The Global Apprentice: Adaptable, Versatile and a Lifelong Learner

Breda Walsh Shanahan[1] and Mary Doyle-Kent[2(✉)]

[1] Department of Education, South East Technological University, Waterford, Ireland
breda.shanahan@setu.ie
[2] Department of Engineering, Technology, South East Technological University, Waterford, Ireland
mary.doyle-kent@setu.ie

Abstract. The future of humanity itself depends on how we adapt to the existential crises we face such as global warming and the loss of biodiversity. Today's work environment demands high-performance teams comprising diverse, multidisciplinary workers with lifelong learning skills that are educated in a manner that will equip them to understand and combat the crises we face. These teams must be capable of adapting and solving present and future problems of our growing population while safeguarding our planet and its resources. This paper presents the findings of two European studies emphasising the importance of education and training in enabling current and future workers to engage with new technologies and new learning. It proposes an educational model based on collaboration between Higher Education institutions, Industry and Commercial companies and learners. It presents the skills required to ensure a successful transition to Industry 5.0 and defines how the four pillars of evolving education. a) Macro credentials, b) Micro credentials, c) Mentoring and Equality, d) Diversity, Belonging and Inclusion, hold specific characteristics designed to meet the challenges of the future workplace.

Keywords: Education · Mentoring · Macro and Micro-credentials · Lifelong Learning · Global Apprentice · Industry 4.0 · Industry 5.0

1 Introduction

The need for climate action to reduce biodiversity loss caused by human environmental damage, the complex social inequalities causing poverty and the lack of inclusivity and diversity are recognised as the existential threats facing humanity in 2023 and beyond. These challenges are further intensified by widespread instability following the Covid-19 Pandemic. Consequently, society and the world of work has changed. Social, environmental and scientific advances have created different workplaces for employees, businesses, governments, educators and society and while some changes bring improvements there are also disruptions and losses to the jobs market where new skills are essentially required by the workforce. Today's work environment demands high-performance teams

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comprising diverse, multi-disciplinary workers with lifelong learning skills. These teams must be capable of adapting and solving present and future problems of our growing population while safeguarding our planet and its resources.

Prior to the pandemic the European Union (EU) publication Breque et al. in 2021, described how inter-connected the future of Industry 5.0 and emerging social trends will need to interact and co-exist as Industry 5.0 complements and extends the hallmark features of Industry 4.0. It emphasises factors that are not just economic or technological in nature, but also have important environmental and social dimensions [1].

2 Smart Manufacturing and Industry 4.0/Industry 5.0

As Industry 4.0 and its inclusive technologies are connected to the Internet of Things (IOT) it follows that all the data that is being generated by connected sensors can be captured, processed and used to optimise processes and factories. One of the main goals of these developments is a "smart factory" being able to produce economically "Lot Size One". This new smart way of manufacturing has become a revolution by the increasing levels of automation, cyber physical systems, digital twins and the intensive use of data analytics [2]. The synchronisation of humans with robotic systems and the need for Science, Technology, Engineering and Maths (STEM) life-long learners, with a mixed disciplinary approach to learning, is now more urgent than ever.

The Community Research and Development Information Service (CORDIS) is the European Commission's primary source of results from the projects funded by the EU's framework programmes for research and innovation. They emphasise the importance of multifaceted approaches to learning from two studies coordinated in Norway by Sintef AS and in Italy by the Universita Degli Studi Di Modena E Reggio Emilia from 2016 to 2019 [3].

- The HUMAN study conducted in Norway emphasizes the importance of workers with specific skills, experience, competences, and flexibility in the successful adoption of automation solutions by European Union (EU) manufacturers. It acknowledges the need for a cooperative environment that effectively utilizes and nurtures workers' capabilities and knowledge. Integrating automation and robotics is crucial for achieving productive growth, but it must prioritize the safety of workers and value their cognitive and physical abilities.
- The INCLUSIVE study, conducted in Italy, focuses on the complexity of modern automatic machines and robotic cells in production plants. With the increasing demand for faster production rates, Human Machine Interfaces (HMIs) have become essential tools for human operators, engineers, technologists, and scientists. However, the constant updates and intricate nature of these HMIs can present challenges for operators, especially when considering factors such as age and ability. The primary goal of the study is to investigate how the human-machine interface can be modified to accommodate the capabilities of the operators. This objective revolves around three main pillars: assessing operator capabilities, adapting the HMI accordingly, and providing training and support to operators.

Both studies stress the crucial role of education and training in enabling workers to effectively collaborate with the rapid advancement of automation and robotics in

production plants. A workforce that possesses the necessary skills and knowledge to operate and interact with these technologies is not only desirable but is essential for future economic growth and productivity.

