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Regular Article

Higher education via the lens of industry 5.0: Strategy and perspective☆

Mohamed Ashmel Mohamed Hashim [a,*], Issam Tlemsani [b], Rachel Mason-Jones [a], Robin Matthews [c], Vera Ndrecaj [a]

[a] Cardiff School of Management, Cardiff Metropolitan University, United Kingdom
[b] The Centre for International Business, United Kingdom
[c] The Russian Presidential Academy of National Economy and Public Administration (RANEPA).Russia

A R T I C L E I N F O

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A B S T R A C T

This study delves into the transformative potential of Industry 5.0 (I5.0) within the realm of higher education, employing a robust empirical model. Significantly, this model incorporates (a) research and development, (b) business innovation, and (c) human centricity, placing a pivotal emphasis on unravelling the conclusive impact of I5.0 on higher education. The overarching objective is to position human elements at the core of the higher education system, thereby not only enhancing operational efficiency and growth but also fostering sustainable development for the greater good of humanity.

The primary research objectives are to elevate the focus on the evolutionary literature of I5.0, develop pertinent I5.0 profiles specific to higher education, chart a comprehensive roadmap for the cultivation of I5.0, and construct a fundamental model for the systematic analysis of its emerging impact. I5.0, with its novel strategic opportunities, proves particularly instrumental in enhancing resilience within higher education institutions. This allows for a strategic reorientation towards sustainability, with a heightened commitment to societal and environmental contributions (people, profit, and planet).

Employing a grounded theory methodology, this research selectively underscores the evolutionary and systematic impact of I5.0 on higher education by leveraging theoretical concepts, individual experiences, and diverse perspectives. Our findings highlight the nascent awareness of I5.0 within higher education institutions, with relatively scarce new insights. The adoption of novel knowledge is characterized by a lack of systematic approach, necessitating innovative methods and models for effective implementation.

This paper articulates a tetra-dimensional empirical model (experimental model) tailored for the integration of I5.0 in higher education, comprising the theoretical dimension, application dimension, technical dimension, and practice dimension. It is essential to acknowledge the limitation of this research, which confines its assessment of I5.0 impact to the higher education sector. Ultimately, the implications of this research extend beyond the theoretical realm, offering practical insights and implementable recommendations for policy development.

1. Introduction

The ground-breaking I5.0 perspective has major repercussions on the higher education sector's competitiveness (Gürdür et al., 2022; United Nations, 2021; Togo & Gandidzanwa, 2021). Higher education institutions (HEIs) are viewed as the immune system for society's knowledge base. Thus, the higher education sector plays a centric role in terms of producing new knowledge, emerging technologies, and agile processes for social innovations (Carayannis & Morawska, 2022; Ali, 2021; Gürdür et al., 2022; Mohamed Hashim, Tlemsani, Matthews, et al., 2022; Zizic et al., 2022).

Primarily due to Covid 19 and the rapid adoption of technology that had to happen - thereby introducing the adoption of usage and integration of technology at a much more rapid rate. The challenge now is integrating it with the new classroom environment. However, as of today, the higher education sector is under pressure in terms of (a) what changes they need to adopt, (b) how they need to react, and (c) what rational tools and processes they must utilize to cope with the agility imposed by the I5.0 on delivery of education. We constructively argue that I5.0 opens a new paradigm/perspective for HEIs. I5.0 can become

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* Corresponding author.
E-mail address: MMohamedHashim@cardiffmet.ac.uk (M.A. Mohamed Hashim).

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one of the key drivers of macro-environmental change in global education (Gürdür et al., 2022).

The forces of I5.0 have considerably altered higher education (HE) and its delivery landscape (Zizic et al., 2022). These changes are supported by advancements in digital transformation, information exchange and simulation-based decisions (Mohamed Hashim, Tlemsani, Matthews, et al., 2022; Tlemsani, Zaman, et al., 2023). While debates on the cross-fertilization of the phenomenon of Industry 4.0 (I4.0) in HE is not over, the dynamism of the fifth industrial revolution, I5.0 is going beyond the HEIs' operational borders producing sustainable education services for profit. As a result of the converging agility of I5.0, HE undergoes rapid changes in terms of content, pedagogy, and delivery. The boundaries between portfolios of courses are shrinking, it also triggers a new dialogue and new strategies on what university education should be within the era of I5.0 (Breque et al., 2021; Cillo, Gregori, Daniele, Caputo, & Bitbol-Saba, 2021; Rhayem et al., 2020; Togo & Gandidzanwa, 2021; United Nations, 2021; Xu et al., 2021).

I5.0, as a ground-breaking reality, has common ideas with the common goals of the United Nations Sustainable Development Goals. Integrating the elements of I5.0 (planet 5.0, society 5.0, economy 5.0) into higher education practices will permit HEIs and their stakeholders to produce sustainable beneficial outcomes for society, the planet, and economic resilience. But it requires the re-engineering of the value chains from tech-driven to human-tech-orientation (Tlemsani, Zaman, et al., 2023; Zaman et al., 2023).

The European Commission acknowledges that the strategic move from I4.0 to I5.0 is significant. The agility of I5.0 prompts us to develop new thinking, which is how we can use the intelligent system to create new values not only limited to the triple bottom line. Despite the debates regarding revolution versus the evolution of I5.0, the Internet of Things (IoT) propels the transformation of I5.0 beyond the digital transformation boundaries. This means that the global education industry is experiencing and witnessing a global phenomenon where convergence is being driven by the specialty of the IoT digital twins (virtual simulations used to shape data models and diminish ineffective changes) (Breque et al., 2021; Xu et al., 2021).

As I4.0 decays from technology-driven to value-driven, the universities must integrate their functions and processes closely with the new paradigm 5.0 (Sung, 2018). To examine the impact of I5.0 in the education industry, the new value chain analysis amid IoT is critical. The converging phenomenon of I5.0 promotes continuous innovations through research and development. Thus, the HEIs need to capture the innovation's reciprocal associations and avenues to capitalize on the production of new knowledge across the portfolio of education. Scholars have recognized the triple helix model to assess the impacts of innovation on HE (Etzkowitz and Leydesdorff, 2007; Tlemsani & Matthews, 2021).

We argue that it is also important for the HEIs (specifically universities) to explore the unique roles of each entity and develop performance indicators to measure and determine compatibility with each other's operations. Fig. 1 demonstrates the overview triple helix model of university 5.0, education 5.0 and I5.0: (a) government source of relation and building the green infrastructure plays a regulating part in terms of developing I5.0 shock, (b) universities – society's immune systems, and (c) the I5.0 emergence (Etzkowitz & Leydesdorff, 2007), are viewed as the primary source for developing new and green technological knowledge for developing resilience. I5.0 – Converging paradigm, which implements green technologies, energy efficiency, and human-intelligent strengths to the world derived from the position of manufacturing.

Comparatively, the new way of I5.0 questions the need to develop an institutional innovation mechanism using human-technology capabilities and strengths. Thus, universities must assess their preparedness for unique education models (both conceptual/empirical) that deliver lifelong learning to global students using sustainable digital transformation (Hashim et al., 2022).

At this juncture, it is important to frame the impact of I5.0 on HEIs (specifically universities) using relevant contemporary literature. This

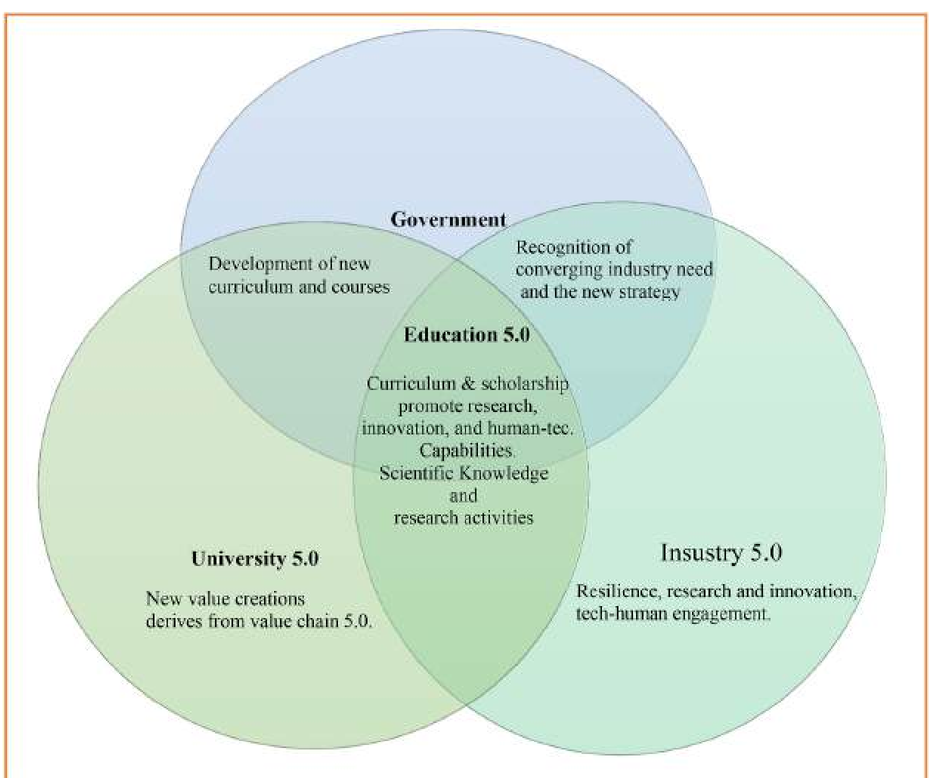

Fig. 1. Demonstrates the overview triple helix model of university 5.0, education 5.0 and I5.0 (Etzkowitz & Leydesdorff, 1997).

approach enables us to further develop a fundamental model to an empirical model (variable view) for implementation. Conclusively assessing the impact of I5.0 on universities requires a careful assessment and integration of both macro and micro environmental factors. Fig. 2 is viewed as a fundamental model that enables us to develop clarity of thought about how universities and education deliver societal values by integrating the core components of I5.0 into their value chain (Li et al., 2020; Leydesdorff & Etzkowitz, 1998; Tlemsani & Matthews, 2020; Hameeda et al., 2022). As factually validated in this section, I5.0 has a direct, influential, significant, and positive impact on HE: strategy, mechanism, and operation.

We foresee that because of the propelling force, I5.0 universities may seek new/niche institutional innovation models and processes for integrating the accumulated impact on them from the changes derived from the government and I5.0. In this context, universities 5.0 have the potential to become the powerhouse of tomorrow's innovations. Thus, to evaluate the conclusive impact of institutional innovation of I5.0, the methodology of triple helix twins and their extension becomes a necessity. Relatively, the convergence of two global phenomena (I5.0 and education 5.0) has enabled us to formulate the following primary research questions (PRQ) and secondary research questions (SRQ) and the aim. These questions are derived from the literature review, and to a dependable level, the research questions shed light on the applicability of I5.0 to the educational society.

PRQ_1: How does the phenomenon I5.0 scientifically impact higher education operations?

The secondary research questions are.

SRQ_1: Are we living amid two Industrial Revolutions 4.0 or 5.0?
SRQ_2: Relatively one – sustainable-techno-social revolution?

I5.0 positions human orientation at the core of HEI's operations, educational systems, growth, and employment, surpassing the confines of the triple bottom-line effect associated with sustainable development for society. Nonetheless, the successful adoption of I5.0 necessitates robust theoretical frameworks, practical methodologies, and executable models. Consequently, the primary objective of this research encompasses synthesizing the evolutionary literature surrounding I5.0, crafting relevant I5.0 profiles tailored to Higher Education (HE), devising a developmental roadmap for I5.0, and formulating implementable models for the systematic analysis of I5.0's burgeoning impact on HE strategy.

Despite the profitable opportunities for the HE sectors, the existing gap in the literature reveals that there is a paucity of HE-specific I5.0 literature. This gap is current, compelling, sizeable, and relevant for HEIs' operations. This paper fulfills the contemporary gap in the literature by amalgamating I5.0 and HE theoretical notions. It also shows a dependable roadmap for implementing I5.0 practices in the HE sectors amalgamating the operation, delivery, and systems of HEIs. These critical findings aid in the evolution of I5.0 practices by proposing empirical insights in determining significant changes and their connections to evolutionary learning (see Fig. 7).

Finally, this paper builds a tetra-dimension empirical model (fundamental model-Fig. 8, empirical model/variable view-Fig. 9.) for implementing I5.0 in HE: the theoretical dimension, application dimension, technical dimension, and practice dimension. Hence, this research suggests original, implementable, and significant models of I5.0 implementation. Also, by developing the applicable models this paper fosters I5.0 system thinking/system state. It is anticipated that the suggested models, a roadmap for I5.0, and proposed I5.0 practices of this paper will fill a significant gap in the current literature and will arouse lively discussions.

2. Literature

This section is classified into four coherent subsections to enable the readers to conclusively recognize the impact of I5.0 H E: recognition, reflection, comparison, and co-evolution.

The first section offers a theoretical view of I5.0, emphasizes the transition from I4.0 to I5.0, and discusses the role of sustainable technologies in superior value creation. The second section stresses the necessity of I5.0 to HE, the development of relevant measures, and the assessment of the impact. The third section examines the importance of developing sustainable I5.0 architecture and the integral role of green IoT. The fourth section sheds light on the challenges of I5.0.

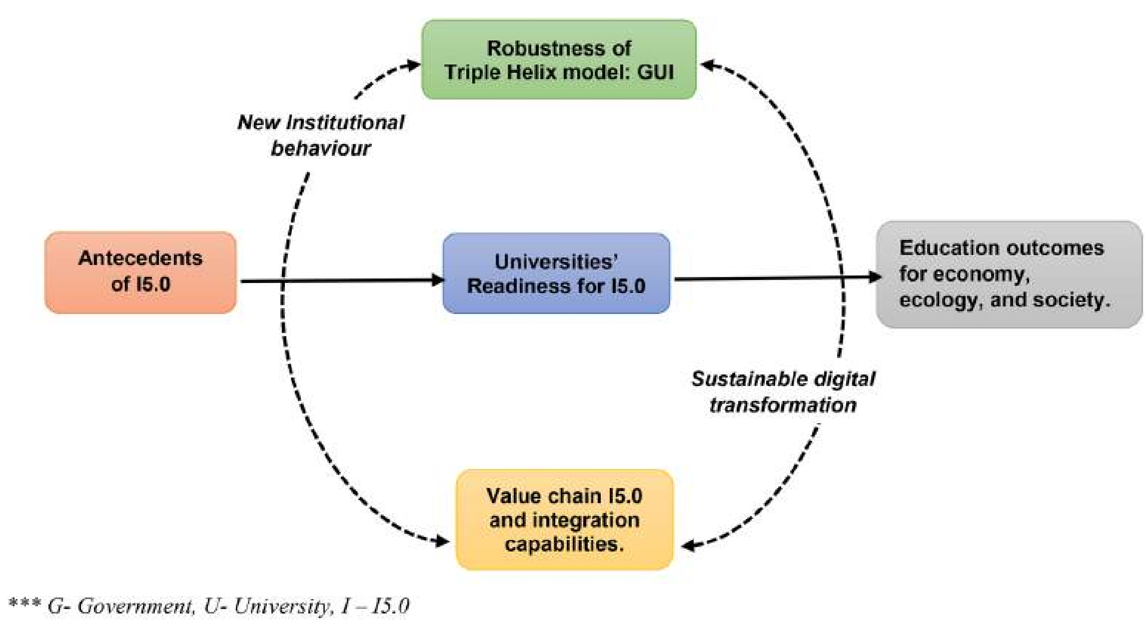

Fig. 2. Fundamental Model framing (Li et al., 2020; Leydesdorff & Etzkowitz, 1998; Hameeda et al., 2022).
*** G- Government, U- University, I – I5.0.

2.1. *The theoretical view*

I5.0 has become a propelling force (rapid change and immense impact) in the education sector (Tlemsani, 2022: Ivanov, 2022; Etzkowitz, 2007). Although it originated in the manufacturing sector its impact is felt in many global industries. The impact has put pressure that may challenge universities' business models and operations. Design for sustainability has become a centric orientation in the university delivery model. In recent years, universities have evolved from classical research and teaching institutions to innovation-driven knowledge hubs offering education demanded by emerging industries transitioning from I4.0 to I5.0. Innovation hubs in the universities have the potential to produce and offer expert knowledge, manage prioritized innovation, and foster new and unique ideas to support society, benefit the economy, and address the critical challenges of dynamic societies. We constructively argue that the impact of I5.0 on universities enabled them to think about ranking beyond academic excellence and count their role in society's well-being, planet, and building resilience.

As of today, universities have started developing a set of compatibility guidelines or policies to regulate their e-learning strategies. It reveals that long-term re-engineering is required to make the strategy align with I5.0 and therefore enhance and continue with the human participatory process. However, there is a lack of knowledge and transparency among universities on the underpinning design of I5.0, its integration, and its effective usage.

Scholars argue that the success of I5.0 requires sizable investment from the government (Ivanov, 2022). It is more likely that the government's objective is to develop (a) sustainable, (b) human-centric and (c) resilience in developing business enterprises and social progress relative to the private sector-the value creation captured **in** Fig. 3 (EFFRA, 2022). In this context, universities have a leading role to play in terms of adopting the core values of I5.0, which is promoting societal-sustainable-resilience across their value chain to deliver education 5.0 instead of delivering education driven by the GDP or revenue growth (Heilbronn, 2018).

Experts suggest that I4.0 is no longer enough for many enterprises to ensure they maximize their opportunity potential from the effective utilization of technology within their process. Thus, the education sector cannot be an exception. We constructively argue that for universities to examine and estimate the potential impact of I5.0, they need to understand the similarities and specifically distinct differences between I4.0 and I5.0 based on its underlying and regulating forces as shown in Table 1.

The sustainable digital transformation era in which I4.0 starting to decay and I5.0 starts as explained in Fig. 4, has enabled universities to selectively invest in new educational technologies tools and solutions (Internet of Things) that permit them to be integrated into a unique I5.0 process to examine the universities' performance and performance improvement (see Table 2). This process focuses on creating superior values in education using their value chain effectively (Kuehnl et al., 2016; Pathak & Pathak, 2010; Tlemsani, Zaman, et al., 2023).

2.1.1. *The convergence from industry 4.0 to industry 5.0*

The fourth industrial revolution enabled universities to utilize technology to a greater extent to build intelligence education systems (Metz et al., 2020; Oliver & Oliver, 2022). The use of AI, cloud computing, big data, and IoT played a critical role in the facilitation of information exchange and communication in the era of I4.0. Simply the I4.0 is a technocentric digital automation process. Thus, the potential competitive advantage to stepping beyond into the new realm of I5.0. Notably, the I4.0 made a significant change in terms of regulating people's work-life in a technocentric way (Fig. 4). IT development and flexibility have been the key characteristics of I4.0 and have relatively impacted the organizational financial performances. It was found that in previous research exploring the impact of I4.0, the cost of services/production decreases by 3.6% per annum in return for spending 5% on digital transformation capabilities over the next few years (Geissbauer et al., 2022).

The fifth industrial revolution (I5.0) is interpreted as the power of an industrial driving force to achieve societal goods and services beyond conventional benefits, such as the development of employment opportunities, multiplying wealth, new systems and technologies, and economic growth (United Nations, 2021). As far as university 5.0 and education 5.0 are concerned, there are five distinct developments considered for evaluations/adjustments (a) digital workload, (b) trust of the intelligent systems (c) the morphology of robotics, and (d) functional

Fig. 3. Core components of I5.0 (ECERA, 2020).

Table 1
Demonstrates the I4.0 and I5.0 university profiles.

Elements/ Forces	I4.0 settings	I5.0 settings	Potential impact on higher education.
Definitions and Philosophy	The process is a significant transformation in terms of how products/services are delivered using digital transformation capabilities. The current trend toward automation and data exchange using emerging technologies. It is defined as the collective phenomenon of the internet and emerging technologies that pilot a new paradigm shift across industries/ particularly in the production industry.	The converging phenomenon places research and innovation at the centre of using green and ethical technologies to achieve new transformation, which is (a) sustainable, (b) human-centric and (c) resilient university/ education industry. Industrialization'.	Transforms the conceptual design of university operation, education delivery, contents, and operational systems. There is a need for placing human-centric and sustainable university/ education systems across the value chain. The emergence of ethical/green and recyclable technologies regulating the university 5.0 and education 5.0.
Focus	Use emerging digital transformation in business operations. The process is dominated by artificial intelligence systems and automation.	Interpreted as the power of industry to gain social goals beyond standard outcomes such as employment and growth	Differences in original principles introduce reusable/green and recyclable technologies towards achieving social fairness, well-being, and sustainability.
Orientation	Driven by technologies and intelligent systems.	Highlights the centric emphasis on research and development to develop sustainable innovation.	Value differences.
Information systems	Leads to flexible service delivery, customisation, and mass customisation.	Green/ethical/ reusable/energy efficient and recyclable systems.	Age of augmentation versus human and machine reconcile systems. The I.50 systems work in symbiosis. Co-existence.
Approach	Organized but cross-sectoral	Developing sustainable models	The difference is sustainability/ resilience in universities' operation and delivery of education.
Time Frame	Projected to be between 2011 and 2025.	Since 2017 an ongoing	The new wave enabled HE to rethink and reshape their operational models/need for new models.
Decision Making Process	Based on information derived from the big data.	Based on a combination of information and experience models.	Simulation to resolve universities/ educational problems.
Nature of workers	Technocentric knowledge workers	Knowledge workers believe in Augmented technologies.	Universities and education systems must involve workers in the development of systems.
Organizational boundaries	Decentralized distributed	Collaborative distribution	One standard across distrusted/ collaborative organizational operations.

design/resign and (e) usability and re-use (Gürdür Broo et al., 2022; Xu et al., 2021; Zizic et al., 2022).

