction. This approach fosters a flexible and collaborative learning environment. The programmes are designed to equip graduates with expertise in well engineering and reservoir engineering, enabling them to make a valuable contribution to their future employers' success early in their careers. The programmes are formulated with a balanced emphasis on theory and practical learning activities. Students engage in a variety of learning activities, such as industry visits, geology field trips, lab work, software workshops, group work, work placement (hands-on experience), and industry project-based learning focused on real-world company challenges. Assessment is conducted through knowledge and work-based evidence portfolios or oral presentations that align with workplace tasks to enhance company operations (Figure 4).

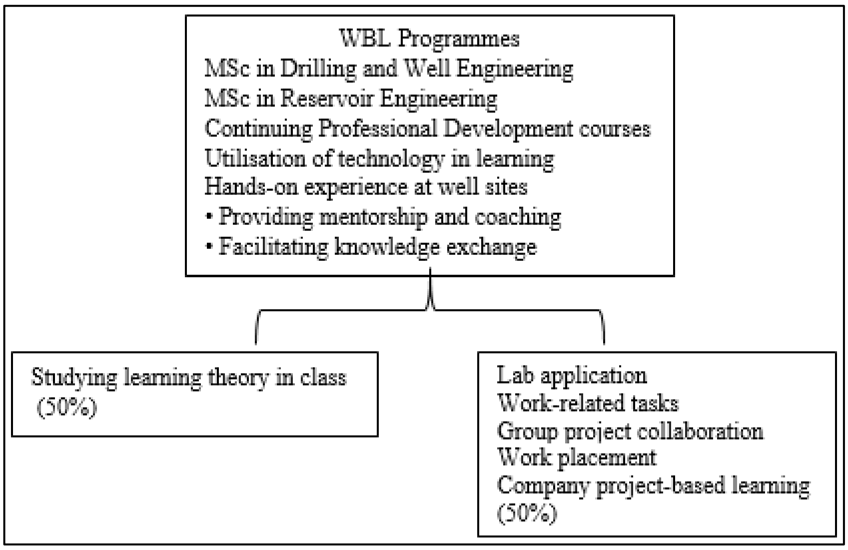

Fig 4. WBL Model Development Two (Sonatrach corporate programmes)

- *Model Three*

Shell partnership programmes' WBL model, endorsed by the university, provide learners with the opportunity to gain practical skills alongside their academic knowledge through on-the-job training. This includes practical experience on workplace rigs and platforms, laboratory applications, integrated assessment, mentoring, formal learning activities, and formative assessments (Figure 5). The projects undertaken should be relevant to workplace tasks and add value to the company's operations, with supervisors from both the HEI and the company involved. Shell's WBL model strategy includes key components of the Wells Distance Learning Package, blended learning events at central and regional levels, practical experience at worksites, mentoring, cumulative coursework, and centrally administered exams. The programmes aim to create an independent and effective learning environment, with workplace learning supplemented by the creation of a portfolio of evidence. The learners are exposed to industry-specific knowledge through blended learning approach and various learning formats. Additionally, learners are required to undertake a company-based project that involves conducting an in-depth analysis of a specific company issue, with assessment based on a portfolio of evidence reflecting skills and work performed, as well as a formal report (thesis).

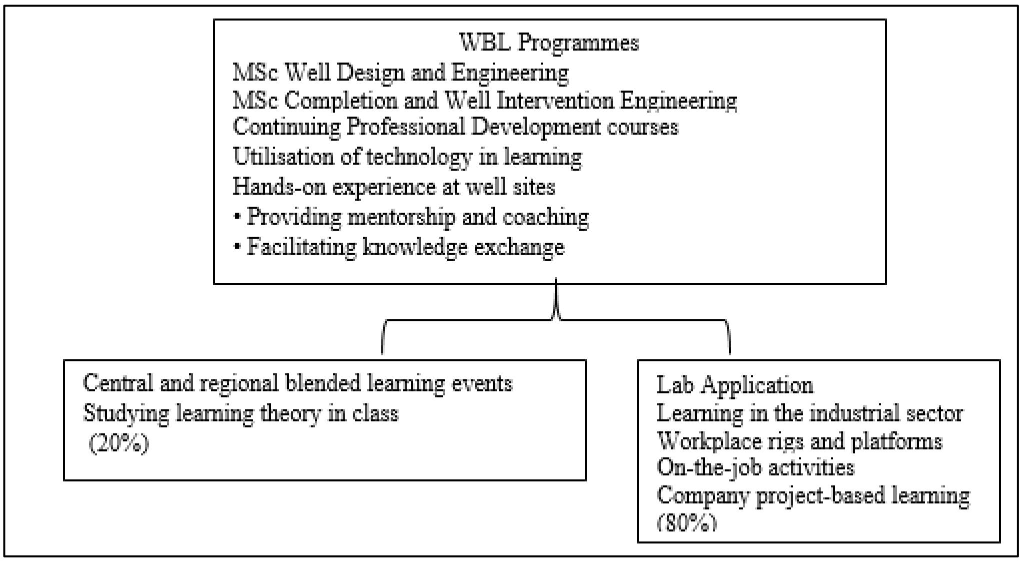

Fig 5. WBL Model Three (Shell corporate programmes)

VIII. CONCLUSIONS

The WBL framework for partnership blended learning programmes was developed using MPI, which emphasises theory through problem-based learning. The four phases are: activation, demonstration, application, and integration. Real workplace-based problems are identified for the students and using the existing knowledge base, new concepts are learned, applied, and integrated. These principles are designed for workplace programmes and should be adapted for employer-university partnerships using collaborative and blended learning technologies. The University Campus Moodle platform provides essential facilities for educators to improve the quality of programmes and students learning experiences. For example, certain types of online pedagogical activities support communication and collaboration such as discussion forums. External applications with comparable features can be utilised to support a collaborative learning approach. Work-based tasks and industrial projects require the use of internal company resources and experiences. Collaboration among academic and employer personnel improves sharing of knowledge and technology utilisation for module delivery, support, resources, activities, conversations, and job-related assessments. This strategy increases professional skill acquisition while also accommodating different learning styles. Modules are tailored to practical workplace requirements, allowing for hands-on skill application. Training courses combine classroom learning with real-world applications, encouraging learners to participate actively and independently. This boosts employees' confidence and self-motivation, leading to skilled management professionals' development. Technology integration enhances teaching and learning experiences, illustrating complex theories and practical applications effectively. By incorporating WBL engineering education models into industry projects, partner organisations have seen a significant increase in the technical and economic value of their assets. This has led to the development of innovative products and effective solutions to technical challenges at various stages of the projects. These models enable employers to customise their workforce to meet business needs, enhance and retain employee skills cost-effectively, and broaden access to higher education. Employees benefit from career advancement opportunities within the company, locally and internationally.

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