The imminent paradigm shift in manufacturing and production, known as Industry 5.0, is rapidly approaching. This new era is characterized by a focus on personalization and customization, the two key elements highlighted in the EU studies HUMAN and INCLUSIVE. The HUMAN study proposes enhancing human/computer interaction by educating individuals about system requirements, while the INCLUSIVE study suggests improving computer/human interaction by adapting software and mechanisms to human ergonomics. Both studies revolve around the central theme of new knowledge acquisition and training (Fig. 1).

Fig. 1. Conceptual framework illustrating Industry 5.0 [4]

In narrative terms, enhancing the above diagram, Doyle-Kent states*: "Industry 5.0 is the human-centered industrial revolution which consolidates the agile, data driven digital tools of Industry 4.0 and synchronises them with highly trained humans working with collaborative technology resulting in innovative, personalised, customised, high value, environmentally optimized, high quality products with a lot size one"* [4].

3 The Global Apprentice

A key question in achieving a successful transition to Industry 5.0 is: "How can we effectively train and retain multi-skilled STEM workers, equip them with diverse learning abilities, and empower them to be lifelong learners with transferable qualifications?" In essence, the goal is to foster a mindset and create a "Global Apprentice". Becoming a "Global Apprentice" encapsulates the aspiration to be globally competitive, equipped with a diverse range of skills, and capable of applying knowledge in various contexts. It

signifies a commitment to lifelong learning, adaptability, and the pursuit of excellence in an interconnected and rapidly changing world.

To resolve the problem of attaining knowledge and training the approach outlined here draws upon theories from various fields such as education, business, engineering, and psychology. It proposes an amalgamation of Higher Education macro credentials, micro credential learning, mentoring programmes and an awareness of diversity, equality, belonging and inclusion (DEBI). This collaborative approach offers a solution that benefits humans, technology, robotics, economics, and society. It advocates for a threefold inclusive partnership among Higher Education institutions, Industry, and the Lifelong learner, each contributing unique strengths and values [5]. The partnership involves:

1. Higher Education and Training Institutes: The institutions that serve as providers of knowledge and skills.
2. Industry and Commercial Companies: The competitive markets that deliver products and services through employment, social/environmental involvement and wealth creation.
3. Employees/Learners: The individual members of society who earn a wage and strive for personal growth.

Human capital, not financial, is the most important asset available to any successful company. A critical requirement of a modern manufacturing environment is to attract and retain top talent, to communicate knowledge and create an environment which nurtures growth and creativity [4]. The main problem requiring employees to return to education or to engage with new learning is often based in the way the 'new training' or 'education' is delivered or on the employee's negative learning experiences of the past, time commitments or personal reasons for non-engagement [6].

4 Current Educational Models

In 1972 Malcolm Knowles developed the theory of Adult Learning on four main assumptions which are as important today as they were 50 years ago. Knowles' four main assumptions on adult learning are: Changes in Self Concept, Role of Experience, Readiness to Learn and Orientation to Learning. Each of the assumptions has a place in new learning experiences and each holds personal value for the learner in various degrees of importance [7] (Fig. 2).

In the evolving landscape of industries, where dynamic work practices align with scientific and technological advancements, the pursuit of quality educational models has also experienced dynamic changes. While obtaining a 3 or 4 year undergraduate degree from a university remains a highly esteemed achievement for individuals and society, the methods of attaining such credentials have evolved. This macro-credential serves as evidence of intelligence and focused study in a chosen professional field. Traditionally, holding a degree has provided individuals with opportunities to embark on careers, entrepreneurship, or further education. The recognition of degrees is universally acknowledged, with transparent learning outcomes established through Higher Education (HE) programs and educational standards regulated by authorities and ministries in developed and developing countries [5].

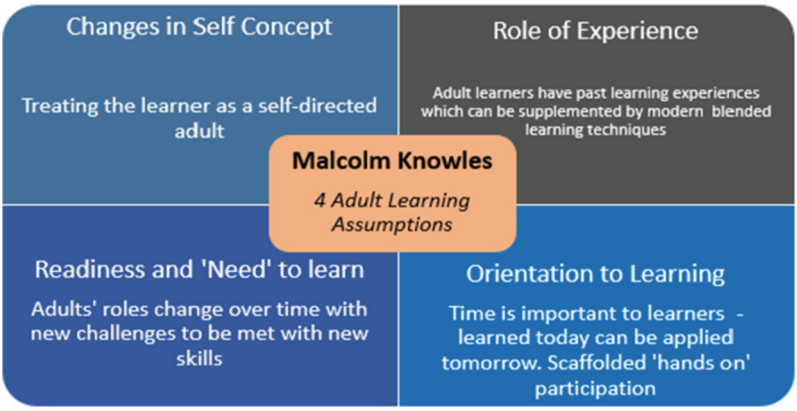

Fig. 2. Interrelated learning assumptions from Malcom Knowles [7].