2.1.2. Sustainable technologies and superior values

There are several research studies conducted about the utility of sustainable technologies and their applicability in business operations (Xu et al., 2021; Zizic et al., 2022; Gürdür et al., 2022). Research has revealed the status quo of sustainable technologies, which is that the challenges of sustainable technologies prevail. Thus, an organization requires business models that can transform sustainable technologies into innovative ways of creating superior values (Bohnsack et al., 2014). The ongoing fuel crisis has become a major concern for HEIs regarding the use of sustainable technologies to cater the future energy needs. This phenomenon signifies that implementation of sustainable digital transformation to be successful; it must be economically feasible, ecologically appropriate, and socially fair while building resilience and innovation. Catering to the fundamental needs of I5.0 means universities need to focus on implementing sustainable systems to examine the trends of power consumption, devise energy efficiency capabilities, reduce e-waste, and introduce a dependable mechanism to recycle waste. A sharp rise in the use of solar power and electrical energy has been observed. Solar energy and electricity energy technology development are believed to be important elements of sustainable digital transformation in HEIs.

2.2. The strategic importance of I5.0

The introduction of I5.0 has enabled new academic development since 2017. European Commission formally declared the I5.0 in 2021 and discussed the prospects and consequences among the participants (European Commission, 2021; Dewi et al., 2021; Longo et al., 2020). They released a formal document titled "I5.0: Towards a Sustainable, Human-centric, and Resilient European Industry", which demonstrates their critical analysis. I5.0 is a roadmap to achieve societal goals beyond the past development of employment opportunities and business growth. It means that if universities are to become resilient amidst I5.0, they need to develop unique service offerings which is readily respectful to aspects of the triple bottom line focusing on the impact of operations and activities on the planet and placing workers' well-being at the centre of educational services.

We envisage that the I5.0 will be experienced by the university and education when its four critical elements, namely (a) intelligent devices, (b) intelligent systems, (c) intelligent automation and (d) intelligent IoT, fully integrate with the business environment (physical world) collaboratively. Specifically, the terminology intelligent automation describes super-intelligent robots as intelligent agents/proxies collaborating with a human in the education environment. Reliability, trust, and security between these two parties will gain productivity improvement, smooth

Table 2
Education Profiles I4.0 verses I5.0.

Elements	Education 4.0	Education 5.0	Comments
Lecturers	Lectures are trained to work with intelligent systems and portals. The education delivery is supported by Artificial intelligence (AI), cloud computing (CC), big data and IoT.	Lectures dealing with human machine interaction technologies demonstrate the acceptance behaviour to work with sustainable technologies. The focus is on building human-centric resilience.	
Delivery of Content	Technology-driven learning based on dynamic portals- integrated and supported by Open Educational Resources (OER).	Impact-based learning. Learner-centric. Dynamic, customizable, and individualistic content.	
Learning Process	Adaptive learning is driven by intelligent systems. The learning process could be tuned according to the dynamic/broad learning profiles of the students.	Independent learning is based on individual patterns but not based on a global/standardised pattern.	For universities, it is the learning process relationship/robustness between Mata pattern-pattern build advantages.
Universities' Learning	Increasingly becoming distributed organizations beyond the local boundaries. The delivery of education is based on the Internet.	Universities use the human-machine learning association and its strength to produce knowledge consistently. The learning process uses digital twins to integrate the physical education world with the virtual world.	The boundaries between portfolios of disciplines are shrinking. Thus, the pattern of education delivery and tools used in a discipline become the key differentiators.
Nature of the student	Intelligent systems help to co-develop the education journey. Pressure on the students to consistently update their profiles using adaptive learning mechanisms.	Prepares for the lifelong learning process. Focus is not acquiring knowledge but gaining skills that offer them a job/career.	Students participate in personalized education delivery, where students participate in the design of delivery.
Platforms	AI-driven platforms	AI and green internet platforms combined.	The I5.0 technologies involve high fixed investment, new knowledge, and know-how.
Learning Architecture	Infrastructure plays a crucial role specifically in supporting adaptive learning and data growth.	Reusable, recyclable, and agile architecture.	

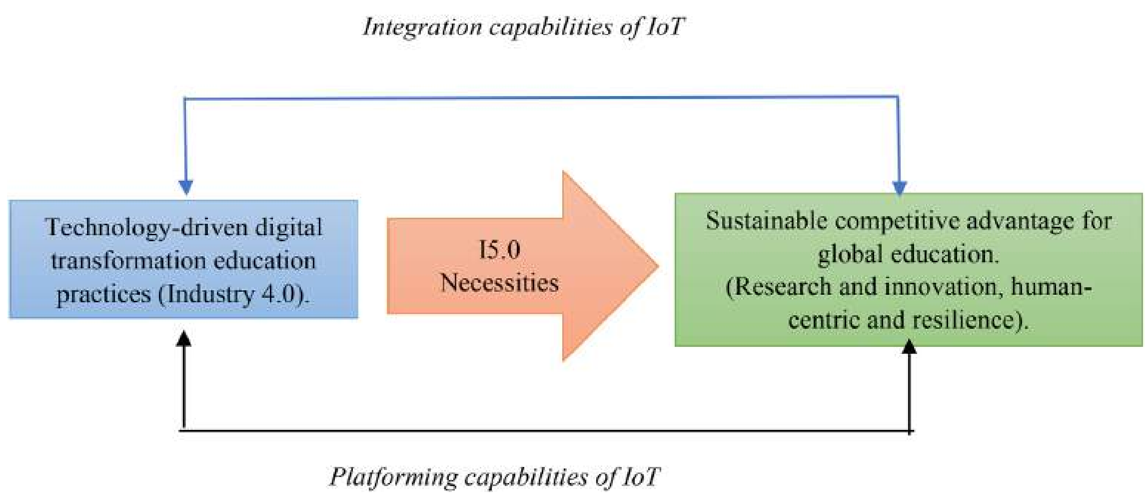

Fig. 4. I5.0 necessities and the role of IoT in university.

delivery, and reduce e-waste while promoting personalized learning.

Although I4.0 does not offer a perspective of sustainability, AI capabilities are significantly used to examine the perspective of sustainability. The results have proved that not sufficient emphasis was given save the environment. Thus, we envisage that I5.0 becomes a solution. This means that I5.0 utilizes human cognitive brainpower and creative imagination to the optimum level to achieve process efficiency. The synergized autonomous workforce is viewed as a distinct differentiation. The emergence of I5.0 does not mean that universities must introduce a new system, function, and process to cope with the agility of I5.0. Instead, they can strategize their service offerings by integrating paradigm 4.0 with research and innovation to drive the transition to a sustainable resilience state.

2.2.1. Economic impact 5.0

The use of robotics to perform cognitive works in universities is becoming important. However, taking advantage of robotic-human collaboration using a brain-machine interface is a niche area and it takes the essence of AI to the next level. Thus, increasing productivity while promoting collaborative involvement becomes a necessity in every aspect/function of university work (Carayannis & MorawskaJancelewicz, 2022). This process best fits the nature of the education industry, unlike other industries, because there is a significant human element in education delivery. The first economic impact we anticipate is the competition in robot-human collaboration.

The second economic impact is that HEIs will develop intelligent education autonomous systems managing the creation and delivery of desired tasks for students based on their profiling. This process not only enables the HEIs to develop new learning strategies but also integrates insights into unforeseen circumstances of students' education with the human cognition interface. We anticipate intelligent autonomous education systems bring two distinct benefits (a) lay the platform to gain economies of scale because of its ability to serve n number of students and n number of tasks and (b) minimising the cost of serving a student because of experience value effect. Thus, it directly contributes to revenue and profitability. I5.0 will increase the university's operational and functional efficiency and shorten the delivery life cycles exponentially. Further, I5.0 is expected to produce significant job opportunities in the education-intelligent-system arena.

2.2.2. Ecological impact 5.0

Efficient management of green hardware and sustainable IT resources, minimising and controlling e-waste, emphasising re-usability, and introducing new recyclable mechanisms and their integration become necessary for universities into their value chain. Comparatively, among universities, e-waste has become a severe issue, and they are forced to explore recyclable mechanisms to the attainment of their sustainable management goals (Chmielarz, 2017). It could be argued in the age of information globalization that digital transformation also could be viewed as a pressing problem. Research reveals that digital transformation produces over 50 million tons of e-waste (electronics and electrical) per annum, and only 20% of it is comparatively recycled. Such amount of waste is forecasted to reach about 120 million by 2050 (PACE, 2019).

The universities need to integrate the recycling mechanism to handle the e-waste and explore solutions. Formulating/instituting advanced processes across universities' value chains continues to be a challenge. Meaning universities must introduce their mechanism for managing e-waste. At this juncture, it needs to be highlighted those certain countries have established unique processes for recycling hardware and e-waste but are not limited to the mainframe, servers, personal computers, laptops, and mobile phones. Particularly in the USA, they charge a $10 recycling fee on hardware unit prices, and that money would be given to recycling agencies to (a) induce the collection of unused/expired hardware items and (b) recycle a wide range of products (Maleshefski, 2007).

As a realistic example, we would like to quote the Apple story, where in the year 2016, Apple recycled 13 million pounds of hardware items, which is nearly equivalent to the 10% range of.

Apple products sold since 2000. This percentage or rate is expected to increase at a 3% compound rate per annum (Maleshefski, 2007). We foresee that the rise of IoT becomes the increasing margin that more hardware devices are expected to be integrated into the universities' value system. However, to what extent is this feasible for universities in emerging economies? Would privately owned universities consider the recycling mechanism as a serious implication unless enforced by the government? How authorities can facilitate the collection of obsolete hardware items is an interesting research topic. Does that mean universities must allocate budgets for their I5.0 recycling need as part of their strategic planning?

The ecological impact (EI) is closely linked to the circular economy as far as the university education 5.0 is concerned (Fraga-Lamas et al., 2021). EI fosters collaborative and effective socio-economic concepts for sustainable development. It aims to serve the current societal needs without risking the needs of future society but is not limited to economic, social, and environmental. We quote The European Green Deal-aiming at achieving new sustainable growth. It is an ambitious strategy that promotes gaining a formidable circular economy that assures biodiversity and minimizes emissions by at least 55% in 2030 (Fraga-Lamas et al., 2021). In this line, cloud computing (CC) and virtualization have drastically reduced the operational workload and power consumption in universities. Specifically, virtualization has helped to minimize the number of computers and savers, whereas cloud computing has a radical impact on reducing the overall fixed cost involved in setting up the IT infrastructure.

2.2.3. Energy impact 5.0

The use of a wide range of hardware items inevitably pushes the university to seek various energy sources. Since the turn of the century, demand for clean and recyclable energy has been rising at an exponential rate. Specifically, the demand for electric power is increasing along with the sustainable digital transformation of education. This phenomenon exerts huge pressure on architects who design power management systems and decision-makers of universities to deal with the power more effectively (scarce utility) while implementing sustainable digital transformation solutions.

I5.0 fosters the mindset among the universities towards energy reduction via multiple channels. However, the most important noteworthy change is that universities are now using big data analysis for (a) energy reduction and (b) efficient usage. The economic utility-electric power is a fundamental requirement for the delivery of online and offline education. The availability of power fluctuates, and electricity is increasingly expensive. Thus, it has an impact on the operational cost of the universities, although it helps the environment by reducing the impact of fossil fuel-based energy. The sustainable digital transformation process in universities requires both the combination of software applications and high-end hardware infrastructure to effectively deliver online and offline courses. Task-wise (a) information processing, (b) information exchange, (c) storing data, (d) running web and multimedia services, and (e) managing the data growth becomes critical. Thus, university power consumption is expected to go high. It is one of the features of university 5.0 (Xu et al., 2020).

Establishing efficient power management and its optimization enables HEIs to minimize operational costs significantly. Particularly, Dell has produced a wide range of hardware items that consume less than 5 W in lower power mode, which is the best sustainable digital transformation because it enables the hardware items to consume less power while in sleep mode (Maleshefski, 2007). Utilizing the power-saving feature as the standard practice of enterprise applications and operating systems would offer the opportunity to significantly reduce power consumption. Operating systems such as Windows and Linux have power-saving features enabled, however, this is not the case for all operating systems.

2.2.4. Data impact 5.0

Big data has become a new knowledge source in the education systems. The sudden rise in big data enabled the senior management of universities to make rapid and shape their decision-making in regular intervals to address the key challenges that readily respect the changing market conditions. It also becomes a knowledge-based resource because it triggers dynamic and adaptive capabilities for strategic decision-making. As the universities operate in the context of I5.0, the education delivery effectiveness depends on the efficient integration of one source bid data resource.

HEIs operation process and their education delivery outcomes rely on the value of the data, which is rapidly changing during the execution. Hence HEIs' education delivery models are increasingly becoming big-data-centric. This is viewed as the university's cognatic capability. It is also essential for universities to establish a mechanism to handle situations of unexpected changes in data values (Tsoury et al., 2019). Universities require in-house or outsourced data centers to operationalize the delivery of education effectively. The digital infrastructure consumes substantial energy. In this context, it needs to be highlighted that the utility of ICT consumes 5–9% of the total electricity requirements, and the trend is expected to increase by 20% by the year 2030 (ECERA, 2020).

2.2.5. Technology impact 5.0

I5.0 attempts to overcome automation anxiety by focusing on the collaborative robotic-human interface. It instils a new type of thinking, which is what technology can do for us. Thus, it is also important for the universities to develop a perspective in terms of (a) the changes in technologies and (b) the emergence of new green technologies so that they become prepared to handle the new green-IoT phenomenon (Longo et al., 2020). The diagram incorporated on the next page indicates the change in technological trends from I4.0 to I5.0. It demonstrates the emergence of (a) ethical technologies, (b) increased use of the human machine, and (c) the use of green Internet of things to a greater degree as demonstrated in Fig. 5 (Zizic et al., 2022).

2.2.6. Social impact

I5.0 introduces human as-knowledge workers 5.0. They use human creativity and innovation enabled by information and technology to

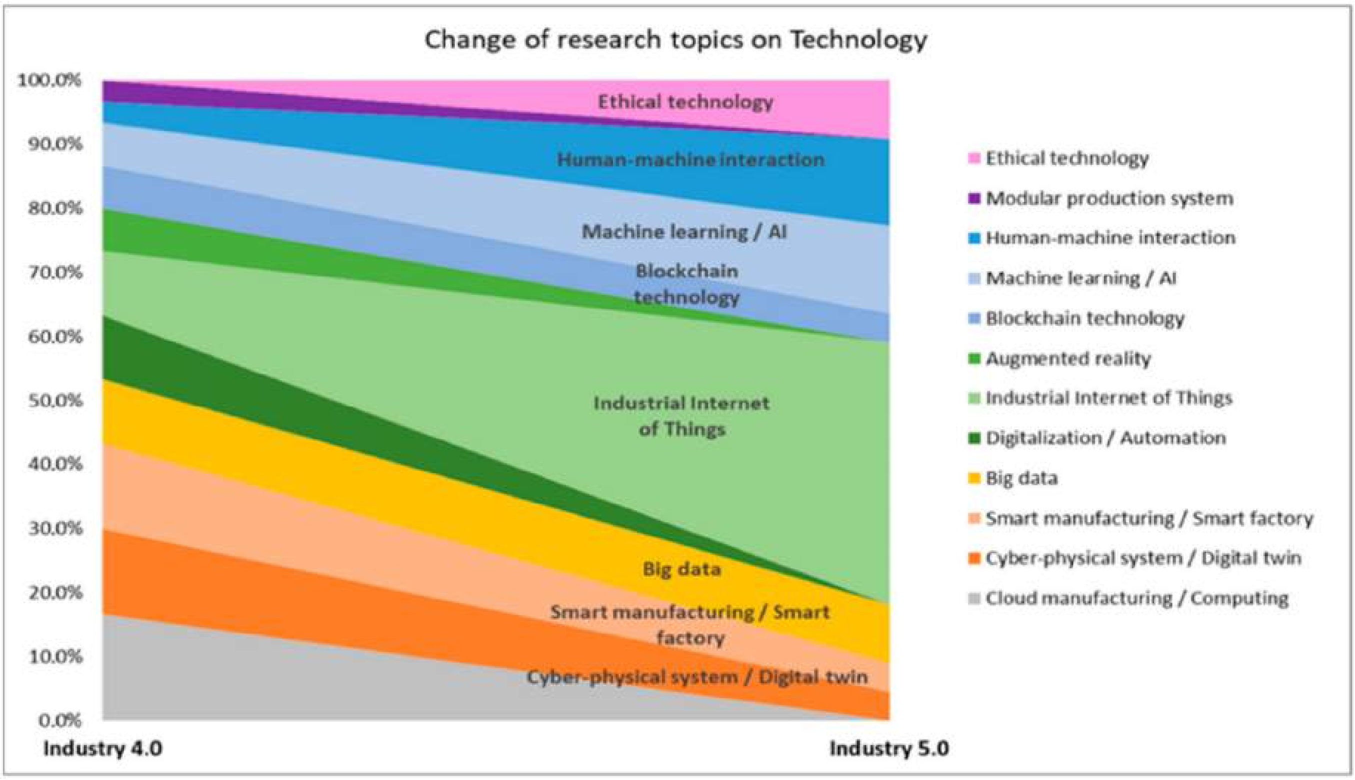

Fig. 5. Strategic shift of technologies from I4.0 to I5.0 (Zizic et al., 2022).

overcome challenges. This paradigm fosters technological development towards social impacts in two distinct directions (a) building self-resilience and (b) developing system resilience. Building self-resilience focuses on fostering human sustainability from (a) physical (b) cognitive and (c) psychological dimensions, meaning the human orientation becomes the centric focus while promoting the technological transitions, i.e., organizational support, human well-being, ethical issues, etc. Developing system resilience demonstrates that it places human-machine functional collaborative strengths as the key emphasis while delivering services (Canbay & Demircioğlu, 2021).

The propelling force of AI, CC, big data, and IoT leads to a more collaborative way to diffuse knowledge from the university to society. In

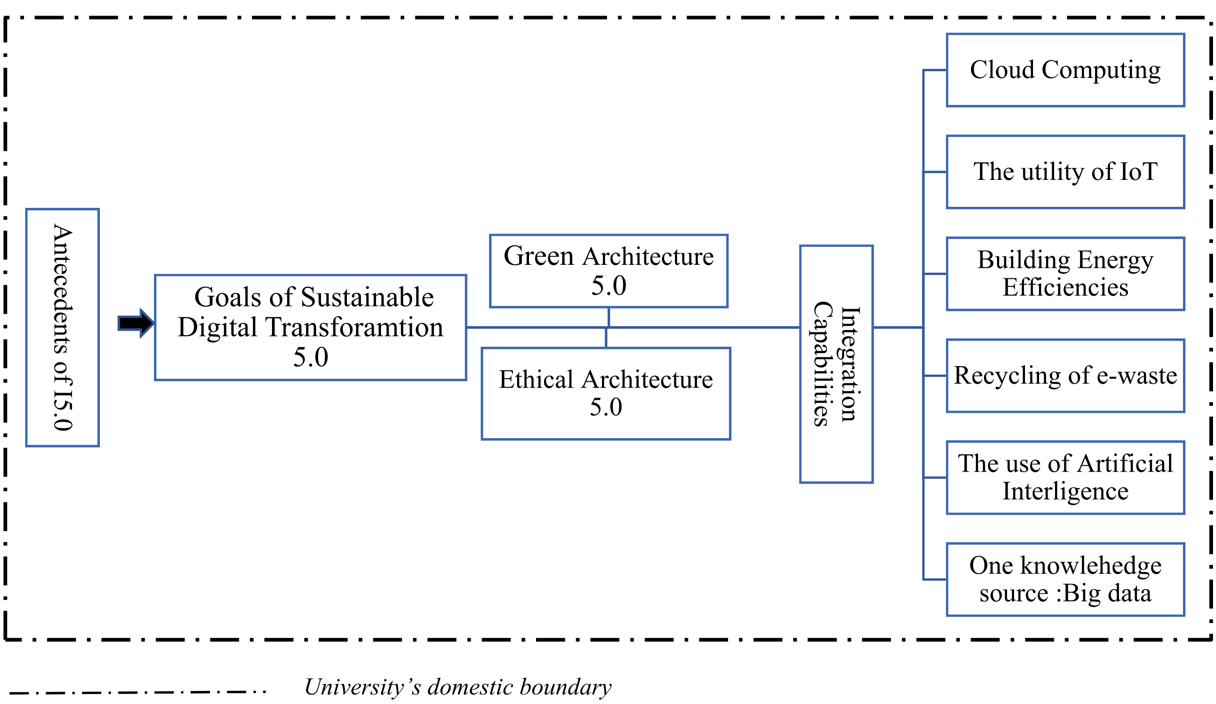

Fig. 6. Information technology elements of Sustainable Digital Transformation I5.0.

any society, universities are viewed as the immune system of societal knowledge. Hence, the new knowledge produced is expected to be reflected in innovative research and scholarships. In line with this, the UN also codified the importance of producing societal value within the context of sustainable development goals and I5.0 (Tlemsani et al., 2023).

2.3. Sustainable digital transformation I5.0 architecture

The utility of SDT has altered and improved the delivery of education to a significant level. We propose the following architectural change to handle robustly the challenges imposed by the I5.0. We constructively argue that education 5.0 requires a new/similar architectural paradigm as below incorporated in Fig. 6.

2.3.1. The integral role of Green-Internet of Things

Green-IoT (G-IoT) has projected a significant growth of hardware devices and the use of emerging software applications across the global networks' worldwide web. Specifically, in the context of a university, it has become an inevitable force because of (a) blended learning, (b) online learning, (c) the emergence of the massive online open course, (d) the birth of online universities and (c) pandemic circumstances (Vogel-Heuser & Hess, 2016). Given the scarcity of IT resources in a university the development of a desirable/environmentally friendly ecosystem is critical. It is also a key area which is to focus on soon because its ultimate focus is to reduce (a) energy consumption, (b) introduce renewable/recyclable resources and (c) reduce the impact of the greenhouse impact on the eco-systems. The G-IoT aims to minimize the global carbon footprint effectively, which is a great priority to incorporate into the university's strategic planning.

We predict that promoting G-IoT as a centric emphasis in the universities' value chains will result in significant changes in human daily life (societal changes) and will help to propose the green ambitious intelligence from the university stakeholders, particularly from the students (future generations) segment-internet of people (IoP). This phenomenon can be achieved by optimizing particularly the power energy consumption and increasing the usage of bandwidth, and both these paradigms are an essential part of education delivery. If universities adopt the G-IoT, then they become the universities 5.0 to actively contribute to the development of a sustainable education ecosystem.

2.4. Challenges of I5.0

The foremost challenge to universities and education is developing education models for business operations that strike a balance between

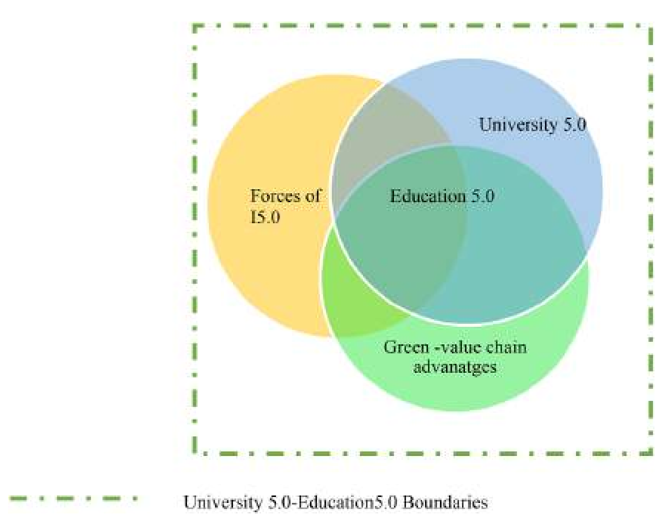

Fig. 7. Potential forces of education 5.0 (Albreem et al., 2021).

monetary, social, and ecological benefits. We envisage that for the state's universities, it will be relatively easy to build competitiveness primarily due to government/state support. However, privately owned universities need to seek new advantages to stay ahead of industry competition. Re-engineering the function, processors, and resources of universities for global education delivery through a new but vial business model is vital. Re-engineering the existing business models of education delivery to be compatible with I5.0 is a complex, multidimensional, and costly task/decision. It requires I5.0 thinking and tools (Albreem et al., 2021).

Amidst the I5.0 revolution enabling human workers to perform high-value tasks using green technologies and or ethical technologies. There may be challenges for staff within universities to adapt to the radical changes imposed by the I.50 because of the requirement to have experience working with green technologies. The demand for I5.0 also may require accelerated skills development within the top management of universities focused on how to utilize the ethical and green system selectively across the value chain to create new values. Thus, such skill gaps must be identified and understood to enable them to be addressed carefully and adequately.

We envisage that strategically integrating the use of G-IoT into the universities' value chain to gain education-social-sustainable values will enhance universities' competitiveness. This process requires sustainable-oriented-innovation-ecosystem policies to build resilience (Figure- 7).

3. Fundamental model and empirical view

In this section, the authors develop simple, realistic, and implementable conceptual models to assess the conclusive impact of I5.0 on education (education 5.0) and universities (universities 5.0). The development of a fundamental model (Fig. 8, Mohamed Hashim, Tlemsani, Matthews, et al., 2022; European Commission, 2020; Breque et al., 202; Togo & Gandidzanwa, 2021; Cillo et al., 2021; Rhayem et al., 2020) for implementation has become a critical aspect of research across various disciplines, including education, information technology, health care, and social sciences.

Developing a fundamental model for implementation is crucial in ensuring that evidence-based practices, programs, and policies are effectively implemented and sustained over time. In recent years, there has been an increasing focus on the implementation of evidence-based practices in various fields, such as healthcare, education, and social sciences. Despite the growing attention, the successful implementation of evidence-based practices has remained challenging, with many implementation efforts failing to achieve the desired outcomes. A well-designed model provides a roadmap that outlines the critical components of successful implementation, including the identification of barriers and facilitators, strategies for overcoming challenges, and the necessary steps for achieving the desired outcomes.

The fundamental model (Fig. 8) exhibits the variable view of the impact of I5.0 on universities and their education delivery. The variable view (Fig. 9) depicts and integrates the goals of I5.0, the mediating impact of I5.0 policies and its key benefits to the university and education delivery. The proposed fundamental model is derived from the contemporary literature on I5.0, university 5.0 and education 5.0. The implementation of the fundamental model is multidiscipline and practical and generates sustainable output as far as the university's global operation is concerned. It also encapsulates (a) one structural model and (b) two unique/distinct measurement models from the structural equation model standpoint. Most importantly, it places the philosophy underlying I5.0 (a) sustainable, (b) human-centric and (c) resilient industries) in the centre to generate the estimated outcomes. This conceptual paper limits the scope of the impact of I5.0 to I5.0 on universities' operation and education globally, interpreted as the outcome -both standard and unique outcomes impacts (i.e., Figs. 8 and 9 described on the next pages).

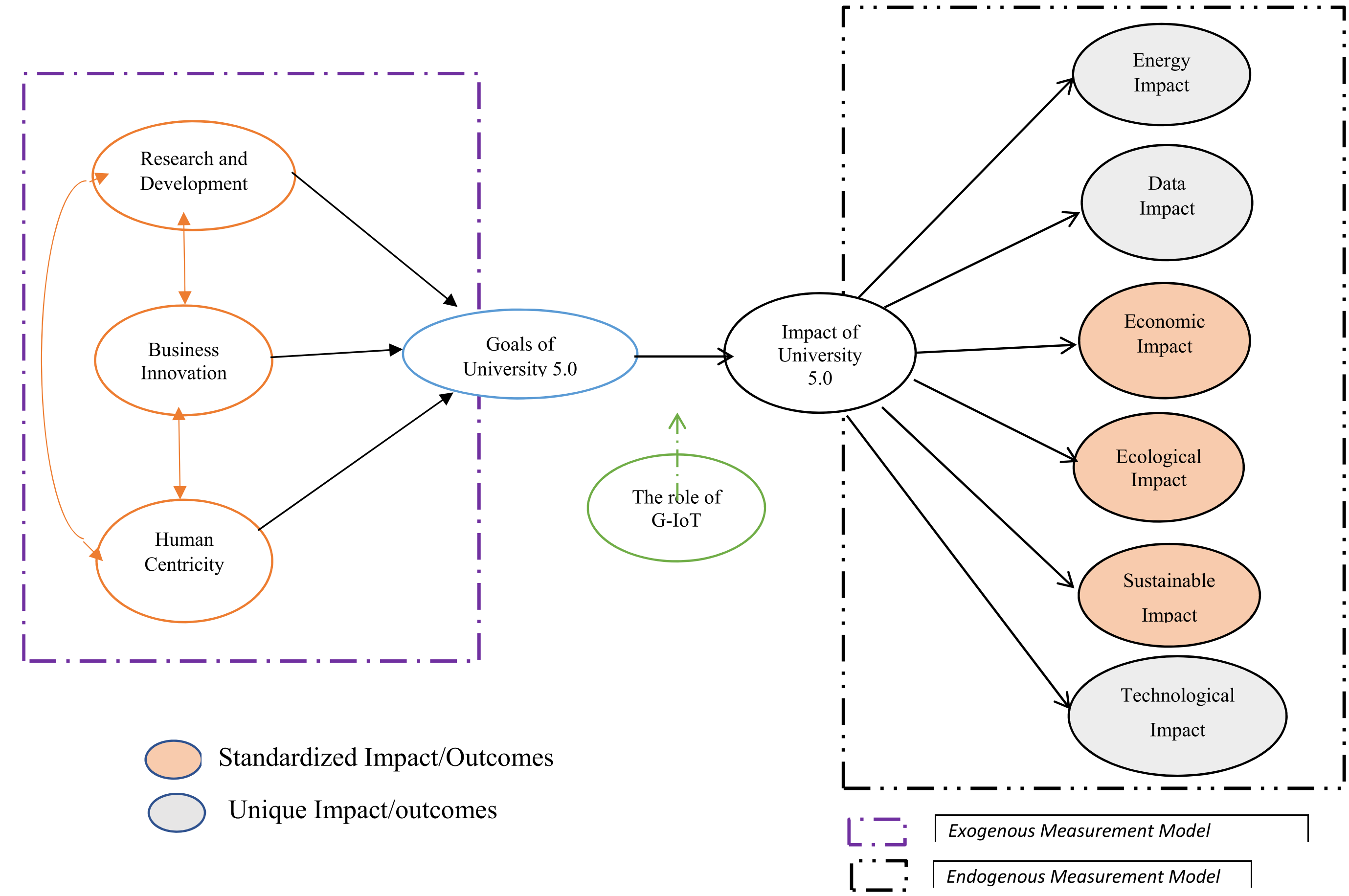

Fig. 8. Impact of I5.0 on higher education.

The detailed model exhibits the exogenous variables (research and development, business innovation and human centricity), endogenous variables/proxies (goals of university 5.0 and the impact of university 5.0) and the endogenous latent (the outcome variables) and the underlying factors/observables. Further, the moderator variable (the role of G-IoT) is linked with the impact on the projected outcome variables. It is important to highlight that proxy variables may play both exogenous and endogenous parts depending upon the changing context.

As stated in Fig. 8 there is a need to develop a perspective on how HEIs interpret and apply the phenomenon of I5.0 and how IoT impact their value creation (Mohamed Hashim et al., 2021; European Commission, 2020; Breque et al., 2021; Togo & Gandidzanwa, 2021; Rhayem et al., 2020). Thus, this research paper critically examines (a) the road to I5.0, (b) its impact on HE, (c) the integral role of IoT in I5.0, and (d) the potential strategies for HE 5.0.

3.1. Extendibility and the robustness of the models

I5.0 capabilities have a significant propelling force and capabilities to enhance the delivery of education by improving the pedagogical design, course delivery, student learning, teaching, motivation, and engagement. Educators must be proactive in terms of adopting and integrating these capabilities into their teaching, learning, and engagement practices. The pedagogical design of the course delivery can be enhanced by promoting learner-centered approaches, enabling personalized, active, and adaptive learning experiences. This approach triggers collaborative real-world learning. Further, I5.0 technologies have the potential to increase student motivation and student retainability via interactive simulation, immersive learning, and gamification. The detailed model (Fig. 9, **Mohamed** Hashim et al., 2021; Aydin & Dikmen., 2021; Puig et al., 2021) could be developed/integrated with other concepts such as (a) students' motivation and (b) regulated learning to enrich its broader application of it. In this case, although the influence of I5.0 remains unchanged-exogenous measurement model, the endogenous measurement model needs to be configured integrating concepts such as collaborative learning, (b) problem-based learning, (c) flipped classroom, and (d) virtual learning. In this paper, the authors also offer insights into the integration process (i.e., Fig. 10).

4. Methodology

Grounded theory (Mohamed Hashim, Tlemsani, Matthews, et al., 2022; Intezari & Pauleen, 2018; Strauss & Corbin, 1990; Tsai et al., 2011) is a novel and methodical approach used in this study to thoroughly evaluate the impact of I5.0 on HE. When a researcher imagines developing a theory about an emerging phenomenon, the grounded theory methods appear to be most appropriate because they offer a window to use peoples' experiences and perspectives (Corbin & Strauss, 2015; Suddaby, 2006). Three distinct coding mechanisms and the thematic analysis combination are recommended as the data analysis techniques. The thematic analysis aims at identifying, clustering, and recognizing existing and emerging themes of I5.0 on HE. This unique approach can create a unique structure for placing the I5.0 theoretical sensitivity and its impact into practice, which will enable them to methodically recognize and grasp its influences on universities' operations/performance.

The I5.0 elements, forces, and major antecedents are mapped and sized using this qualitative research method: research and development, business innovation, and human centricity. Then, the exogenous variable is yielded into a proxy variable which yields predicting the impact.

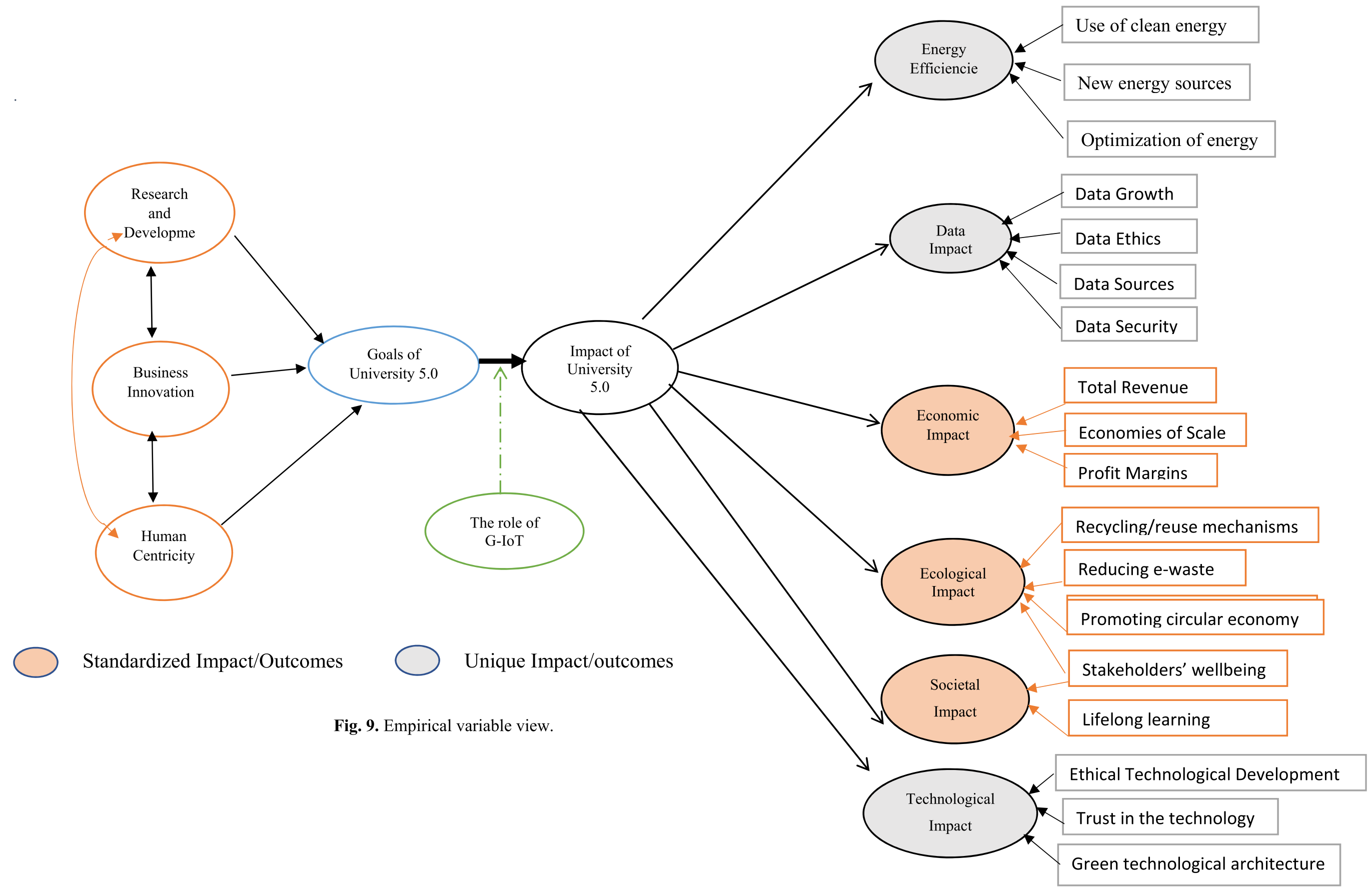

Fig. 9. Empirical variable view.

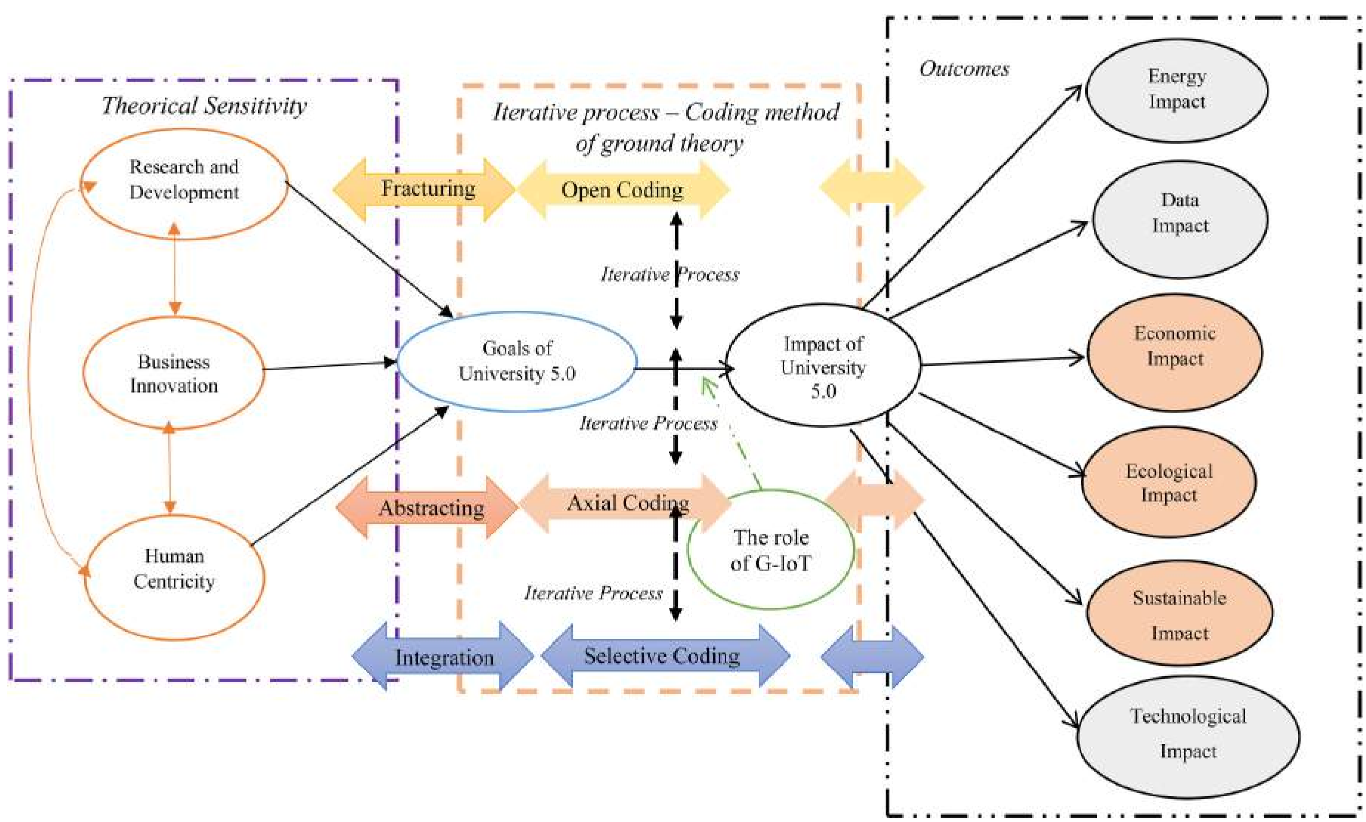

Fig. 10. Impact of I5.0 on higher education.

Predicting the impact is categorized into four distinct outcomes namely (a) triple bottom line (b) energy (c) data and (d) technology related. Thus, the study highlights the importance of identifying, measuring, and normalizing the effects of I5.0 based on the unique characteristics of the HE sectors (Mohamed Hashim et al., 2021 & 2022). Establishing the empirical relationship and causal independence of variables, the fundamental model in Fig. 10, exhibits the data analysis design of the impact of I5.0 on higher education, paves the way for an in-depth investigation of the effects of I5.0 on HEIs operations and performance. Researchers can also apply the model to a particular context by selecting a sector or industry for a case study or carrying out cross-sectional analysis to assess the usefulness and resilience of the grounded theory logic.

Unlike conventional models, we contend that universities operating in the I5.0 era need innovative, uncomplicated, and workable empirical models. Grounded theory has been used by earlier researchers (Mohamed Hashim et al., 2021 & 2022) to investigate, forecast, and project patterns of human behavior as well as the logical integration of systems, which includes facts, patterns, and real-world phenomena. Grounded theory analysis can be used by researchers to examine the precise effects of I5.0 b y conducting several rounds of interviews with faculties, program directors, academic researchers, and managerial workers in HE. It is necessary to have this strong grounded theory feature/composition established before creating the niche body of knowledge known as the impact of I5.0.

Multidisciplinary research uses grounded theory. It uses a methodical approach to gather, analyse, and interpret data. The foundation of ground theory methodology is the idea that multidisciplinary data collected in distinct social settings can be developed into social science theoretical models (Gligor et al., 2015; Mohamed Hashim et al., 2021).

4.1. Coding mechanism

When utilizing grounded theory as research methodology coding mechanisms become a significant source of description that needs to logically be developed, integrated, and controlled. Developing emergent and theoretically sensitive concepts and their underlying properties that fit as vital functions and their relevance to be transformed into niche theory is the purpose of using grounded theory. To do this process effectively, the researchers code data to the extent to which it is imaginable, thus we propose three distinct coding mechanisms (Barney & Glaser, 2016).