However, there is overwhelming evidence that many current models in higher education will not be able to meet a growing demand for a depth and breadth of new skills and competences across multiple sectors or for the jobs of tomorrow. It is predicted that 50% of all employees will need reskilling by 2025 and widely accepted that over the next decade "…new technologies will reshape millions of jobs in the EU" [8].

In 2018 Deloitte and The Manufacturing Industry listed the main skills required for future manufacturing success [9]. Including these skills into modern educational courses is a challenge which has been met in many instances through the attainment of long term macro and short term micro credentials (Table 1).

Table 1. The Top Ten Skills Required for Future Manufacturing [9].

Digital literacy as a holistic skill to interact with, understand, enable, and even develop new digital manufacturing systems, technologies, applications, and tools
Ability to use and design new AI and data analytics solutions while critically interpreting results
Creative problem solving in times of abundant data and technological opportunities in smart manufacturing systems
A strong entrepreneurial mind-set including pro activeness and the ability to think outside the box
Ability to work physically and psychologically safely and effectively with new technologies
Inter-cultural and -disciplinary, inclusive, and diversity-oriented mind-set to address new challenges arising from a more diverse manufacturing workforce
Cybersecurity, privacy, and data/information mindfulness to reflect the rapidly increasing digital footprint of the manufacturing value chain

(*continued*)

Table 1. (*continued*)

Ability to handle increasing complexity of multiple requirements and simultaneous tasks
Effective communication skills with humans, IT, and AI systems through different platforms and technologies
Open-mindedness towards constant change, and transformation skills that constantly question the status quo and initiate knowledge transfer from other domains

The attainment of the skills listed above are becoming mandatory for the future successes of the individual and the manufacturing industry. The following outlines four pillars of evolving education, each with inherent characteristics, designed to meet the challenges of the future workplace: *A.* Macro credentials, *B.* Micro credentials, *C.* Mentoring and *D.* Equality, Diversity, Belonging and Inclusion.

5 Educational Models

Content-laden macro degrees, whilst valued in the long term, are not always effective for adult learners in today's fast paced environment. Employees and employers need 'just-in-time' skills that are immediately applicable and easily attainable. This trend is likely to accelerate with the economic crisis triggered by the COVID-19 pandemic [10]. The efforts of Higher Education Institutes, Industry and Governments are shown below as examples of what is being done and what can be achieved with collaboration and creativity.

5.1 Macro Credentials

In 2019 Costello et al. described a case study in an Irish bio-medical company where the company's engineers acted as educators to upskill the current technical workforce [6]. The criteria for this 'in house' training system was to develop a low cost, adaptable structure of upskilling whilst catering for different employee operational work shifts. As a result of this action research study the following challenges were recognised as some of the main project learnings:

1) Reluctance by technicians to learn from engineers who were not teachers. 2) Attendance was low and sporadic due to shift work. 3) 'Off site' was preferred by learners/Older technicians not engaging with new learning compared to younger technicians. 4) Lack of IT knowledge and fear of new learning techniques. 5) Technicians not happy with 'Book Learning' preferred practical learning. 6) Essential 'Communication and Information Technology Skills' studies were not included in the industry training programme.

Following on from the findings of this industry initiative researchers in a third level technological university saw the opportunity to create an alternative training model which is outlined in their paper 'The development of a novel educational model to successfully upskill technical workers for Industry 5.0: Ireland a case study'. The research was interpreted to offer a new course of instruction for upskilling engineers and engage with

modern blended learning techniques, a college environment, and professional educators from diverse engineering, technology and humanities disciplines at a pre-university level [11].

Another example of a university engaging with large corporations and small and medium size enterprises is shown in the study in 2022 by Kopacek and Doyle-Kent who described the success of the Technical University of Vienna (TUWien) and the Oakland University of Rochester (Michigan, America) who co-operated in a joint MSc in Engineering Management programme beginning in 1995. The successful programme has over 25 years of experience, runs as part of the Bologna Convention which encourages integration between higher education and industry, is an international collaboration with content updated regularly and the graduates continue into higher management or have founded their own companies [12].