- **Open coding:** Investigation of the data analysis approach starts with open coding. Breaking down, classifying, analyzing, and developing the framework for conceptualizing the data of I5.0 is referred to as “open coding’. This approach is specifically used to dissect two distinct theoretical concepts: I5.0 and its relationship to HE performance.
- **Axial coding:** The axial coding process is completed once the open coding procedure is implemented. It is a special technique for determining and demonstrating the crucial and empirical connections between two categories. This is made possible by incorporating coding patterns such as scenario, action, results, and interaction.
- **Selective coding:** The core-coding process is selected, filtered, and identified in this task. This process establishes categories that require additional modifications and performs the necessary cross-category validation. Having a reliable degree of data transcription is essential. This method was chosen with great care to guarantee an accurate assessment of the performance impact of strategic I5.0.

The imperative to cultivate novel insights and empirical models stands as a cornerstone in advancing Industry 5.0 (I5.0) research within Higher Education (HE). In this pursuit, the adoption of grounded theory emerges as a robust methodology, empowering researchers to envision fresh perspectives, elucidate previously obscure phenomena, and stimulate debates on emerging issues. The strengths of this approach, however, must be navigated within certain limitations.

Firstly, while grounded theory is adept at facilitating model building and elaboration, its primary focus lies in the development of mid-range theories grounded in the observations, actions, and behaviors of participants across various levels of generality (Gligor et al., 2015). This method inherently leans towards inductive research approaches (Corley, 2015). Secondly, some researchers, in pursuit of the “flexibility of integration from practice and experience,’ may inadvertently disregard existing literature and established methods. A careful balance is required to harness the benefits of flexibility while maintaining a connection to the proven foundations of I5.0 and HE (Eriksson & Kovalainen, 2008). Thirdly, though open-sensitive, and flexible coding approaches are advocated by some researchers, it is imperative that the results remain anchored to the established literature of I5.0 and HE. Failure to do so risks eroding the competitive advantages gained from a balanced utilization of theory, practice, and experience.

Fourthly, the thorough application of grounded theory demands substantial time and intellectual effort, including diligence regarding key assumptions underlying the theory. Despite being a complex methodology, grounded theory is not entirely mechanical, necessitating a blend of creativity, logical interpretation, and a systematic approach when evaluating the conclusive impact of I5.0 on HE. While grounded theory-specific guidelines exist, their application should be conducive to the emergence of the empirical model in this specific case (Gligor et al., 2015).

Hence, the utility of grounded theory in this research underscores its capacity to foster creativity, encourage logical interpretation, and guide a systematic exploration of the transformative impact of I5.0 on HE. Although this research paper brings a heavy theoretical emphasis on the practicality of I5.0 impacting the universities’ operation and education globally, it raises the critical questions of (a) the need for university and education 5.0, (b) critical issues, (c) benefits for the universities for further analysis. Hence, it systematically captures extensive literature which is critical for developing both conceptual/empirical models.

The phenomenon-the impact of I5.0 on global education is a niche phenomenon, a new body of knowledge, emerging research topic. Thus, applying the grounded theory as a methodology to recognize the existing themes and new themes will enable the researchers to recognize the causal relationships in changing contexts, and that process led to developing a theoretical model is a necessity. Transcribing and establishing the connections among themes using an iterative coding approach using either *N*-Vivo/Ucinet/Pajek is recommended.

5. Findings and discussion

This research provided a wide range of evidence that captures the influence of I5.0 fosters important trends that significantly affect the design, development, and delivery of education and university operations. The influence of I5.0 is viewed as an enormous change in our time. Our findings validate that the impact of I5.0 is being experienced by HEIs in the forms of.

(a) Formulating HE strategies to enable lifelong learning.
(b) Designing and re-designing the education portfolios to impart transdisciplinary

Education.

(c) Revamping their education value chain to integrate I5.0 elements in line with

Sustainability, resilience, and human-centric design modules.

(d) Increasingly using I4.0 and I5.0 technologies to stimulate pedagogical delivery.

(e) Utilizing big data, state-of-the-art information technology infrastructure, and AI

Capabilities combined to manage the delivery of courses.

(f) And significantly shaping the students as tomorrow's valuable knowledge workers.

The green-sustainable digital transformation included in the I5.0, university 5.0, and education 5.0 is to ensure that students still lead the human-driven, sustainable, and creative innovation in their education life. Universities have increasingly a vital role to play in this process because their role in society is to develop new knowledge. It requires progressive green/ethical development in information technology, and it also needs to be accompanied by raising the bar of innovation and I5.0 literacy in every citizen, specifically in every student. It was found that the use of I4.0 technologies alone has potentially undesirable impacts on the environment. I.e., generating polluting waste and intensive utilization of raw materials. However, by adopting green and ethical technologies, the utility of the energy can be reduced by analyzing the insights of big data during the education delivery and operations of the universities and their integration into the value chain. Universities using augmented reality as a key element in their education delivery saves about 10–30% in energy efficiencies, the use of cloud computing helps to save about 70% energy reduction and the analysis of big data helps to save 11–14% by selectively utilizing the energies (Mohamed et al., 2021 & 2022).

The need for HE strategy factually analysed and emphasized in this research in line with the I5.0 paper is an interpretation/discussion on how (a) the converging phenomenon of I5.0 creates values for global education and universities, (b) stresses the importance of developing I5.0 measures (c) dialogues the strategic importance of utilizing opportunities created by I5.0. (d) Stem relevant managerial implications for driving the shock of I 5.0 and (e) propose a fundamental model, detailed model, and an empirical framework for spearheading the implementation of I 5.0.

The wave of I5.0 on HE triggers a new change in education in education delivery and university operations. This new change will bring a common attitude among universities which is how to utilize the advancement of I5.0 technologies to foster superior values in course design (pedagogical design), delivery, and university operations. The integration of ethical and green technologies will assure significant reliability, security, and transparency relative to I4.0 technologies. Thus, the potential of I5.0 will further widen the effective implementation of Massive Open and Online Courses (MOOCs) and boundaryless organizations (Mohamed Hashim, Tlemsani, Matthews, et al., 2022).

HEIs should play an effective role in defining the future vision in alignment with I5.0 and they must consistently respond to them. It means they need to re-engineer their role and the way they are going to react to the radical changes of I5.0. Meaning how they can bring the human-robotic collaboration in (a) online, (b) blended and (c) virtual learning while promoting ethical/green technologies to satisfy novel expectations of the students (Gerrard, 2007). With all disruptive changes, there is a recognized adjustment within the agents within the system, this will also be true within the university environment. However, raising the importance of developing Education 5.0 and mobilization of funds to serve its objectives is vital. Also, the innovation hub is responsible for providing a full explanation in terms of how they are going to create value. Well-developed I5.0 policies and guidelines. Established learning curve support and re-skilling support can aid a smoother and better-managed change transition.

I5.0 brings a new equation to the table, which is, how will the sustainable digital advantages of universities be in the age of I5.0? What competitiveness does it bring? Thus, universities need to develop perceptual mapping to mind map the alternative possibilities and explore a roadmap of sustainable advantages for I5.0 so that universities recognize, re-design, re-engineer, and aim towards gaining digital value chain advantages for education 5.0. It is argued that sustainable digital advantages are vital. It is usually closely linked with the business model innovation of universities. The below diagram exhibits the distinct perspective of sustainable digital advantages of HE. Although all the HEIs would want to end up in a high-high grid as far as their strategic sustainable digital advantages are concerned to meet the I5.0 need, they still envisage other possibilities are possible as exhibited **in** Figure 12 (Mohamed Hashim et al., 2021, 2022).

Another critical element of I5.0 which have garnered attention in the recent past is the use of ethical technology and this is very strongly associated with the other aim of I5.0 human centricity, which overlaps with the application of sustainability. The acceptance that lowers ethical standards, practices and their application generate an unsustainable society are a key driver to the adoption of more sustainable approaches. Unfortunately, I4.0 alone has the potential to subordinate the knowledge workers in education to technology, but it should have been vice versa. We envisage that I5.0 is a new ethical paradigm. It is argued that sustainable digital advantages are vital. It is usually closely linked with the business model innovation of universities. The below diagram exhibits the distinct perspective of sustainable digital advantages of HE. Although all the universities would want to end up in a high-high grid as far as their strategic sustainable digital advantages are concerned to meet the I5.0 need, they still envisage other possibilities possible as exhibited in Fig. 11.

Well-architected sustainable digital advantages will guarantee projectable results for universities, i.e., revenue performance, sustainable priorities, and student retention ability. However, universities should be able to obtain relevant information just in time to develop key performance indicators to track/trace their performance.

The vision of developing university 5.0/education 5.0 capabilities is to build sustainable advantages for the universities, particularly in their education delivery, making a desirable I5.0 shock to society and promoting the sustainable initiative. Investments in the I5.0 project are comparatively expensive due to the higher fixed cost associated with the implementation. Thus, return on investment may take time.

University 5.0 and Education 5.0 need to recognize that society is at the core of the I5.0 system. Business innovation and research and development are designed, developed, and delivered by the universities, which reflects their strong association with the regional innovation systems. They have the sole responsibility for promoting lifelong learning. We argue that the impact of I5.0 on universities and education systems has an implicit meaning for the future society.

6. Conclusions

This research presents a niche and distinct perspective on HE amidst I5.0 and emphasizes the need to prepare for and enter the I5.0 era. The academic evidence reveals that the impact of I5.0 is a key trend in HE. It is a converging but new phenomenon, not simply a chronological continuation of I4.0. It means the wave of I5.0 will put the robotic cognitive ability very close to the knowledge workers' lives in education delivery. However, the awareness, adoption, and implementation of Industry 5.0 are still in the infancy stage of the HE sectors.

It is strategically important for HE to recognize the remarkable change in our times, human knowledge is significantly growing, it is increasingly becoming more temporary, the boundaries between the body of knowledge are eroding and we may have reached a point where absorption of knowledge is at its optimum level. Thus, the implementation and integration of I5.0 requires significant investment. It is also equally important to indicate that in this context, two questions are critical (a) how long the human cognition can cope with the disruptive changes of I5.0, and (b) will the cognition of robotic cognition grow beyond human cognitive capabilities to rescue when we fail? I5.0 enables the HEIs to develop research-innovation hubs to address the key/

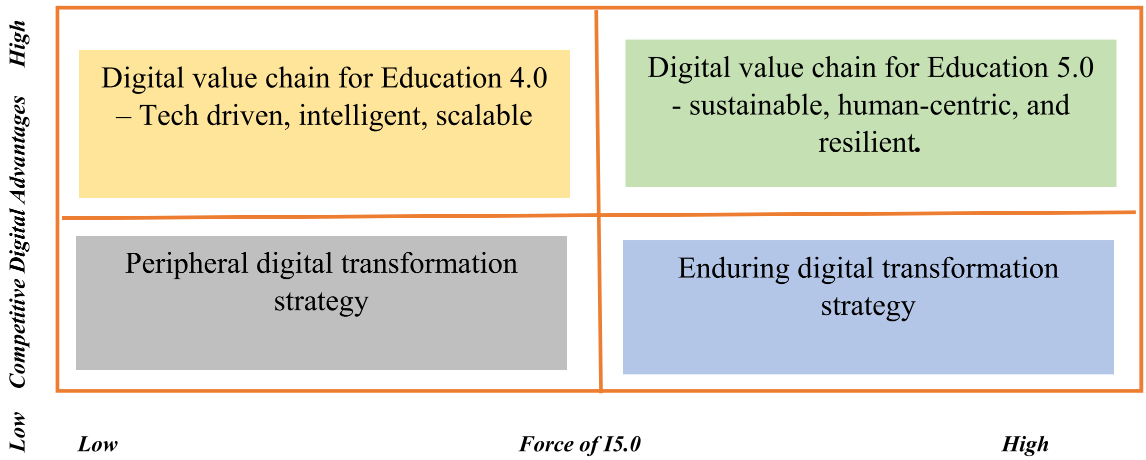

Fig. 11. I5.0 digital advantages perceptual map (Mohamed Hashim et al., 2021, 2022).

potential challenges as part of university 5.0 and education 5.0 mandates. Through this research-innovation hub, universities can promote I5.0 practices, motivate their workers, and ultimately create an I5.0 shock on societal behaviour.

Unlike I4.0, I5.0 is built on a value-driven approach. It embarks on placing importance on necessary societal needs, gaining sustainability, and pursuing resilience as the ultimate goals of HE as far as the global education sector is concerned. Thus, it demands a new but green and ethical technological push. Paradigms such as I4.0, I5.0 and in the future industry 6.0 are not too distanced when you consider the speed at which information technology is growing. We believe this article sparks and encourages researchers to conduct extensive research around this research topic as we provide a blueprint for the impact of I5.0 on education's future. I5.0 influences on education cause paradigm shifts for knowledge workers, students, the HEIs themselves, and current technologies, stressing the importance of revisiting the existing functions and processes they deal with. People will always continue to be the centric focus/drivers of I5.0. To manage this process effectively, they need two-way knowledge transfer from the virtual world to the physical world.

I5.0 demands extensive research in terms of adapting green and ethical information technology to human-centric work delivery. Thus, significant research efforts should be made in the areas of (a) identifying dependable methods (b) data collection, and (c) interpretations aiming at developing a new body of knowledge. I5.0 attempts to utilize the competitive advantage of human-robotic cognitive strength in a collaborative manner, which leads to the development of autonomous robots that can collaborate with humans and contribute to excelling in global education delivery. However, these collaborative endeavors must influence building research, innovation, and resilience.

I5.0 creates an opportunity for technologies to be at people's disposal. In other words, it enables the technology to work for people while building energy efficiencies and diminishing potential work for the environment. It is a challenge to strike a balance between all key elements of I5.0 (literature) in a new context while placing a centric emphasis on the human aspect. In a sense industry, the 5.0 paradigm triggered the change of the main objective from I4.0 (autonomous) to human centricity and sustainability while building resilience. From a different angle, it focuses on knowledge workers' education and the development of new knowledge and promotes the unique feature of lifelong learning. Promoting lifelong learning instead of seeking a modern technology to substitute potential and future tasks.

The advancement in classroom sensors, smart hardware objects, the use of a CC for lab, the use of big data in students' experiences, and information exchange on global delivery of education will induce innovations continuously in the G-IoT. It may lead to developing a new domain of knowledge either in the short or the long run. However, the practicality and the deployment of G-IoT remain to be in the early stages of HE. The wave of I5.0 is believed to be impacting education 5.0 in terms of (a) mode of learning (b) principles of learning and (c) perceptions of the students to a greater degree. In this context, we conclude that the utility of G-IoT could prove to be a paradigm shift-as an enabler of sustainable smart HEIs.

To address the challenges we propose four distinct strategic options for HE delivery to embed into their I5.0 vision (a) promoting lifelong learning and transdisciplinary courses for bridging the gap of I5.0, (b) penetrating the strategic importance of utilizing the strengths of human-robotic cognition effectively across the education value chain (c) building a research-innovation hub to promote agility and (d) investing/exploring green/ethical technologies to contributes to the planet while promoting innovative/resilience education delivery. In conclusion, HE benefits from the I5.0 influence if they understand the potential impact and can embrace the disruptive changes to utilize them for effective strategic development. Sustained adaptation is the key to best managing the ongoing influence of I5.0 on HEIs' operation and delivery of HE worldwide.

Finally, this paper structured a tetra-dimension empirical model (experimental model) for implementing I5.0 in HE, namely, the theoretical dimension, application dimension, technical dimension, and practice dimension. Numerous limitations and the stated challenges need to be addressed for the potential researchers to develop relevant and complex I5.0 theories specific to education because the awareness in the service industries has not grown significantly as good as the manufacturing industries. Hence, establishing an open-ended dialogue in the I5.0 realm is necessary. Future researchers could focus on using structural equations or double helix methods to develop a more complex and contextual model so that distinct differences in the impact could be captured. Further, future researchers also deepen the understanding of how I5.0 could be positioned as a system to achieve sustainable development such as a smart society, triple bottom line effects, and green strategic values. The authors expect that the originality, rigger, and impact of this research will lead to lively discussion and dialogue in HE and its relevant field.

Ethical statement

Ethical approval is not required – concept paper.

CRediT authorship contribution statement

Mohamed Ashmel Mohamed Hashim: Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Issam**

Tlemsani: Writing – review & editing, Supervision, Conceptualization. **Rachel Mason-Jones:** Writing – review & editing, Supervision. **Robin Matthews:** Validation, Methodology. **Vera Ndrecaj:** Writing – review & editing, Validation, Resources.

Declaration of competing interest

Hereby authors declare no conflict of interest.

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ARTICLES FOR UTM SENATE MEMBERS

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Review

Transitioning towards Tomorrow's Workforce: Education 5.0 in the Landscape of Society 5.0: A Systematic Literature Review

Sharareh Shahidi Hamedani [1], Sarfraz Aslam [2,*], Bha Aldan Mundher Oraibi [1], Yap Bee Wah [1] and Shervin Shahidi Hamedani [3]

1 Faculty of Business, UNITAR International University, Petaling Jaya 47301, Malaysia; sharareh.pt@unitar.my (S.S.H.); bha.aldan@unitar.my (B.A.M.O.); bee.wah@unitar.my (Y.B.W.)
2 Faculty of Education and Humanities, UNITAR International University, Petaling Jaya 47301, Malaysia
3 Sofiveco SDN BHD, Kuala Lumpur 58000, Malaysia; shervin@sofiveco.com
* Correspondence: sarfrazmian@nenu.edu.cn

Abstract: Globalization and technology are presently impacting every aspect of life, with digital technologies helping to set the trend. Human-centricity and the ethical use of technology are integral components of Society 5.0, which emphasizes quality of life, productivity, social responsibility, and sustainability. The purpose of this study was to develop a deeper understanding of how Higher Education 5.0 empowers the future workforce in the landscape of Society 5.0. A systematic literature review was conducted using 18 full-text research papers from the Scopus database. It shows that the number of studies in this area is limited. The results revealed the critical role of education in cultivating the digital skills necessary for upcoming professionals. In order to transition from higher education to the workplace, fresh graduates need academic and practical readiness to meet the demands of a future-ready workforce. The contribution of the future workforce will also be crucial in building a harmonious human-centric society that will use technology to improve the quality of life towards sustainable living as envisioned by the United Nations' SDGs. Additionally, we identify the current gaps in the research on Education 5.0 in the landscape of Society 5.0 and subsequently provide recommendations for the future.

Keywords: globalization; digital skills; Society 5.0; Higher Education 5.0; sustainable development

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1. Introduction

The world is presently experiencing a wave of change that is impacting every aspect of life, with digital technologies and tech-savvy shifts setting the trend. The speed of technology is improving human life in several beneficial ways. Society 5.0 (S5.0) was launched in Japan in 2016 with the slogan "super smart society", and it was announced to the whole world [1]. The Japanese government unveiled the idea of S5.0 as a vision of human existence in which technology is used through the integration of cyberspace and physical space for social and economic development. S5.0 focuses on a human-centric society with the ethical use of technology for improving quality of life, productivity, social responsibility, and sustainability [2,3].

The evolution of society shown in Figure 1 depicts how society moved from an industrial society in the 18th century to an information society in the latter half of the 20th century, and with rapid technological advancement, we will move towards a super-smart society (S5.0), a new era of the seamless integration of human society with advanced technology [1,4,5]. The application of information and communication technology serves to integrate processes across the realms of intellect, reality, and virtuality, thereby intertwining technology with the essence of humanity. In other words, by acting as a link, S5.0 facilitates the convergence of digital innovations and information resources to create a more cohesive and effective society [6].

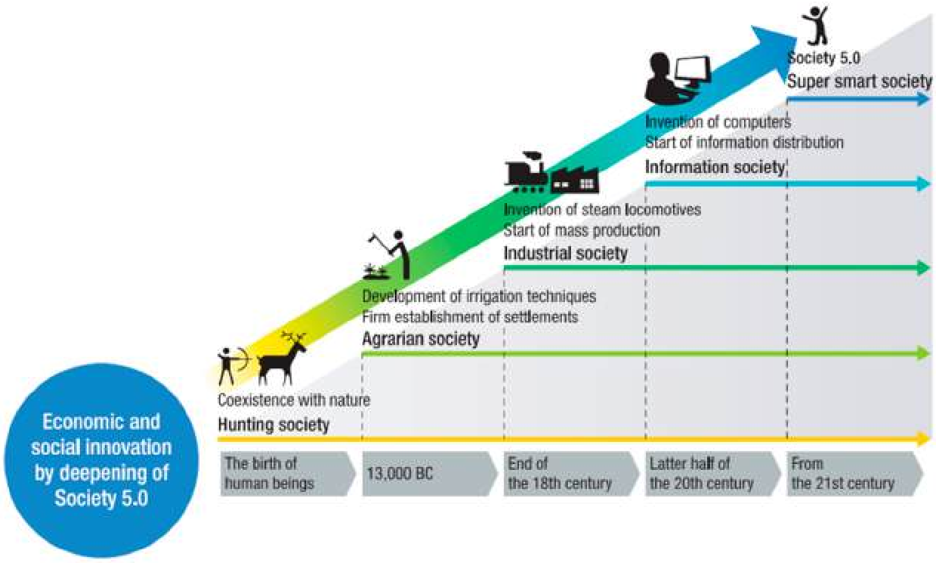

Figure 1. Society 5.0: Aiming for a new human-centered society: adopted from [4].

In their study, [7] highlight how Malaysia is positioning itself to transition towards Society 5.0, a framework that integrates both physical and digital technologies to address societal challenges. This initiative seeks to enhance economic and community development through emerging technologies. The Malaysia Digital Economy Corporation (MDEC) is playing a pivotal role in this transition, aiming to create a more sustainable and inclusive society for all citizens. A key component of achieving Society 5.0 is the development of Education 5.0, which focuses on preparing students for a future where technology and human values are seamlessly integrated. Education 5.0 emphasizes not only technological skills but also critical thinking, creativity, and ethical considerations. To shift toward this transition, Malaysia must update its educational system to prioritize these aspects from an early age. This involves incorporating technologies into the curriculum and fostering a learning environment that encourages innovation and problem solving.

Penmetsa and Bruque Camara [8] highlighted the significance of education institutions as foundational pillars for the development of super-smart societies within the framework of S5.0. In parallel, the evolution of higher education institutions (HEIs) is deemed inevitable due to the evolving landscape influenced by technological advancements, which will impact the traditional roles of HEIs in knowledge creation, transmission, and conservation [6]. In fact, the foundation of empowering a future-ready workforce through higher education lies in digital transformation, which will create a more effective, efficient, and equitable education system capable of adapting to the needs of future society and the industrial revolution [9].

The concepts of S5.0 and Industry 5.0 (I5.0) are not a simple chronological continuation or alternative to the Industry 4.0 (I4.0) paradigm. Industry 4.0 revolves around the idea of the smart factory, where intelligent products, machines, storage systems, and data converge within cyber-physical production systems [10], enhancing human–machine interaction from a technical perspective. However, its technological advancements need to place greater emphasis on the central role of humans in social sustainability [11]. Industry 5.0 complements the current Industry 4.0 paradigm [12], combining human intelligence, subjectivity, and creativity with the efficiency, artificial intelligence, and precision of machines through this approach, in which human-centric values are emphasized [13].

The Sustainable Development Goals (SDGs) encompass 17 objectives that serve as a framework for operationalizing the three pillars of sustainability through targeted goals and indicators. These measures help evaluate how governments, industries, and communities contribute to sustainability efforts [14]. S5.0 aims to place human beings at the midpoint of innovation, and I5.0 focuses on technological integration to achieve the SDGs, which aim to reduce poverty and inequality, provide quality education for all, protect the environment, and develop a smart society that can use the application of digital technology for social and economic development. It also has major implications for university transformation; in order to achieve S5.0, the university needs to have an education paradigm shift and focus on improving the people, processes, and technology in the university to align with I5.0 and S5.0.

Digitalization is a key driver of the university transformation towards S5.0. By prioritizing human-centered innovation and developing new cooperative models, universities can effectively achieve their sustainability goals. In this context, utilizing the Quintuple Helix Model (QHM) can facilitate the development of essential transformation capacities by incorporating diverse perspectives and establishing a foundation for sustainability priorities and considerations. In terms of practical goals, the study proposes a range of suggestions for universities seeking to develop new methods and avenues for delivering education, research, and innovation within the frameworks of QHM and Society 5.0, described as socially and digitally engaged models S5.0 [6,15]. The quintuple innovation helix highlights the significant role of resilience in understanding complex innovation processes, especially within dynamic external and internal environments [16].

Education 5.0 integrates cutting-edge technologies, like artificial intelligence, big data, and advanced virtual reality, with collaborative learning and practical experience. Its main objective is to equip students with critical thinking, problem solving, and teamwork to thrive in a rapidly changing world [17]. According to Felcher and Folmer (2021), Education 5.0 focuses on developing individuals capable of applying knowledge in practical and innovative ways while collaborating with others [18]. Education 5.0 acknowledges the crucial role that cutting-edge technologies play in the educational process while also stressing the importance of developing interpersonal skills and applying knowledge in evolving contexts. By addressing the needs of a rapidly changing world, this approach marks a significant shift in preparing students for future challenges, equipping them with not only theoretical insights but also the adaptability, innovation, and collaboration skills necessary for success [17].

Collaborative teaching methods, such as co-teaching, team teaching, and peer coaching, provide instructors with the opportunity to work together in course planning and delivery (Carty & Marie Farrell, 2018). Often referred to as "co-teaching", these approaches enable educators to combine their knowledge and expertise, collaborate on lesson development, and offer personalized support to students with diverse needs. Personalized learning is a learning approach that aims to personalize the learning experience according to the unique needs, goals, and skills of individuals, which can be achieved by using current instructional technology that provides unique learning experiences in different learning environments [19].

HEIs will need to transform and offer quality education through Education 5.0 (E5.0). E5.0 includes digital technologies, collaborative teaching, personalized learning, and lifelong learning, which means it encourages the use of more humane instruments and methods to enhance individualized learning. Humans are placed at the center of education through E5.0. Therefore, HEIs need to leverage digital transformation to equip students with technical skills and knowledge, as well as with the soft skills required for future work in the industry. HEIs need to prepare the workforce for S5.0 [20]. Likewise, in Malaysia, HEIs have a significant responsibility to lead society to move towards the vision of S5.0. One issue highlighted the disparity between educational achievement and job requirements among Malaysian graduates, leading to a mismatch between the competencies demonstrated by graduates and the competencies desired by employers [21].

Fundamentally, education is the cornerstone of all progress and development. E5.0 will focus on providing people with resources, customizing the educational process to meet the needs of each learner, and incorporating advanced technological educational instruments to prepare learners for future career prospects. Universities play a threefold role in fostering innovation: (1) providing knowledge, either existing or created through partnerships with the outside world, to support innovation creation; (2) sharing their material and immaterial resources; and (3) supporting the development of (digital) social innovation by providing support to social innovators and involving stakeholders [6].

This paper investigates how HEIs can adopt E5.0 to prepare graduates for the future workforce for the shift to the S5.0 paradigm. This research contributes to the body of literature by elucidating the requirement of a future-ready workforce through E5.0 within the framework of S5.0. This research was guided by the following research question: How can Higher Education 5.0 empower the future workforce for Society 5.0?

2. Methodology

To prepare the future workforce for S5.0, we must bridge the above-discussed gaps in Higher E5.0. An Integrative Systematic Review [22] of the literature is the most appropriate methodology to address the objectives.

2.1. PRISMA Protocol

A systematic review of the literature was conducted, and the reporting of this systematic review was guided by the standards of the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA). In the PRISMA guidelines, 27 items are listed, and a four-phase flow diagram is shown (Figure 2) that outlines essential elements for ensuring clarity in literature reviews [23,24]. This study was framed using the PRISMA analysis. A thorough data collection approach and meticulous and detailed procedures ensured that our approach adhered to high-quality-literature-review guidelines. A systematic approach is recognized due to its adherence to a defined protocol for data synthesis that incorporates relevant and reusable material used by previous researchers. This systematic review was conducted following the PRISMA guidelines. The completed PRISMA checklist is provided as a Supplementary Materials.

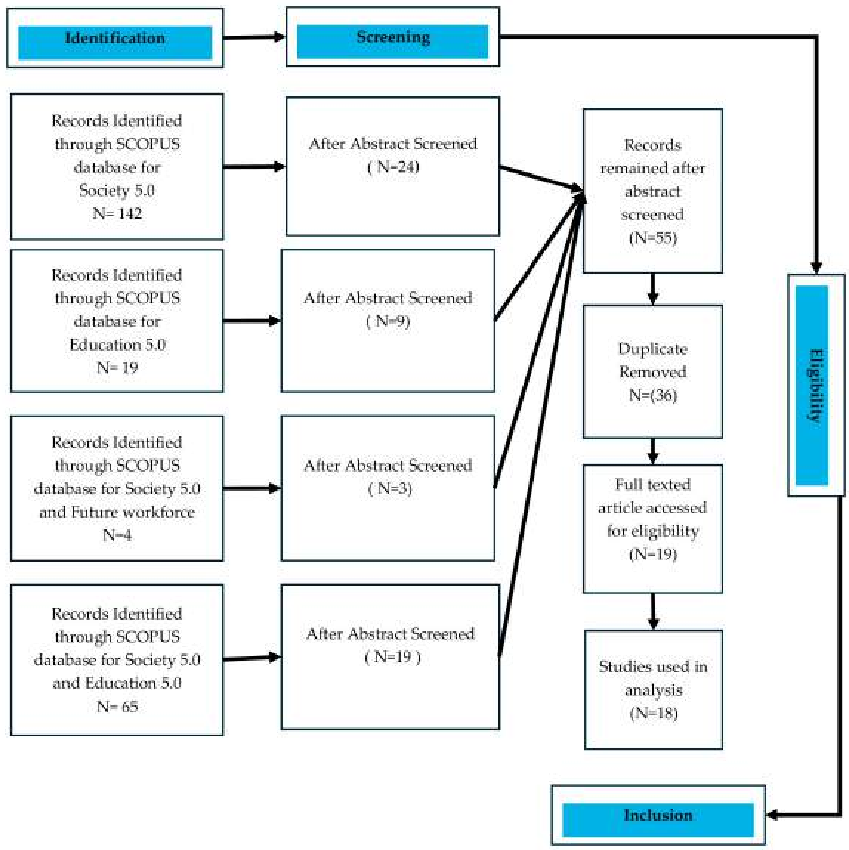

Figure 2. PRISMA flow diagram.

By utilizing the PRISMA method, researchers can access reliable and well-known databases in the social sciences [25,26]. Researchers can use keywords to precisely define the scope and limitations of a study using this approach. These guidelines also help researchers to avoid wasting time and second-guessing whether their highlights are sufficient. PRISMA assists researchers in locating the relevant literature by following four steps: identification, screening, eligibility, and inclusion.

Methodological criteria must be adhered to in the systematic review [27]. First, we conducted a search of Scopus-indexed journals for all relevant articles published. This comprehensive database covers many fields, such as social science, business, marketing, development, accounting, economics, environment, medicine, law, technology, and engineering. Scopus is widely recognized for its reliability and high utilization as a resource for quantitative analysis [28,29].

2.2. Timeline

Based on the Fifth Basic Plan for Science and Technology (2016–2020), S5.0 was introduced in 2016 as a government initiative to address social issues related to technology in Japan [30]. Based on the evolution of the S5.0 domain and the objectives of our review, it was logical to begin in the year 2016. Therefore, to offer new insights to researchers and society, we focused on the period from 2016 to 2024.

2.3. Search Strategy

In the first phase, the SCOPUS database was used for the search. This search strategy was used to identify the search string that produced the most precise results based on the following terms: "Education 5.0", "Society 5.0", "Education 5.0" AND/OR "Society 5.0"; "Society 5.0" AND/OR "Future workforce"; "Society 5.0" AND/OR "Transition"; "Society 5.0" AND/OR "Digital skills"; "Society 5.0" AND/OR "Higher education"; "Society 5.0" AND/OR "Universities"; "Education 5.0" AND/OR "Competencies"; "Education 5.0" AND/OR "Future workforce"; "Society 5.0" AND/OR "Transition"; "Society 5.0" AND/OR "Malaysia"; "Education 5.0" AND/OR "Malaysia".

In order to achieve the same result in the Malaysia setting, the Malaysia location was also added to the keyword section of the Scopus search.

2.4. Inclusion and Exclusion Criteria

The screening process was carried out following the PRISMA protocol (Figure 2). We engaged two reviewers to ensure that the screening process was reliable and robust [31,32]. The articles needed to satisfy the following criteria:

1. Published in Scopus-indexed journals;
2. Studies published between the years 2016 and 2024;
3. Studies published only in English;
4. Only research and review papers that were subjected to peer review;
5. Studies that focused on at least one aspect of S5.0 and E5.0.

The articles that did not focus on the subjects S5.0 and E5.0 were omitted from the studies searched. This process led to the incorporation of 18 articles that satisfied the inclusion and basic quality criteria, making them eligible for thorough analysis. Conference papers, dissertations, and books were not included in the search due to their resource-intensive nature, potential lack of comprehensive information, and tendency to offer less reliable data.

2.5. Data Analysis

"Critical analysis of literature involves carefully examining the main ideas and relationships of an issue and providing a critique of existing literature" [33]. Data analysis pinpointed recurring themes within the chosen studies and created a narrative synthesis of the findings incorporated in our study (n = 18). In the initial stage of our review, inductive coding was employed. A label has been assigned to each paper for ease of reference, and the results of each study are delineated, highlighting the scope and related discipline.

Two authors reviewed each article. The inter-rater reliability was then determined by selecting about 20% of the cases. After independently coding these cases, we achieved a contract score of 93.5%, demonstrating strong agreement with a Krippendorff's alpha of 0.85 [34]. The high level of inter-rater reliability noted above indicates that there was strong consistency and impartiality in the inclusion judgments [35].

3. Results

3.1. Preliminary Findings

After using the inclusion criterion for selection, the final 18 studies were selected for review. Among these studies, 6 were quantitative, 12 used qualitative methods, and 5 involved a review of the literature. The results of each study are shown in Table 1. Furthermore, the domain of each study is specified, and a label (e.g., SE01) has been assigned. Most study cohorts consisted of university students or teachers. The foci of the studies' disciplines were diverse, encompassing research on technology, education, engineering, S5.0, and sustainability, and a majority of the studies examined the use and adoption of technology in educational settings. Four studies [36–39] focused on engineering education and provided recommendations on the process of teaching, measurement, and improvement throughout the curriculum. Two studies [40,41] revealed that universities should take initiatives in sustainable development, which is vital for S5.0.

Table 1. Content analysis of academic literature.

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE001	[38]	Prof. Dr. Marcelo Mejía Olvera plays a key role in higher education management and is engaged in several professional organizations, highlighting his dedication to advancing technology and education.	Engineering and S5.0	Quantitative	Instructors and students	• The primary goal of this paper is to examine and assess a continuous improvement strategy for engineering programs that aligns educational competencies with the demands of Society 5.0.	• Competencies required by engineers to develop professionally within S5.0; • A robust approach to the use of a Learning Management System (Canvas) in a straightforward manner; • Developing the computer programming skills and Python programs required by professionals in S5.0; • Engineering programs should outline disciplinary competencies for students; • Engineers should be equipped with digital and soft skills for solutions that consider environmental, health, safety, and welfare aspects globally.	Digital Proficiency Empowering Skill Sets
SE002	[6]	Dr. Elias G. Carayannis is a professor of Information Systems and Technology Management and a prolific author with over fifty books on technology and innovation. He also serves as editor-in-chief for multiple academic series and journals. Additionally, he has consulted major organizations like the World Bank and the European Commission.	ICT and S5.0	SLR	Universities	• The objectives of this paper are to examine how institutional changes and incentives affect universities' participation in digital and green innovation and to identify the connections between Society 5.0, Industry 5.0, and the Q2HM framework.	• Digitalization presents new perspectives for universities; • Emphasis on human-oriented innovation and sustainability goals; • Universities should aim for innovation, developing adaptive learning programs, supporting research, fostering collaborative technologies, and creating widely accessible online resources.	Innovative Pedagogy Sustainable Education

Table 1. *Cont.*

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE003	[42]	Dr. Guillermo Rodríguez-Abitia is an Associate Professor with over 35 years of academic experience. He holds advanced degrees in information systems and business administration, has numerous publications in journals and conferences, and serves in key editorial roles for major information systems journals. His areas of interest include Digital Transformation, Innovation, and Educational Technology.	ICT and S5.0	Qualitative	Working groups in an organization	• The paper aims to develop competency-based curricular models for IT programs in line with the Society 5.0 framework, offering guidance to educational institutions for the design of curricula that tackle the challenges of the modern work environment.	• Developing competency-based referential curriculum models for IT programs assists education institutions in designing curricula that meet the demands of the modern workplace; • To excel in self-learning and personal transformation, professionals in information technology and other disciplines need to identify transversal competencies crucial to adapting to the changing work environment of S5.0.	Holistic Learning
SE004	[43]	Dr. Julhadi, a researcher at Universitas Muhammadiyah Sumatera Barat, specializes in Islamic education, religious moderation, and the integration of local wisdom with linguistics. His well-cited work has significantly contributed to the development of Islamic education curricula.	E5.0 and S5.0	Qualitative	Three types of Islamic educational institutions	• The study aims to evaluate how human resource management in educational institutions is preparing for Society 5.0 by comparing traditional, modern, and integrated institutions.	• Modern and integrated Islamic educational institutions should be equipped with technology; • Technology presence in Islamic educational institutions mirrors readiness for the S5.0 era; • Modern and integrated Islamic educational institutions seamlessly blend the virtual and real worlds, which is crucial for enhancing efficiency in the S5.0 era.	Tech-Driven Education

Table 1. *Cont.*

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE005	[39]	José Roberto Santamaría Sandoval is a professor with expertise in integrating virtual and blended learning methodologies into telecommunications education. His research centers on the implementation of virtual laboratories and distance learning models.	ICT and S5.0	Qualitative	15 graduates	• The study aims to assess whether the program's virtual learning environment and curriculum effectively cultivate the digital competencies and skills needed for professionals to succeed in a technology-driven and socially conscious Society 5.0.	• The Telecommunications Engineering program needs to evaluate how it incorporates S5.0 competencies; • Forums emphasizing communication skills are found to be the most relevant to the S5.0 approach, while online tests are the least relevant; • Explicit integration of topics within subjects and incorporating extracurricular activities linking future engineers with society are crucial for program enhancement.	Building Competencies
SE006	[44]	Dr. Maria José Sampaio de Sá, who holds a PhD in Studies in Higher Education, focuses on student satisfaction, institutional actors, and quality assurance. With over 120 publications, she is actively involved in international journals and conferences. Her expertise also encompasses higher education in developing countries and accreditation.	Education and S5.0	Qualitative		• The paper aims to investigate the importance of soft skills in higher education amid digitalization and Society 5.0 and to analyze how institutions can incorporate these skills into their curricula, addressing the associated challenges.	• Analyzing the importance of soft skills in the context of S5.0 reveals their critical role in professional and personal success; • The increasing digitalization of S5.0 prompts significant changes in higher education, particularly in teaching about digitalization, sustainability, and interculturality; • Higher education's emphasis on interdisciplinarity fosters the development of soft skills in students, which are highly valued by the labor market. This requires innovative pedagogical approaches and flexible curricula, departing from traditional methods.	Soft Skills in the Digital Age Adapting to Change

Table 1. *Cont.*

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE007	[41]	Dr. Joanna Rosak-Szyrocka is a researcher with a focus on distance learning, digitalization, and quality 4.0 and has significantly contributed to research on student satisfaction, digitalization, and sustainability in higher education.	Education and S5.0	Quantitative	115 university students	• The objective of this study is to assess students' perceptions of their universities' sustainability efforts and the effectiveness of their sustainable development initiatives.	• Public awareness in education emphasizes sustainable development, stress management ethics, entrepreneurship, environmental studies, systems thinking, and self-awareness; • Ensuring the success of sustainability education involves adhering to specified pedagogical and content standards as outlined by the U.N.; • University programs must integrate sustainable thinking, accountability, and social commitment, fostering an interdisciplinary understanding of climate, economy, and society while emphasizing partnerships and communication.	Sustainable Education
SE008	[40]	Dr. Lavinia Dovleac holds a PhD in Marketing. Her research interests include marketing, innovation, high-tech products, new communication technologies, and sustainable business development. She has over 20 articles in international journals.	ICT and S5.0	Quantitative	13 EU-developed countries	• The study aims to explore how sustainability and digitalization can enhance inclusivity in society, encapsulating this as the "digitainability" phenomenon.	• Connecting the digital divide, sustainability, and digitalization; • Incorporating communication and collaboration skills, security concerns, and medium to high computer skills highlights the importance of integrating these skills for future generations to be included in upcoming jobs and specializations; • Optimizing the teaching and learning process to high standards for digital skills is imperative.	Digital Skills Sustainable Development Adapting to the New Era

Table 1. *Cont.*

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE009	[45]	Manuel Alejandro Pastrana Pardo is a full-time professor and researcher at Antonio José Camacho University Institution. His research focuses on software engineering, smart campuses, decision support systems, and business process modeling. He holds the designation of Associate Researcher from the Ministry of Sciences.	S5.0	Qualitative	19 students	• The study aims to improve students' technical and soft skills using a structured framework, in line with the Society 5.0 vision, to better equip them for the dynamic challenges of the software development industry.	• Enhancing soft and technical skills through continuous evaluation in systems engineering programs; • Promoting competitiveness through information technologies enhances project efficiency and quality, necessitating industry–academia synergy to train professionals skilled in modern technologies, work models, quality approaches, and problem solving; • Creating a learning environment that replicates real situations in the industry, where various elements of the student's professional training are put to the test to work together for the solution; • Key soft skills crucial in S5.0, such as motivation, adaptability, and creativity, are strengthened, but improving interpersonal relationship-building approaches is necessary; • Effective communication is crucial for successfully overcoming challenges. Respondents emphasize the importance of enhancing technical skills, which are essential for S5.0, as they enhance their professional profile, competitiveness, and industry opportunities, significantly impacting their professional development.	Fostering Soft Skills Developing Technical Skills

Table 1. *Cont.*

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE010	[46] Digital Literacy	Dr. Andayani Andayani is a lecturer who focuses on teaching strategies, digital literacy, and environmental education. She has published extensively on character education, digital learning, and educational games. Her research also covers the impact of technology and games on primary education.	Education and S5.0	Qualitative	173 university graduates	• This study aims to evaluate the competencies of Primary Education graduates to determine their preparedness as professional educators in the Society 5.0 era.	• Determining the competencies of professional educators in the era of S5.0 is vitally important; • Several critical skills for the 21st century include leadership skills, digital literacy, communication, emotional intelligence, pedagogy, teamwork, and problem solving.	Building Essential Skills Effective Leadership
SE011	[1]	Darkhan Ydyrysbayev is a doctoral student specializing in Informatics. His research focuses on digital transformation in education within the Society 5.0 process. He has also worked on the mathematical modeling of porous adsorption layers for membranous gas separation.	E5.0 and S5.0	Qualitative	120 university students	• The study aims to evaluate university students' experiences with digital transformation tools during Society 5.0.	• Determining the digital transformation in education in the S5.0 process is essential; • With the advancement of technology, traditional classroom environments are transitioning into new learning environments, facilitating easier tasks, offering learning diversity, and signifying an era of adaptation to technological advancements; • Distance education offers diverse co-educational learning opportunities. Methods such as online education, learning from home, and accessing lecture notes anytime and anywhere provide lasting learning experiences.	Digital Transformation Reshaping Education

Table 1. *Cont.*

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE012	[47]	Laura Icela González-Pérez has a PhD in Training in the Knowledge Society. She has extensively researched Education 4.0, user experience, and institutional repositories. Her recent work includes book chapters and systematic reviews, with active involvement in evaluating educational contributions.	ICT and Education	Qualitative SLR	NA	• This paper aims to analyze higher education frameworks to identify the components of Education 4.0 that contribute to achieving Society 5.0, exploring the dimensions and levels associated with key stakeholders and institutional missions.	• HEIs should promptly develop an S5.0 model, analyzing Education 4.0 components in a balanced manner, driving change management, and fostering holistic responses to societal, industrial, governmental, and environmental needs using a core technological platform; • HEIs need technology transfer services, training, and data centers to stay competitive with industries and governments. They require quality infrastructure and technology to deliver research-based services; • Implementing Maturity Models effectively via technological platforms for integration and information architectures demands multidisciplinary teams comprising researchers, educators, engineers, and designers; • Education 4.0 and S5.0 highlight the strategic integration and synergy of technologies such as artificial intelligence, the Internet of Things, robotics, and automation. They prioritize personalized learning, stakeholder collaboration, creativity, innovation, lifelong learning, and sustainability with a human-centered approach.	Revolutionizing Education Innovative ICT Solutions

Table 1. *Cont.*

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE013	[48]	Dr. Feri Sulianta is a lecturer at several universities and holds the record for publishing the most books on Information Technology, with over 100 titles. He is also actively involved in professional communities.	S5.0	Qualitative SLR	NA	• The study seeks to understand how digital literacy can facilitate the shift from Society 4.0 to a more human-centered Society 5.0, focusing on equipping individuals for active participation in the advancing technological environment.	• Media literacy plays a crucial role in educating the public on accessing information. However, creating digital content is equally vital to ensure the production of valuable information tailored to various media platforms; • A digital content model was proposed as a guideline to create useful content that has high visibility and quality; • This model must be implemented in digital communities to support digital literacy.	Digital Literacy
SE014	[49]	Jesus Antonio Alvarez-Cedillo is a professor with a Ph.D. in Education, focusing on parallel processing, technology, and SMEs. He has published extensively, including scientific articles, books, and chapters, and is involved in various research networks. His notable work includes optimization techniques for waste treatment and contributions to Education 4.0.	S5.0 and Education	Qualitative	NA	• The study aims to address educational deficiencies and propose strategies for adapting to Education 4.0, supporting the transition to Society 5.0 by enhancing educational autonomy and responsibility.	• The essence of economic progress lies in technological change; • From a cybernetic perspective, a route that could help the understanding of the method for the design of actions to be taken before Education 4.0 and S5.0 are as follows: a. Understand the theory and context of the Fourth Industrial Revolution (inputs). b. An integral analysis of the soft and hard technologies required for such a revolution (process). c. Finally, a holistic study of the possible impacts on education, economy, society, and sustainability (outputs).	Integration of Soft and Hard Technologies in the Fourth Industrial Revolution Cybernetic Approaches to Holistic Analysis of the Impact on Education.