5.2 Micro Credentials

Micro-credentials, as defined by the European Commission, serve as *proof of learning outcomes* acquired through short learning experiences and follow transparent standards [10]. Examples of micro-credentials can be obtained from providers such as Future-Learn, Microsoft, Coursera and edX. These credentials are available online or through a blended teaching techniques based on Massive Online Open Courses (MOOCs). The design and delivery of courses leading to micro-credentials can vary in length, difficulty, workload and assessment practices. To ensure transparency and informative communication, micro-credentials should include essential information such as the title, learning outcomes, content description, assessment type, and quality assurance. The portability and stackability features of micro-credentials play a significant role in their global acceptance and success [5] (Table 2).

Table 2. Micro-Credentials – Common Characteristics [13]

Micro-Credentials – Common Characteristics	
1	Limited length of learning activities – larger than a single course but less than a degree
2	Labour market relevance: focus is on delivery of specific knowledge, skills, and competences useful in the workplace
3	Wider societal impact: focus on lifelong learning opportunities that are reasonably priced, short and convenient to access

The recognition, *validation and value* attributed to micro-credentials are crucial for their acceptance in the workplace, by employers and learners. To establish this recognition, micro-credentials can align with formal criteria used in degree programs, known as “credits”. These credits are based on the estimated and agreed time a learner must spend on a specific element of study, as defined by the European Credit Transfer and

Accumulation System (ECTS). The ECTS system is adopted by 48 countries in the European Higher Education Area. This transferability allows for international acceptance of qualifications leading to a truly Global Apprenticeship.

In designing programmes to include Micro-credentials Hudak and Camilleri offer two recommendations to Higher Education Institutes which benefit all three stakeholders – the HE institutes, the employer and the learner (including future learners) [14].

Recommendation 1 - Micro-credentials should be developed with partners from outside academia wherever possible and are most successful when they are reflections of academy-industry partnerships.

Recommendation 2 - Micro-credentials should be used to increase flexibility and innovation as they are smaller-scale than full degrees, and micro-credentials have fewer standardized requirements. Thus, micro-credentials are often more easily fundamental to innovation.

Aligning Higher Education quality assurance standards to micro-credentials ensures the standards of the HE institute are aligned with the micro-credentials as assessment forms the essential component of a qualification and Ireland is one of only three countries within the EU who have the independent authority to include and authenticate their own higher education programmes – the others are Norway and Finland [15]. In 2020 the European Commissioner Ursula Von der Leyen stated, "The best investment in our future is the investment in our people. Skills and education drive Europe's competitiveness and innovation. But Europe is not yet fully ready. I will ensure that we use all the tools and funds at our disposal to redress this balance" [16]. This statement was prompted by figures which showed between 2008 and 2018 Industry accounted for 20% of EU GDP [17] and Manufacturing provided 14.5% to the EU economy [18].

There are many countries throughout the world investing huge capital resources to achieve the goal of creating a lifelong learner and a global apprentice through the introduction of micro credentials. Research by Walsh Shanahan and Organ in 2022 outlines the efforts of the Irish and Australian government's initiatives to combat the effects of the Covid-19 pandemic, job losses, new technologies entering the workforce and the need for new skills. Ireland's 'Human Capital Initiative (HCI)' focuses on seven Irish universities engagement with industry to progress changes in educational methods to enable learners to re-skill, up-skill or change careers [5, 19]. The Australian Federal Government reviewed their Qualifications Framework in 2020 following a study which showed that 2.6 million people engaged with non-qualification courses to meet industry requirements with over 90% of the training market being provided by private companies without government assistance [5, 20].

5.3 Mentoring

Traditionally, mentorship in industry has often involved 'apprenticeships' or 'on-site' learning following initial training. In this approach, a seasoned and knowledgeable mentor is assigned to guide and teach a younger or novice individual, imparting the skills required for the position. Through mentoring experiences, students learn to combine their foundational knowledge with shared or role-modelled experiences [21]. The following outlines an evolved version of the mentoring model to cater for evolving and dynamic

work practices which can be passed up and down through the all-inclusive professional chain allowing new ideas, technologies, creative problem solving to be introduced at all levels.

I) Mentoring Models: Mentoring can take different forms, and its effectiveness depends on the context and goals involved. One way to conceptualize mentoring is through a hierarchical model, where the primary emphasis is on achieving specific outcomes such as knowledge transfer, continued learning, and professional assimilation. This model is often observed in fields like medicine and scientific professions, where experienced individuals share their expertise with less-experienced mentees in a top-down manner. However, the collaborative model of mentoring values the contributions of both mentors and mentees. By embracing the collaborative model, mentoring becomes a two-way process that goes beyond the mere transfer of knowledge. It creates an environment that nurtures innovation, creativity, and the exploration of new ideas. This approach can be particularly beneficial in fields where multidisciplinary collaboration and adaptability are essential, as it encourages mentees to become active participants in their own learning and professional growth [21].