Table 1. *Cont.*

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE015	[50]	Dr. Rajeswari Raju is a senior lecturer with a PhD in Image Processing, specializing in image processing, computer security, and computational intelligence. She has authored numerous scientific articles and book chapters, focusing on digital tools in education, cybersecurity awareness, and image-processing innovations.	E5.0 and Technology	Quantitative	110 students	• The study aims to evaluate cybersecurity awareness among students through a digital learning platform, identifying vulnerabilities and providing education on cyber risks and protection measures.	• Education 5.0 represents a revolution in human intelligence and cognitive computing. As the world transitions towards this, key challenges include those posed by digitalization and cybersecurity risks; • Despite using digital learning platforms to assess cybersecurity awareness programs, there is currently no active program to enhance students' cybersecurity knowledge; • Mastery in cybersecurity primarily relies on taking computer and cybersecurity courses, with additional opportunities for students to attend external cybersecurity awareness programs.	Empowering Digital Citizens Integrating Cybersecurity into Educational Curricula
SE016	[51]	Dr. Andrés Díaz Lantada is an Associate Professor. His research focuses on rapid prototyping, biomedical devices, and smart materials, with significant contributions to journals and conferences. He has authored numerous influential papers.	E5.0 and Technology	Qualitative SLR	NA	• The objective of this study is to introduce "Engineering Education 5.0", which focuses on integrating technology with ethics and humanism to prepare engineers for a sustainable and equitable future.	• In Engineering Education 5.0, technological development extends into the realms of ethics and humanism, becoming essential for the next generation of engineers. Engineers must lead and mentor toward technological singularity; • Engineering Education 5.0 is a vision backed by evidence for educational transformation, highlighting key features of this evolution and analyzing potential structures for engineering degrees that align with modern professional roles.	Innovating Engineering Education

Table 1. *Cont.*

Label	Authors	Authors' Orientation	Subject	Method	Participants	Objectives	Key Findings	Themes
SE017	[52]	Dr. Karuna Nikum is a researcher with a focus on renewable energy sources. She has contributed to various conferences and journals on related topics. Her notable papers cover power quality issues, harmonic analysis, and the design of solutions to improve power quality.	E5.0	Qualitative SLR	NA	• The objective is to identify gaps in the current educational system and propose improvements to align it with evolving societal and technological needs.	• To bridge the gap between theoretical concepts and practical knowledge in education, the initial step involves elevating research-based knowledge through experiments and innovation, leading to improved outcomes; • Curricula should be simple, realistic, and futuristic; • Promoting and expanding intellectual infrastructure, technical and non-technical infrastructure, innovation, inquiry, and research-based services.	Future-Ready Education Industry-Driven Learning
SE018	[36]	Metka Kordigel Abersek is a professor with a research focus on digital learning environments and teacher education. Her work examines online reading skills and communication competence in primary education. She has published notable studies on rhetoric in virtual exchanges and digital learning strategies.	Education and S5.0	Quantitative	85 students of a teacher-training program	• The objective is to explore how advancements in technology, changes in pedagogy, and shifting labor market requirements influence education and teacher training.	• The primary challenge in education involves changes in educators' attitudes, textbooks, curricula, education technologies, pedagogies, innovation, and research; • Goal setting, task value, self-efficacy, and effort regulation are the primary strategies for enhancing academic achievement in distance learning programs; • S5.0 demands an understanding of technology, personal data protection, cybersecurity, and the ethical dilemmas of AI-based technologies, especially in sensitive areas like education. Achieving this requires new digital competencies, DC 2.0, and a revamped approach to thinking and education.	Functional Digital Competency The Future of Learning

3.2. Research on Higher Education Role to Empower the Future Workforce in Society 5.0

3.2.1. Future-Ready Higher Education

This study aimed to investigate how E5.0 empowers the future workforce for S5.0. Based on the reviews of the papers, digital advancements will require the future workforce to be equipped with the relevant digital knowledge, skills, and abilities to meet the needs of organizations. This is in line with the study by [6], who suggested that universities play a pivotal role in delivering and advancing education and research and developing digital innovation. However, digital transformations require establishing appropriate structures and facilitating the adoption of digital innovation to prepare universities for the S5.0 era [6]. Additionally, developing digital competency is essential for future professional development, and university curricula should be improved to reflect this need [39]. New curricula focused on green, digital literacy modules across all programs should be promoted, and the curricula should be revised regularly to include emerging technologies and should adopt blended and project-based learning approaches. Quantitative and ethical skills are necessary to ensure the effective and appropriate utilization of the latest trends for the updated curricula. The curricula should also integrate interdisciplinary courses, use digital portfolios for assessment, and foster industry collaboration to ensure relevance and continuous improvement. These changes will equip students with the necessary skills to thrive in a digital world [6] and, in fact, they can provide a framework for universities.

In the same vein, [44] emphasize the critical role of education in cultivating the digital skills necessary for upcoming professionals. Furthermore, they underscore the importance of higher education institutions in promoting the integration of smart education into the learning process for future work readiness. Thus, HEIs will require a paradigm shift focusing on digital transformation to revolutionize the teaching and learning environment, aiming to develop digitally skilled, industry-ready graduates with higher-order cognitive skills and a global outlook.

Educational teaching methodologies must be tailored to accommodate the differing characteristics of digital natives and digital immigrants [40]. In a similar vein, refs. [1,50] posited that the implementation of digital transformation within the educational system can streamline teaching and learning procedures. Considering current developments, higher education institutions must transform to meet the future needs of the workforce by ensuring that their people, processes, and technology are improved to enable quality education for developing a new generation of graduates for the industry workforce.

3.2.2. Navigating the Transition from Academia to Industry

Fresh graduates entering the workforce will need the required attributes of a future-ready workforce achieved through academic and practical readiness when transitioning from higher education to the working world [53]. Digital transformation in society brings significant changes to global economies around the world, which act as the driving force for transformation, especially towards future workforce needs. As the emphasis on creating a future people-centric, super-smart society because of S5.0 grows, a fundamental shift in society will leverage human–machine interactions and skill matching to solve problems and create social well-being [54].

The contribution of the future workforce will also be crucial in building a harmonious human-centric society that will use technology to improve the quality of life towards sustainable living as envisioned by the United Nations' SDGs and future S5.0. As the skills needed in the industry continue to evolve, HEIs need a flexible approach to skill competency development. Specifically, HEIs must empower the future workforce in emerging digital capabilities and technology responsibility while also including student-centered learning of the 21st century by leveraging the technology advancement brought about by I4.0 and I5.0.

Higher education has undergone a significant transformation in recent decades, spurred by rising enrollment, the increased mobility of graduates, an expanding array of educational options, evolving research landscapes, and the surge in global connectivity. This evolution has accelerated the development of online and blended learning while underscoring the critical role of digital technologies such as artificial intelligence and big data [55].

Southeast Asia is witnessing substantial changes in its labor market and skill demands due to its increasing involvement in global trade, which has raised the need for a diverse skill set among employees. The region must transition from labor-intensive industries to high-skill, innovation-driven sectors. This transition highlights the urgent need for upskilling to boost workforce employability. Meanwhile, Southeast Asian countries are striving to unify their higher education systems to foster a regional identity, enhance their international standing, and increase labor mobility and competitiveness within the ASEAN economic zone. Concurrently, the region is facing significant shifts in the labor market due to its growing role in global trade, leading to a greater need for diverse skills. In response, Southeast Asia is transitioning toward high-skill, innovation-driven sectors, underscoring the urgent need for upskilling to enhance workforce employability [56].

The current state of higher education in Malaysia is changing from traditional teaching and learning to the use of technology-driven approaches that are poised to revolutionize the HEI ecosystem. Malaysian higher education has seen significant transformation through the different phases of the evolution of education. The most important role of HEIs in Malaysia and around the world is to generate graduates who become quality workers with the knowledge, skills, and abilities required not only by the current job market but also by the future requirements of the industry [57].

A study by Sandoval and Sánchez (2022) found that technology competency and soft skills are two transferable skills on which HEIs must focus. Therefore, in a world of rapid technology development, shifting industries, and global interconnectivity, a future-ready workforce must be able to address complex problems and understand market demands through higher education that promotes interdisciplinary learning [58].

Similarly, HEIs must ensure that students develop skills that will be linked to their career paths and that they obtain suitable jobs after graduation. Furthermore, the adoption of intelligent systems will allow Malaysian HEIs to empower a future-ready workforce who will be ready to meet the demands of S5.0. From another perspective, as the nature of work and industry is changing, education in general and higher education, in particular, must adapt to these changes as a broader range of skills and knowledge is in demand to meet the needs of future industries; therefore, Malaysian higher education institutions need to be equipped in terms of personnel, facilities, procedures, and technology to meet the needs of the future workforce in S5.0. Table 1 presents the label assigned to each article and its authors, subject, method, participants, key findings, and themes.

4. Discussion

The majority of the studies were found to be qualitative. This ties in well with what was mentioned previously: the concept of S5.0 was only introduced in 2016 as an initiative by the Japanese government to address social issues that affected Japan [30]. Therefore, we are new to researching the subject. This calls for studies of an exploratory nature. Qualitative studies are often used in the exploratory phase of research to generate hypotheses or theories, thereby providing a foundation for further research by identifying variables of interest and potential relationships. This also implicitly tells us that the researchers who have addressed the subject up to this point needed the flexibility in data collection and analysis that qualitative research methods provide, allowing them to adapt their approaches based on emerging findings.

This flexibility is particularly valuable when studying S5.0, a dynamic and evolving phenomenon. This may also provide insight into the methodological variations among the many academic disciplines, which, in turn, helps us gauge how comprehensively these disciplines have investigated the topic of this study. It is important to understand that methodological tools vary across disciplines, which has an impact on the types of questions that can be posed. As suggested by Creswell and Plano Clark [59], methodologies must be adapted to the disciplinary tradition and the objectives of the research.

In order to grasp the scope of S5.0's applicability and impending influence across all academic disciplines, one does not need to deliberate for an extended period. In this respect, S5.0 is akin to climate change, as it can be examined from various perspectives, encompassing economic, scientific, and sociological perspectives. Each discipline brings its own unique perspective and approach to the table, unlike other study areas that may fall outside the scope of particular disciplines. Some topics may lie beyond the scope or interest of particular disciplines altogether. For example, whereas medical scholars may study topics related to healthcare, they may not be as readily approached within the context of physics or mathematics. This reflects the limitations and specialties specific to each discipline. Similarly, research areas often entail precise methodologies, tools, and expertise that may not be readily accessible in all disciplines.

This study revealed that, contrary to our common perceptions regarding the issue of S5.0 and its potential for discussion in any research domain or academic discipline, the subject remains relatively underexplored in the literature. Research on the area of S5.0, according to the outcomes reached by this study, did not surpass three research areas, namely, ICT, education, and engineering. Furthermore, the study's findings underscore that an interdisciplinary approach to research is unquestionably essential to tackle the subject of S5.0 effectively. Scholars from diverse disciplines collaborate in multidisciplinary research to address the intricate landscape of S5.0. As highlighted by [60], interdisciplinary approaches are crucial for addressing multifaceted issues that cannot be adequately addressed within the confines of a solitary discipline.

Each discipline has the potential to provide its unique perspective on the topic S5.0. For instance, a study on urbanization might be approached through different lenses by urban planners, sociologists, and environmental scientists. As highlighted by [61], these disciplinary perspectives shape the formulation of research questions, methodologies, and interpretations. S5.0 is one of the research topics that necessitates interdisciplinary collaboration, considering the unique perspectives, methodologies, and scopes that each discipline offers. This is due to the importance of engaging diverse expertise to address the complex challenges related to S5.0 comprehensively.

S5.0 initiatives predominantly emphasize the impact of technological advancements on students' learning experiences and prospects. Research within this framework often explores topics such as the integration of digital skills (hard and soft skills) and AI into educational practices, personalized learning approaches, developing new forms of and channels or platforms for the distribution of education, curriculum evaluation, and digital competencies and literacy [6,36,38,39,41,45,46,50].

Despite the centrality of instructors in shaping educational practices and facilitating learning, their perspectives are often overlooked in S5.0 studies. This neglect may stem from a focus on technological innovations and student-centric outcomes rather than considering the experiences and challenges faced by educators [62]. Instructors play a pivotal role in implementing technological innovations, adapting pedagogical approaches, and supporting students in navigating societal changes. Designing successful educational interventions within the S5.0 framework requires an understanding of their perspectives (Freitas & Pistilli, 2019). To bridge the gap and incorporate instructors' perspectives into S5.0 studies, researchers can employ qualitative research methods such as interviews and focus groups to explore educators' attitudes, experiences, and needs in the context of technological integration.

5. Conclusions

As we move from an information society to an intelligent society (S5.0), an education paradigm shift in higher education institutions is imperative to ensure that the programs are aligned with industry and society needs. Universities are socially and digitally engaged institutions where the teaching methodologies will need to transform to the digital space. Educational technology enables adaptive learning programs, collaborative teaching, and personalized learning, which will be the new forms of education. Digital literacy and skills are of the utmost importance for S5.0 and necessitate an urgent need to improve university curricula, as future professionals will need to be able to be efficient and productive in technology-driven organizations. It is important to leverage digital technologies to enhance teaching and learning methods. The upskilling of educators in the use of new digital teaching and learning platforms is also necessary to ensure quality education. With automation displacing routine tasks, graduates should have high emotional intelligence, creativity, complex reasoning, and a strong ethical grounding, as these soft skills will become indispensable workforce differentiators. The use and integration of digital technologies allow universities to transcend their virtual boundaries, impacting their course portfolios, regulating their delivery models, and streamlining their value chains [63]. Currently, universities are adopting technologies as part of a paradigm shift, where technology is envisioned as a complex and interconnected system that facilitates digital learning [64]. Finally, universities need proper strategies, educational planning, and policies to ensure that they continue to play an important role in producing competent graduates for the era of S5.0.

6. Recommendations

Three key areas must be emphasized to empower the future workforce in the context of S5.0: the development of innovative curricula, human-centric skills, and industry collaboration. These are three critical areas for empowering the future workforce in S5.0. Students should gain practical and theoretical knowledge aligned with market needs by integrating interdisciplinary courses that emphasize digital literacy, ethical considerations, and sustainability. Students should be prepared for success in a technologically advanced society by ensuring that they have critical thinking and collaboration skills and that they use technology ethically. A seamless transition from academia to the workplace will be made possible by strengthening industry collaboration through partnerships and hands-on training opportunities.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/educsci14101041/s1, PRISMA 2020 Main Checklist. PRIMSA Abstract Checklist [65].

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Bridging the skills gap: Enhancing employability for chemical engineering graduates

Maryam Malekshahian *, Jessica Dautelle, Salman Shahid

Department of Chemical Engineering, University of Manchester, Oxford Road, Manchester M13 9PL, UK

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ABSTRACT

Extensive research underscores a persistent skills gap among graduates across various disciplines. However, identifying the precise skill gaps in engineering education remains challenging due to inconsistencies in existing research, and studies specifically addressing employability skills in chemical engineering are limited. This study aims to address these knowledge gaps by identifying the critical employability skills necessary for chemical engineering graduates. The study employs a multi-method approach, incorporating a systematic literature review, surveys of students, alumni, and employers, and a statistical analysis of job advertisements for graduate positions. The objective is to establish a comprehensive understanding of required competencies and evaluate the alignment between employer expectations and graduate competencies. A structured skill framework was developed, encompassing 15 primary skill groups and over 75 sub-skills. Comparative analysis of employer perceptions and job advertisement data highlighted discrepancies in perceived versus stated skill priorities. However, competencies such as communication, interpersonal skills, self-management, and adaptability were consistently recognised as essential across sectors. Significant skill gaps were observed in areas such as communication, problem-solving, literacy, interpersonal, self-management, and business acumen. Survey findings indicate that engineering students often overestimate their technical proficiency while underestimating the importance of transferable skills such as resilience, ethics, and integrity. Conversely, employers consistently emphasise the need for a well-rounded skillset that integrates technical expertise with strong communication and management capabilities. This disconnect underscores the need for educational programmes to promote greater self-awareness among students and ensure their skill development aligns with industry demands. These results align with existing literature, reinforcing the importance of embedding transferable skills within engineering curricula to better prepare graduates for professional success.

1. Introduction

Engineering graduates face a rapidly evolving job market where technical expertise alone is no longer enough. Employers value graduates who demonstrate a combination of strong technical knowledge, transferable skills, and data and digitalisation skills. Reflecting this demand, the CBI (Confederation of British Industry) defined employability skills as “A set of attributes, skills and knowledge that all labour market participants should possess to ensure they have the capability of being effective in the workplace – to the benefit of themselves, their employer and the wider economy” (Sheldon, 2009). However, persistent gaps remain between the employability skills graduates possess and those demanded by industry. Despite the significance of addressing this gap, there is no clear consensus on which skills should be prioritised within engineering education, making curriculum development particularly challenging. For example, the American Society for Engineering Education (ASEE) highlights deficiencies in ethics and critical thinking (American Society for Engineering Education, 2020), while the Institution of Engineering and Technology (IET) points to shortcomings in teamwork, leadership, and management skills (The Institution of Engineering and Technology, 2021). Recent findings from the National Centre for Universities and Business (NCUB) further underscore the importance of problem-solving, communication, digital literacy, critical thinking, and analytical abilities, ranking them as the top five skills sought by employers (National Centre for Universities and Business, 2024). Determining which aspects of the curriculum require modification and how to effectively implement these changes further complicates the integration of employability skills (Winberg et al., 2020).

* Corresponding author.
E-mail address: Maryam.malekshahian@manchester.ac.uk (M. Malekshahian).

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Addressing these challenges is especially pronounced in chemical engineering, a field characterised by technical complexity, a wide breadth of industrial sectors, and rapid advancements driven by automation and artificial intelligence. To address industrial demands, chemical engineering education must go beyond technical expertise, embedding transferable skills that are critical for modern workplaces, not only for immediate employment but also for broader opportunities, such as enterprise creation, further study, and diverse career paths. The significance of the employability skills is evidenced by the learning outcome requirements of accredited programmes by the Institution of Chemical Engineers (IChemE). These learning outcomes not only include demonstrating knowledge and understanding of essential concepts, applying appropriate quantitative science and engineering tools, and possessing relevant practical skills, but also emphasise that 'Students must have developed and demonstrated ability to integrate transferable professional skills (such as communications, time management, team working, interpersonal, effective use of IT and digital technologies including information retrieval skills)' (Institution of Chemical Engineers, 2021).

Despite widespread recognition of the importance of employability skills, studies focusing specifically on assessing these skills among chemical engineering graduates remain limited. Grant and Dickson advocate for embedding transferable skills such as communication, teamwork, and problem-solving into chemical engineering curricula, noting perceived gaps in business and management-related thinking (Grant and Dickson, 2006). Similarly, Fletcher et al. highlight a disconnect between the technical focus of educational programmes and the broader competencies required by industry, including interdisciplinary approaches and business acumen (Fletcher et al., 2017). Complementing these findings, Pott and de Jager explored the career trajectories of chemical engineering graduates over a decade, highlighting the increasing importance of transferable skills such as communication and management in their professional roles (Pott and de Jager, 2021). Their research also underscores the need for curriculum renewal to better align with industry demands, particularly in fostering skills like risk management and leadership.

Although these studies identify recurring themes, they lack a cohesive and comprehensive framework for evaluating employability skills. A systematic approach is necessary, one that encompasses technical, transferable, and data and digitalisation skills. Moreover, there is insufficient research into the specific skills most valued by employers in the chemical engineering sector, highlighting a crucial knowledge gap.

This study aims to address these gaps by improving our understanding of employability skills within chemical engineering education. It seeks to develop a comprehensive framework to identify and classify employability skills relevant to chemical engineering. This framework is then used to evaluate the importance of various skills by analysing job advertisements and comparing them with perceptions of employers, students and alumni. Additionally, by analysing job advertisements specifically targeted at chemical engineering graduates and comparing the results to broader job advertisements for STEM and engineering roles, the study aims to provide insights into the unique employability skill requirements for chemical engineering graduates.

Furthermore, the study examines skill gaps by comparing employers' evaluations of graduates' competencies with students' self-assessments. This analysis highlights discrepancies between employer expectations and student preparedness. Finally, the study investigates the factors that contribute to skill development through both curricular and extracurricular activities within the Department of Chemical Engineering at The University of Manchester. This involves analysing student surveys to identify which skills are fostered in specific modules.

2. Methodology

Many studies have explored employability skills across different disciplines and participant groups. However, this study adopts a more disciplinary (Chemical Engineering) approach. By gathering input from students, employers, and alumni, and employing multiple methods such as literature reviews, surveys, and job advertisement analyses, this study aims to provide a detailed and practical understanding of employability skills. A multi-method approach ensures a well-rounded perspective, enhances the reliability of findings through triangulation, and supports actionable recommendations (Esteves and Pastor, 2004). Furthermore, combining different methods broadens the applicability of results to a wider population and helps address limitations associated with smaller sample sizes (Vivek and Nanthagopan, 2021). Conflicting findings or disagreements identified during the study can also serve as a basis for further research, deepening our understanding of employability skills.

2.1. Data Collection from Literature to Identify and Classify the Skills

To develop a structured framework for analysing employability skills across various data sources, a systematic literature review was conducted to identify studies related to employability skills. Keywords used in the search included terms like "Graduate employability skills," "Job/Workplace/Professional/Career skills," "Industry/Career/Work/Workforce readiness," "Graduate job performance," and "Employability competencies." These terms were also combined with "Engineering" and "Chemical engineering." The reviewed publications comprised articles, peer-reviewed journals, reports, and both conceptual and empirical studies. The scope included chemical engineering, general engineering, and multidisciplinary studies, with data drawn from multiple countries.

. The literature review focused on studies published in the past 25 years to capture changes in engineering practice, particularly the impact of digitalisation, evolving workplace expectations, and shifting industry skill demands. While older studies were reviewed to avoid overlooking significant findings, the emphasis remained on more recent publications to align with current industry needs. Publications that did not specifically address employability skills were excluded. After applying these criteria, 58 studies were selected for detailed analysis.

The data collection process involved a thorough review of the selected studies to compile a comprehensive list of employability skills. Synonyms or alternate descriptions of the same skill were standardised to avoid duplication. For instance, "enthusiasm" was grouped under "positive attitude." This analysis identified recurring themes and patterns, resulting in the classification of employability skills into 15 core skill groups and 74 sub-skills. Additionally, the study identified 9 specialised software tools, 3 programming languages, and 20 methodologies and tools related to continuous improvement, project management, and quality management. This structured framework provided a consistent and clear approach to analysing employability skills across multiple data sources throughout the research.

2.2. Surveys

In line with the stated objectives, three separate surveys were designed with distinct participant demographics to quantitatively assess viewpoints on employability skills. Surveys were selected as the primary methodology due to their widespread use in academic research and reports by professional organisations for evaluating skills (Hawse, 2016; The Institution of Engineering and Technology, 2021). The target demographics included employers with recent experience in hiring chemical engineering graduates (within the past 5 years), recent chemical engineering alumni (within 3 years of graduation), and current chemical engineering students from The University of Manchester. The student survey was conducted within one institution to ensure consistency in curriculum content, learning environments, and educational experiences. This approach allowed for a detailed and controlled examination of skill development. While this is a limitation, combining these findings with job advertisements and literature review helps mitigate the restricted sample size. No additional demographic restrictions were applied to minimise sampling bias. A pilot test for the surveys was conducted in advance, and the feedback obtained was used to refine the questions and optimise the design. The surveys were administered through the online platform Qualtrics and distributed via email and LinkedIn to effectively reach the target demographics and maximise accessibility.

The questionnaires collected distinct types of information, summarised in Table 1, and utilised a conditional question system for students to streamline the survey length. The skill competency levels of graduates, students, and alumni were evaluated using a 5-point Likert scale, ranging from 1 (very poor) to 5 (very good). Similarly, the perceived importance of these skills for employment was assessed on a 5-point Likert scale, from 1 (not at all important) to 5 (extremely important). In the student survey, participants were distributed evenly across Years 1–4, with 23 % in Year 1, 24 % in Year 2, 23 % in Year 3, and 31 % in Year 4.

Descriptive statistics, including means, were calculated for each employability skill's importance and competency level. Eq. (1) displays the mean Likert score $\bar{x}_j$ for an employability skill j, calculated by summing all individual scores x_j and dividing by the number of responses n_d for that question. This approach was applied to each participant group separately.

Table 1
Information Collected Across Three Distributed Surveys.

	Employers	Alumni	Students
Participants	27	25	79
Demographic Information	Company industrial sector; Company size; Current role.	Year of graduation; University attended; Degree type (BEng/MEng); Industrial sectors previously & currently worked in	Year of study; Industrial sectors interested to work in
Employability Skill Assessment (5-point Likert scale)	Skill importance for employment; Skill competence level of graduates	Skill importance for employment; Self-assessed skill competence level upon graduation	Perceived skill importance for employment; Self-assessed current skill competence level
Sub-skill Assessment (Multiple Choice Question)	Sub-skill importance for employment	Sub-skill importance for employment	IF a skill's importance is greater than or equal to 3 and the corresponding skill competency level is less than or equal to 3: Related sub-skills interested in improving
Skill Contribution	Selection of chemical engineering specific modules important for employment	N/A	IF a skill's competency level is assessed at greater than or equal to 4: Selection of curricula and extra-curricular activities as well as modules that have contributed to the student's skill proficiency
Electives	Willingness to hire a graduate with electives	Open response for electives alumni wished to take	Willingness to undertake specific electives; Open response for desired electives

$$\bar{x}_j = \sum_{1}^{n_d} x_j \Big/ n_d \qquad \text{Eq. (1)}$$

The skill gap was calculated as the difference between the mean perceived importance of skills and the mean perceived competency levels reported by employers, students, and alumni. This approach is commonly used in the literature to assess gaps, where graduates' competencies may also be evaluated based on employers' satisfaction with their skillsets (Nair et al., 2009), (Blom and Saeki, 2011), (Rizwan et al., 2018),(Azami et al., 2018).

2.3. Job Advertisement Analysis

In addition to surveys, a job advertisement analysis was conducted to identify the skills most sought by employers, offering industry-specific insights. Job advertisement analysis has been used in literature to explore how employability skills vary across engineering disciplines and education levels. (Fleming et al., 2024), (Passow and Passow, 2017), (Grinis, 2019). Job advertisements were chosen as a data source for this study because they provide accessible and direct insights into the skills employers actively seek. While job postings may emphasise technical competencies more than broader employability skills, they still offer valuable information on both essential and desired skills. By combining findings from this method with employer surveys and existing literature on skill requirements, a comprehensive understanding of the skills needed by chemical engineering graduates can be achieved. This approach integrated the explicit demands stated in job advertisements with the less tangible, yet equally important, attributes valued in professional practice.

A systematic study was conducted, collecting 216 job advertisements over 10 months from various sources, including company websites and job portals (Gradcracker, Reed, TotalJobs, Engineering Jobs, and The University of Manchester's Career Connect). In cases where a built-in filtering tool was unavailable, keywords such as "Graduate chemical engineer," "Graduate engineer," and "STEM graduate" were used to identify relevant job advertisements. Duplicate postings were removed from the sample, and employability skills were categorised based on the predefined skill categories outlined in Section 2.1. Although the number of analysed job postings and the study period were limited, the postings covered positions across fourteen different industries, suggesting that the findings are applicable to a wide range of sectors rather than being industry-specific.The inclusion criteria for job advertisements in the sample analysed required them to: be UK-based and full-time roles; have a clear job description with specified requirements for skills and qualifications; be targeted specifically to chemical engineers as well as engineering and STEM graduates, including chemical engineering graduates; and require a maximum of 2 years of work experience.

3. Results and discussions

3.1. Identification and Classification of Employability Skills

To assess the skill gap among chemical engineering graduates, the first step was to develop a comprehensive employability skill framework. This framework includes a detailed compilation of essential technical knowledge, transferable skills, and data and digitalisation skills relevant to chemical engineers, serving as a benchmark for comparing skill classifications identified in this study with those from related research. Table 2 summarises the skill groups and sub-skills identified through the literature.

While frequently mentioned skills such as self-management, collaboration, personal attributes, communication, and problem-solving abilities were incorporated, this framework also addresses skills often overlooked in existing studies. For instance, specialised software usage, integral to chemical engineering, is not frequently highlighted in

Table 2
Overview of employability skills and sub-skills required for chemical engineering graduates.

Main Skill	Sub-Skill
Self-Management	Self-organisation, Time management, Self-regulation, Taking initiative, Multi-tasking, Continuous and self-learning ability, Career management, Stress management, Autonomy
Interpersonal Skills	Teamwork, Receptiveness to feedback, Negotiation, Following instructions, Leadership
Personal Attributes	Motivation, Positive attitude, Flexibility, Adaptability, Resilience, Results-oriented, Common sense
Communication	Written communication, Oral communication, Presentation skills
Problem-Solving Skills	Critical thinking, Decision-making, Identifying and formulating a problem, Methodical approach, Creativity
Literacy (For Engineering)	Report writing, Technical vocabulary comprehension, Fluency in English
Business-Related Skills	Business management, Financial accounting, Commercial awareness, Basic economics knowledge, Regulatory environment knowledge, Networking ability
Data & Digitalisation Skills	Modelling & Optimisation, Data Management, Data analytics, Statistics, Programming & coding (specifically: MATLAB, Python, R), Specialised Software Usage (Spreadsheet software, CAD software, Chemical Process Simulation software, Data analytics software, Computational Fluid Dynamics software, Multiphysics modelling & verification software, Mathematical solver & verification software and tools, Optimisation modelling software & tools, Materials or laboratory simulation software)
Project Management	Planning, Taking responsibility, Organisation, Resource management
Numeracy	Numerical data compilation, Understanding of calculus, algebra, arithmetic
Analytical Skills	Data analysis, Data interpretation, Data handling, Attention to detail
Knowledge And Application Of Science And Engineering	Knowledge of industrial processes and techniques, Knowledge of sustainable development, Laboratory skills, Engineering documentation, Industrial equipment operation, Product design, Process design, Engineering safety, GxP requirements, Risk assessment
Personal Values	Commitment, Social responsibility, Safety ethics, Personal ethics, Integrity
Professionalism	Accuracy, Reliability, Appropriate conduct and attire, Punctuality
Methodologies And Tools for Continuous Improvement, Project Management And Quality Management	Lean Six Sigma, Six Sigma, TPQM, TQM, Agile, Scrum. Waterfall, Kanban, Lean, Lean manufacturing, APF, ISO, Top-down & Bottom-up approach, Kaizen, Cost of quality, APQP, PPAP, FMEA, MSA, SPC

employability skill analyses. Similarly, professionalism and personal values are rarely featured, despite their importance in studies where they appear (Ramadi et al., 2016),(Harun et al., 2017). These gaps highlight the need for further research to explore and include such essential but underrepresented skills.

The developed skill framework in this study offers several advantages. It provides thorough coverage of key skills required by chemical engineering graduates in the current job market, including skills often under-assessed in the literature. Additionally, it introduces a systematic method for categorising and analysing employability skills, moving beyond traditional approaches focused solely on listing skills. Furthermore, the framework facilitates efficient comparisons between studies, enabling concise and effective assessments of over 70 identified skills.

However, this framework also has certain limitations. Firstly, it operates within a defined scope, focusing only on employability skills identified in the literature and excluding broader aspects of job performance, such as industry-specific expertise. For example, Pott examined a narrower set of industry-specific skills frequently used by chemical engineering graduates, including bioprocessing and separations (Pott and de Jager, 2021). Their findings highlighted that risk management, finance, and economics were among the most commonly applied technical skills post-graduation. However, employer surveys indicated that only 31 % prioritised financial accounting, while 47 % emphasised risk assessment and 69 % highlighted basic economics. This suggests that while some technical skills are often utilised in practice, they may not be viewed as essential prerequisites, potentially due to company-provided training, which varies based on organisational size and training schemes (Connor and Shaw, 2008).

It is important to acknowledge that identifying and classifying employability skills inherently involves subjectivity, potentially leading to disagreements about which skills should be included and how they should be categorised. This subjectivity may result in inconsistencies across frameworks, complicating comparisons between studies. The challenge is further amplified by the broad and sometimes ambiguous definitions of certain skill groups, as well as overlaps between categories. For example, fluency in English could reasonably fall under both literacy and communication skills. Similarly, Ssegawa grouped 39 skills into 4 categories, classifying risk management and appropriate demeanour under "Managing Self" (Ssegawa and Kasule, 2017). By contrast, this study placed them under "knowledge and application of science and engineering" and "professionalism," respectively. To ensure a more consistent and detailed assessment, this study's framework adopted concise skill groups with clear sub-skill definitions, facilitating succinct yet comprehensive surveys.

3.2. Assessment of Employability Skill Importance

3.2.1. Skill Importance across Surveys

To summarise respondents' perceptions of skill importance and compare the relative significance of different employability skills, the mean Likert scores are shown in Fig. 1.

Communication, interpersonal, self-management, and problem-solving skills emerged as the most highly valued skills across all participant groups. These results are consistent with previous studies, such as Fletcher et al., which identified communication and teamwork as top priorities among students and alumni (Fletcher et al., 2017). Similarly, Grant (Grant and Dickson, 2006), Male et al. (Male et al., 2011), and Passow (Passow, 2012) emphasised communication, teamwork, self-management, and problem-solving as essential employability skills. The World Chemical Engineering Council also listed teamwork, communication, and self-learning as critical for employment (The World Chemical Engineering Council, 2004).

However, differences emerged between employers and students regarding the perceived importance of employability skills. Assuming that the employers' views, informed by more extensive experience, are likely more aligned with industry requirements, students at the University of Manchester tended to overestimate the importance of many skills. In contrast, they underestimated the significance of personal attributes, personal values, numeracy skills, and the knowledge and application of science and engineering. These discrepancies may reflect students' limited work experience, lack of exposure to real-world scenarios, and assumptions about job market expectations. Addressing these gaps is crucial to helping students better align their skill development with industry needs and enhance their employability.

The observed differences in perceptions do not entirely align with

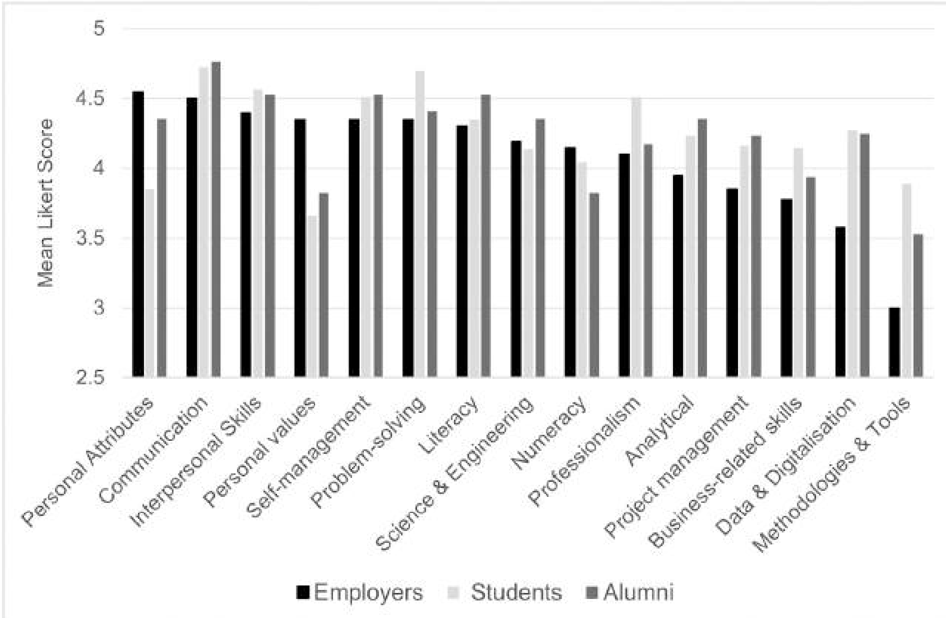

Fig. 1. Mean Likert Scores for Skill Importance perceived by Employers, Students, and Alumni.

Fletcher's findings, where students underestimated interdisciplinary approaches, project management, and business-oriented thinking, while overestimating core chemical engineering knowledge and ethical responsibilities (Fletcher et al., 2017). Fletcher's study primarily focused on comparing the perceptions of students and alumni with less than two years of experience, which may explain this discrepancy. In the present study, alumni perceptions were generally more closely aligned with those of students, yet notable differences with employers persisted. Both alumni and students underestimated the importance of personal values, attributes, and numeracy skills, likely reflecting their limited exposure to industry practices.

Exploring the significance of the sub-skills further, employers highlighted several critical sub-skills in their survey responses. All employers valued self-management skills, including continuous and self-learning ability (100 %), as well as taking initiative (93 %), underscoring the demand for adaptable individuals capable of acquiring new skills independently. Other highly regarded sub-skills included resilience, taking responsibility, oral and written communication, and teamwork, with 93 % of employers emphasizing their importance. In the domain of data and digitalisation, while modelling and simulation were identified as critical sub-skills (92 %), interestingly, spreadsheet software proficiency, particularly Microsoft Excel, was highlighted as the most essential tool in computational and digitalisation technologies. This finding aligns with job advertisement trends, where Microsoft Excel appeared in 47 % of postings related to data and digitalisation skills (see Section 3.2.2). Similarly, Fleming et al. reported that an analysis of over 20,000 engineering job advertisements found Excel proficiency to be the most frequently specified technical skill (Fleming et al., 2024).

One limitation of these results is the relatively small sample size of respondents, which may limit the generalisability of the findings. However, steps were taken to ensure that the sample included a broad range of industries and roles. Specifically, the surveyed employers and alumni represented 12 different industrial sectors, and the student respondents were evenly distributed across different year groups in the undergraduate program. This diversity in respondents' backgrounds helps mitigate potential biases and offers a broader perspective on the employability skills required in the field. Nevertheless, we acknowledge that a larger sample size would strengthen the robustness of the conclusions.

3.2.2. *Comparison of Skill Importance across Surveys and Job Advertisements*

To assess the importance of employability skills and examine correlations between their perceived importance and frequency in job advertisements, survey results were compared with job postings. Likert scores of 5, representing the highest level of importance assigned by participants, were used as a benchmark to identify the most essential skills perceived by respondents and compare them with the frequency of skills mentioned in job advertisements, as shown in Fig. 2.

Communication, personal attributes, interpersonal skills and self-management were frequently mentioned in job advertisements, indicating their high value to employers. Employers also rated these skills highly in survey responses, suggesting alignment between perceived importance and job posting frequency. However, discrepancies emerged when comparing job advertisements and student survey responses. While both groups highly rated communication, students prioritised problem-solving and professionalism, which were less prominent in advertisements. This may reflect differences in how students and employers perceive skill relevance, with students potentially overestimating certain skills based on academic experiences. Notably, the smaller differences between employer survey responses and job advertisements, compared to student surveys, suggest that employer perceptions align more closely with job requirements, reinforcing the reliability of the results.

Interestingly, some essential skills, such as personal values, literacy, numeracy and professionalism, were rarely mentioned in job advertisements but remained important to employers. This could be because these skills are viewed as baseline competencies that candidates are expected to possess, making explicit mentions unnecessary. Employers in job advertisements may prioritise specialised skills tailored to specific roles, assuming that foundational skills are inherent and do not require explicit mention.

Conversely, some technical skills, such as data and digitalisation and methodologies for continuous improvement, appeared more frequently in advertisements than in employer survey responses. This discrepancy may arise because specialised technical skills are often highlighted in job postings to match specific role requirements, whereas employers may prioritise broader competencies during assessments.