Warner presented a multi-level "Mentoring Ladder" where the influence of mentors drawn from higher levels to mentors trained and deployed at all levels [22]. A working example of this model is seen in The University of Michigan's College of Engineering Peer Mentoring Program which matches new students with mentors who are recruited from senior engineering students based on common interests. Santora, Mason and Sheahan presented the model, seen here in Fig. 3, outlining the levels of mentoring intensity in operation between each student and mentor [23].

Mentees, regardless of gender, can experience objective and attitudinal benefits from mentoring [24]. *Objective benefits* encompass positive career planning, increased career involvement, higher income, and more promotions. *Attitudinal benefits* include job and career satisfaction, as well as career commitment. It is often noted that formal organizational mentorships can be less effective than informal ones due to factors like personality conflicts, the need for external support, and insufficient commitment from either party. Nevertheless, organizations have been implementing formal mentoring programs to match mentors and mentees, aiming to capture the qualities of successful mentoring relationships. It is important to note that, on average, formal mentoring programs tend to yield better results than having no mentoring at all [25].

Mentoring and gaining experience significantly increases the opportunities for the Global Apprentice to combine varied work practices with new technologies, remaining current and relevant in their professions within a diverse and inclusive workforce.

5.4 Diversity, Equality, Belonging and Inclusion (DEBI)

High performance teams working in all areas are required to address the global crises. It is widely accepted that an inclusive and diverse workplace inherently attracts top talent that outperforms homogenous teams. Women and other minority groups are often underrepresented in Science, Technology, Engineering and Maths (STEM) globally especially in key areas of engineering and manufacturing [26, 27]. In 2022, Doyle-Kent and Kopacek wrote about Optimising Human Potential through Diversity and Inclusion. They wrote

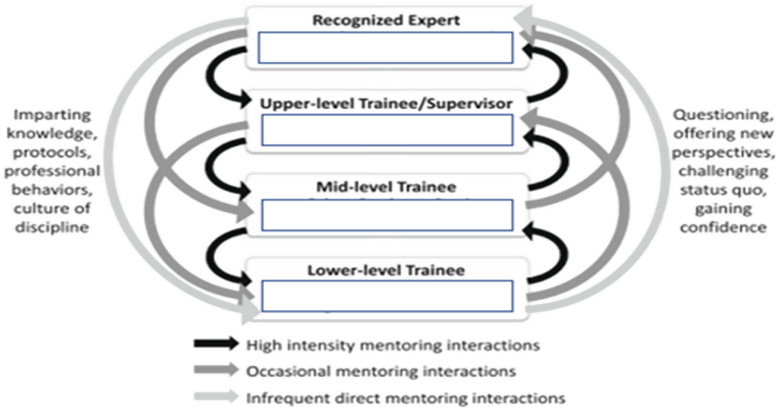

Fig. 3. Progressive Mentoring Model [23]

about the future of industry in Europe which incorporates three dimensions; the regenerative dimension, the social dimension and the environmental dimensions and state that "Traditionally equality, diversity and inclusion (EDI) was not seen as an important consideration in technological work environments. Engineering companies now realise that if they want to have a competitive advantage globally, then their employees need to be the brightest and best". They conclude that to future proof the workplace ensuring the brightest and best can be recruited and retained, it's critical that the workplace is, inclusive and equitable and that the employees will need to feel that they belong to thrive and reach their full potential. In turn this will bring the competitive advantage to the company and ensure long-term survival [28].

6 Conclusions

The main goal for Industry 5.0 is founded on 'human progress' and the best possible pathway to achieving this is through education and training, attaining new skills, upskilling existing work practices and engaging in continuous lifelong learning. This paper is based on current international scientific research from both commercial and educational sectors and outlines the characteristics necessary for human engagement with new technologies and robotic interaction. The four pillars of dynamic lifelong learning are shown here to provide educational opportunities in creating the 'Global Apprentice' through engagement with macro credentials, micro credentials, mentoring practices and being aware of the sense of belonging which can be fostered by colleagues who are people of all genders, ages, race and diversity. The diverse interaction of human skills, practices and cultures has the potential to create a community of collaboration with shared goals, the ability to find sustainable solutions, and advance positive social impact. Future education for the success of Industry 5.0 must include several facets to include industry-oriented curricula, mentoring relationships, micro credentials and a willingness from all parties to promote the sustainability of our resources and the regeneration of our planet for the following generations.

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