Overall, while job advertisements tend to emphasise technical and role-specific skills, employer surveys highlight the importance of both

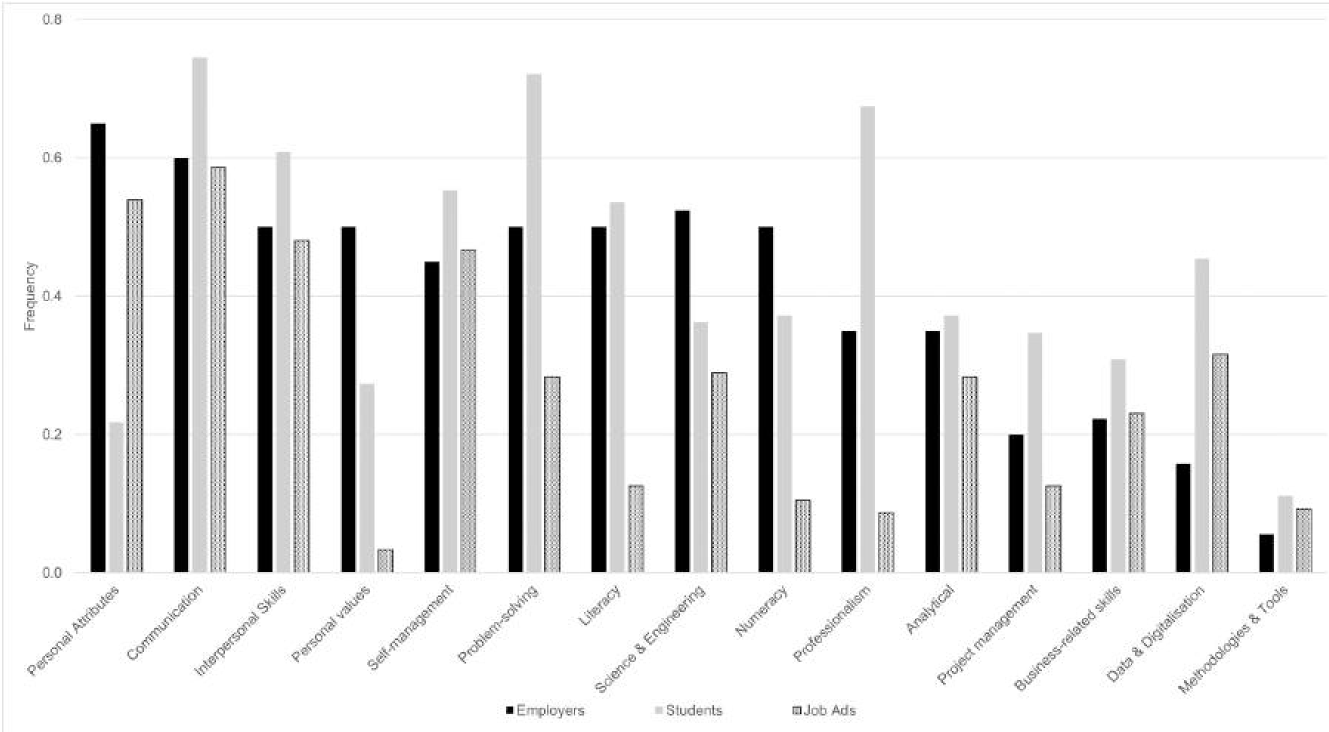

Fig. 2. Comparison of Frequency of Skills in Job Advertisements and Frequency of Highest Level of Importance perceived by Employers and Students.

fundamental and specialised competencies. Students should, therefore, focus on balancing the development of core attributes with technical expertise to meet explicit and implicit employer expectations.

Despite its insights, this analysis has limitations. Firstly, focusing solely on the highest Likert scores may overlook variations in ratings, as two skills with similar top scores could differ in overall distribution. Respondents may also interpret scores differently, introducing subjectivity. Additionally, job advertisements may not fully reflect required skills, as employers might prioritise certain attributes during interviews rather than listing them explicitly. Variations in job requirements across contexts and projects further complicate interpretations. Recruitment practices also pose challenges, as job advertisements are sometimes prepared by HR departments with limited technical knowledge of role requirements. This can result in omissions of critical technical skills. Moreover, the small sample size may have failed to capture highly specific skills essential for certain positions.

Despite these limitations, this analysis highlights the need for a holistic approach to skill development. Relying solely on job advertisements or employer surveys may overlook critical skills valued by industry. Combining insights from multiple sources ensures a more comprehensive understanding of employer expectations and better prepares students for employment.

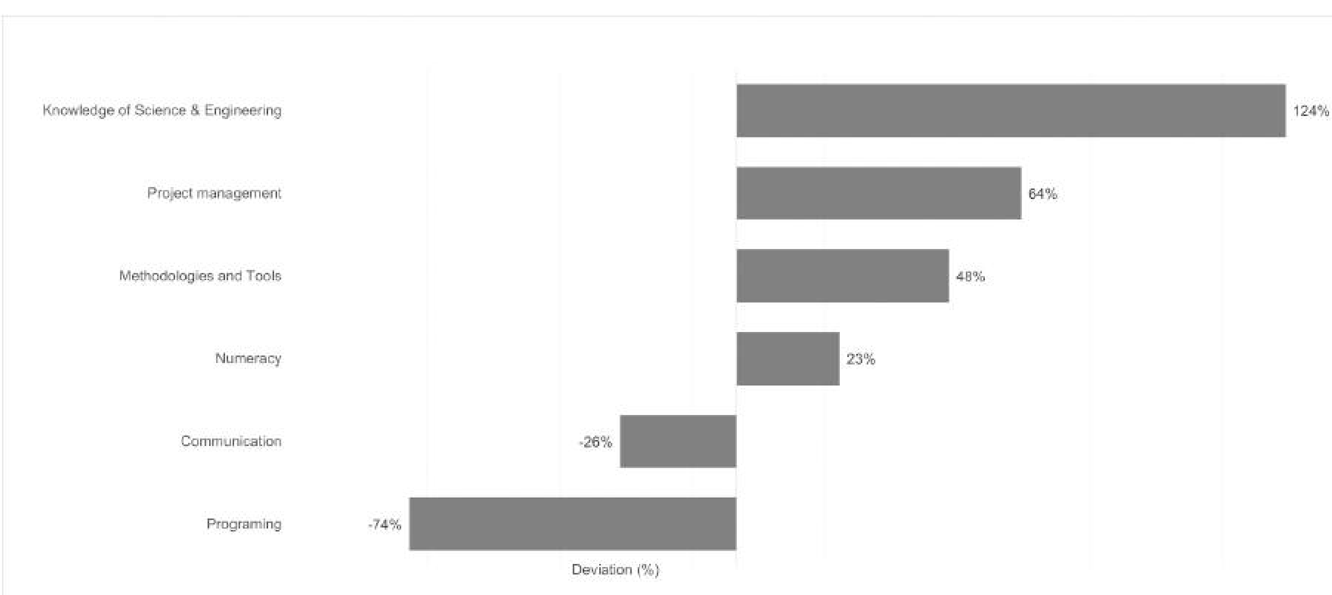

Fig. 3. Deviation (%) of Skills for Chemical Engineering Graduate Roles from STEM and General Engineering Roles in Job Advertisements.

3.2.3. Skill Importance in Roles Solely for Chemical Engineering Graduates

To investigate employability skills specific to chemical engineers, job advertisements for chemical engineering graduates were compared with those targeting general engineering and STEM graduates. Significant differences in skill requirements were observed, as shown in Fig. 3, highlighting key deviations between the requirements for chemical engineering graduates and those in other fields.

The findings revealed that roles specific to chemical engineering graduates place greater emphasis on the knowledge and application of science and engineering, project management, methodologies and tools for continuous improvement and quality management, and numeracy. This higher demand reflects the need for these skills in process and product development, alongside a growing focus on sustainability through quality management and resource efficiency. The frequent requirement for tools supporting continuous improvement highlights the industry's emphasis on optimising processes, enhancing efficiency, and remaining competitive (Bantham and Swanson, 1995). Similarly, numeracy is emphasised due to the quantitative nature of tasks, which often involve mathematical models (Grant and Dickson, 2006), (Rice, et al., 2023). These findings align with previous studies that underscore the importance of knowledge of science and engineering, and numeracy in chemical engineering roles (Fletcher et al., 2017; Meyer Th. et al., 2022; Lopez and Montalvo, 2015). It is also worth noting that more specialised technical knowledge is often specified in job advertisements when only one degree type is required, contributing to the observed skill variations.

Interestingly, communication skills appeared less frequently in advertisements for chemical engineering roles, possibly reflecting the prioritisation of technical expertise over transferable skills in these positions. However, this lower frequency does not imply that communication skills are unimportant but may instead indicate that such competencies are assumed rather than explicitly stated. Similarly, programming skills appeared less frequently in job advertisements specific to chemical engineering graduates. This trend may reflect the prioritisation of other specialised technical skills more directly related to process design, automation, and modelling in chemical engineering. Furthermore, programming may be less emphasised because many chemical engineering roles rely on pre-developed software tools and simulations rather than requiring custom coding solutions.

While job advertisements provide insights into skill requirements, they may underrepresent the broader set of skills valued in the workplace. As earlier comparisons indicated, employers often place high value on foundational skills, such as communication and personal attributes, even if they are not frequently mentioned in advertisements. Therefore, these deviations should be viewed as relative comparisons between chemical engineering and other engineering or STEM roles rather than definitive indicators of skill importance for chemical engineers.

3.3. Assessment of the Employability Skill Gap

To estimate the skill gap, the difference between the mean skill importance and the mean skill competency for graduates, as perceived by employers, students, and alumni, was determined. The results, presented in Fig. 4, reveal persistent gaps across various employability skills, reflecting the disparity between employer expectations and graduate abilities, as well as differing perceptions among the surveyed groups.

Employers reported the most significant gaps in communication, problem-solving, and literacy skills, all of which are essential for effective performance in professional environments. Communication emerged as a recurring concern, with employers stressing deficiencies in graduates' ability to articulate ideas clearly and engage effectively with diverse teams. These findings align with studies like Hirudayaraj et al., which identified communication as the skill with the greatest disparity between importance and proficiency for entry-level engineers (Hirudayaraj et al., 2021). Likewise, the gap in problem-solving skills, including critical thinking and decision-making, reflects graduates' struggles to address complex engineering problems effectively. Fletcher et al. similarly noted that while graduates excel in technical knowledge, they often lack the ability to apply structured problem-solving approaches to real-world challenges (Fletcher et al., 2017).

Interpersonal skills also revealed a noticeable gap, perceived by all groups. Teamwork, leadership, and the ability to follow instructions were identified as challenges for graduates in collaborative environments. Employers emphasised that strong interpersonal skills are vital for team dynamics, conflict resolution, and workplace productivity. However, academic teamwork often fails to replicate real-world complexities like negotiation and leadership. Research highlights that engineers must work effectively with people as well as tools, underscoring the need to develop these competencies early in education (Fletcher et al., 2017; Zandi et al., 2022).

Students perceived a larger gap in business-related skills and project management compared to employers, reflecting their uncertainty about preparedness. Business competencies, including an understanding of economic and regulatory contexts, were perceived as underdeveloped. These findings align with Winberg et al., who highlighted the importance of integrating managerial training and commercial awareness into engineering programs to better prepare graduates for leadership roles (Winberg et al., 2020). Employers emphasised that greater exposure to

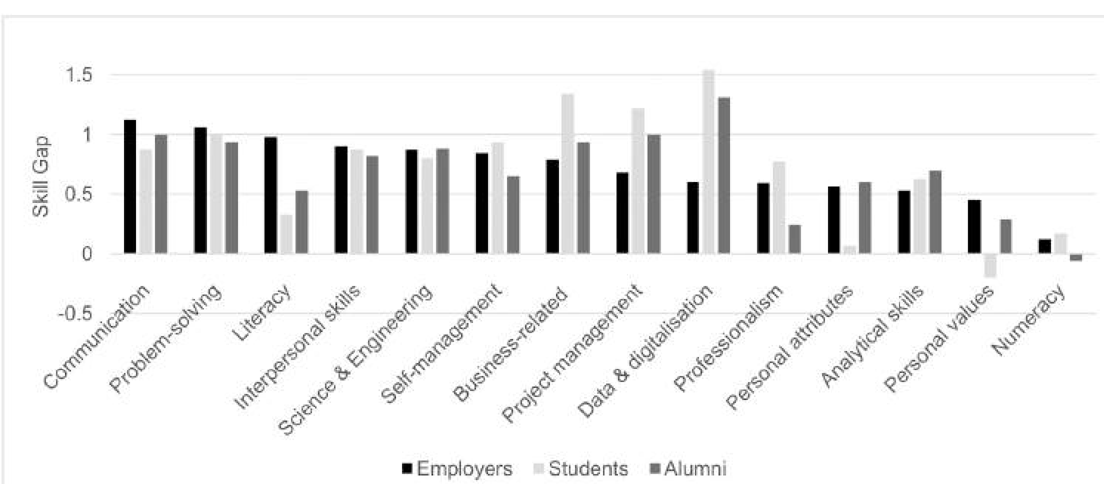

Fig. 4. Employability Skill Gap perceived by Employers, Students and Alumni.

project management methodologies and industry-aligned learning would help graduates better navigate the complexities of real-world projects.

In addition, data and digitalisation skills emerged as an area of concern, particularly as industries increasingly adopt advanced technologies and digital solutions. While students and alumni reported significant gaps in their preparedness, employers were relatively less critical, likely because companies often provide role-specific training. Nevertheless, studies such as Zandi et al. stress that foundational competencies in digital tools, data analytics, and modern software systems are essential for graduates to remain competitive in Industry 4.0 environments (Zandi et al., 2022).

Employers further highlighted gaps in personal attributes and personal values, particularly in the ability to manage workloads, adapt to changing environments, and maintain resilience under pressure. Students' perceptions in this area were notably less critical, reflecting a disconnect between their expectations and workplace realities. This gap reinforces the importance of embedding experiential and reflective learning activities into curricula to foster personal and professional growth. Similarly, professionalism, including reliability and ethical behaviour, was noted as an area requiring greater focus during the educational phase.

A notable finding was the gap in knowledge and application of science and engineering. While students acquire foundational theoretical knowledge during their studies, employers emphasised a shortfall in graduates' ability to apply this knowledge practically. Students also perceived this gap significant, reflecting their lack of confidence in translating theoretical knowledge into practice. This aligns with broader concerns in engineering education, as Winberg et al. identified the lack of hands-on, practical exposure to real industrial environments as a key challenge (Winberg et al., 2020). Similarly, the IET reported that 63 % of 442 employers identified deficiencies in specialist technical knowledge among applicants (The Institution of Engineering and Technology, 2021) .

Employers emphasised that the ability to translate scientific and engineering principles into tangible solutions is essential for industry success, underscoring the need for curricula to incorporate more practical learning experiences. Because of the significance of the specific knowledge of science and engineering, the employer survey requested the selection of the most important subject areas for employment.

The findings indicate that, in particular, sustainable engineering is highly valued by the majority of employers, with 53 % considering it important for employment. This suggests an emphasis on sustainable development in industry, which is in line with current research (van Zanten and van Tulder, 2021; Wan et al., 2020). Furthermore, the implementation of sustainability in engineering has been linked to a number of other desirable transferable skills, such as problem-solving and collaboration (Quelhas et al., 2019).

The results of the skill gap analysis underscore the need for a more integrated approach to skill development in chemical engineering education. While technical knowledge in science and engineering forms the foundation of graduates' competencies, gaps in communication, problem-solving, business-related skills, and data and digitalisation reveal areas where current curricula fall short. By incorporating more experiential learning opportunities—such as internships, project-based work, and stronger industry partnerships—institutions can bridge these gaps effectively. This approach will ensure that graduates possess both the technical expertise and the professional skills required to meet evolving industry demands, enhancing their employability and readiness for the modern workforce.

3.4. Contributions to Employability Skill Development for Students

Understanding how various activities contribute to skill development is essential for designing effective curricula that prepare chemical engineering graduates for the workforce. The results of student surveys highlight the relationship between specific activities and the enhancement of critical skills, as summarised in Table 3.

Group coursework emerged as the most impactful activity, with students reporting significant improvements in project management, interpersonal, and communication skills. These findings align with Winberg et al., who emphasised the importance of teamwork and collaboration in addressing real-world engineering challenges (Winberg et al., 2020). Similarly, design projects were particularly effective in enhancing problem-solving and analytical skills. By applying theoretical knowledge to practical scenarios, students developed critical thinking and creativity, concepts supported by Ocampo-López et al. who identified capstone projects as crucial for integrating knowledge and skills (Ocampo-Lopez et al., 2022) .

In students' view, continuous individual coursework primarily enhanced self-management skills, such as time management and goal-setting, while laboratory work provided opportunities to develop technical precision and analytical abilities. Additionally, group presentations fostered communication and presentation skills, helping students gain confidence in explaining complex ideas to peers and evaluators.

Additionally, extracurricular and co-curricular activities and mentoring programmes such as PASS supported the development of leadership, adaptability, and self-regulation. These co-curricular engagements are recognised by Jackson and Rowe as vital for preparing students to navigate diverse workplace contexts (Jackson and Rowe, 2023).

In a follow-up question within the students' survey, several key modules within the Chemical Engineering curriculum at the University of Manchester were highlighted by students as having a significant impact on their skill development. For instance, Fundamentals of Thermodynamics strongly contributed to self-management, interpersonal skills, and numeracy, while Process Engineering Fundamentals emphasised problem-solving and professionalism. Modules such as Process Design & Simulation, Utility System Design, and Process Safety were particularly effective in developing analytical skills and project management capabilities. It is important to note that the effectiveness of these modules depends on how they are delivered and assessed, and variations across institutions may influence results. These findings support Winberg et al., who advocate aligning curricular content with skill development objectives (Winberg et al., 2020).

The connection between programme-level activities, module design, and skill development is well-supported by existing literature. Active learning strategies, including project-based and problem-based learning, have consistently demonstrated their effectiveness in fostering skill acquisition and application. Recommendations from the literature include embedding active learning, work-integrated learning, and community engagement into engineering programmes. These approaches bridge the gap between academic training and industry expectations, particularly in communication, problem-solving and interpersonal skills. By leveraging these strategies, universities can create balanced curricula that prepare graduates for the complexities of

Table 3
Contribution of Activities to employability Skill Development.

Activity	Average frequency across skills (%)
Group coursework	60
Design project	48
Continuous individual coursework	41
Group presentations	37
Extracurricular activities	34
Lab work	32
Mentoring, Peer Assisted Study Sessions (PASS)	26
Online assessments	24
Tutorial Sessions	13
Workshops / help provided by the University	9

modern engineering roles. A summary of these recommendations along with the associated developed skills are listed in Table 4.

4. Conclusions and Recommendations

In light of rapid technological advancements and changing industry expectations, the employability landscape for chemical engineering graduates is evolving significantly. This study highlights critical insights into graduate preparedness, revealing gaps between the skills graduates possess and those employers demand. The main deficiencies are evident in key transferable skills such as communication, teamwork, problem solving, project management, and business acumen. Employers increasingly stress the importance of adaptability, interpersonal skills, and data and digitalisation skills, emphasising the urgent need for curriculum reforms to address these gaps effectively. Survey results indicate that students often overestimate their technical readiness while undervaluing the importance of transferable skills such as resilience, ethics, and integrity. Employers, however, prioritise a balanced skillset that combines technical expertise with effective communication and management abilities. This misalignment highlights the need for educational programmes to enhance self-awareness among students and better align their competencies with industry expectations.

To address the skill gaps identified in this study, targeted improvements in curriculum design are necessary. Incorporating problem-based and team-based learning approaches could help students strengthen critical thinking, communication, and teamwork skills. Regular feedback through formative assessments and peer evaluations may also support the development of these transferable skills and better prepare students for professional settings. Professional networking opportunities, including career fairs, professional associations, and online platforms, may further expose students to industry expectations and help build valuable connections.

Chemical engineering departments should also consider enhancing curricula by introducing structured modules on project management, business acumen, and leadership. Expanding training in data analytics, computational tools, and software proficiency is also essential to meet the demands of Industry 4.0. Additionally, creating more opportunities for internships, industry placements, and collaborative projects can bridge the gap between academic knowledge and practical application. Interdisciplinary approaches that incorporate business, sustainability, and management principles into chemical engineering education should also be prioritised.

To build on these findings, future research should consider a more comprehensive study that explores the perceptions of students from multiple institutions to capture a broader range of educational experiences. Additionally, expanding the employer sample across diverse industrial sectors would provide deeper insights into sector-specific skill requirements, enhancing the generalisability of the findings. Future research could also explore longitudinal studies to assess the long-term effects of curriculum changes on graduate employability. Examining the effectiveness of specific interventions, such as digital training programmes and interdisciplinary courses, may yield valuable insights for curriculum improvements. Additionally, investigating employer perspectives on industry trends and their influence on engineering education could help maintain alignment with workforce needs. Further studies may also focus on integrating emerging technologies, such as artificial intelligence and machine learning, into chemical engineering curricula. These technologies are expected to play a transformative role in the industry and require new skillsets for graduates. Research on best practices for fostering teamwork, leadership, and adaptability within academic programmes could provide actionable strategies to enhance employability outcomes. By addressing these areas, chemical engineering programmes can better prepare graduates to navigate the complexities of modern industries and compete successfully in an increasingly dynamic job market.

Table 4
Recommendations for Skill Development in Higher Education (Engineering).

Recommendation	Skills Developed	Supporting Literature
Work Integrated Learning: Real-world work experience integrated into the curriculum, combining classroom learning with practical application. Provides students with industry exposure.	Problem-solving, Interpersonal skills, Professionalism	(Reedy et al., 2020), (Lowden et al., 2011), (Thonglek et al., 2013)
Service Learning: Combines community service or social engagement with academic learning. Students gain practical experience and deeper understanding of how engineering principles can be used to address societal needs.	Personal values, Interpersonal skills, Business-related skills, Professionalism	(Huff et al., 2015), (Armstrong et al., 2021)
Project-based learning & Capstone projects: Students work on authentic projects with real-world relevance, applying theoretical knowledge to practical scenarios. Enhanced learning can be achieved through multidisciplinary teams (across departments). Capstone projects integrate knowledge and skills acquired throughout the program.	Interpersonal skills, Problem-solving, Project management, Communication skills, Science and engineering, Self-management	(Ocampo-Lopez et al., 2022), (Winberg et al., 2020), (Forshaw et al., 2016)
Problem-based learning (PBL): Students work collaboratively in small groups to solve real-world problems or complex scenarios. They actively engage in the learning process by identifying knowledge gaps, seeking information, analysing different perspectives, and developing potential solutions.	Problem-solving, Analytical skills, Interpersonal skills, Communication skills, Project management	(Clark, 2008), (De Magalhaes et al., 2007), (Winberg et al., 2020)
Enquiry-based learning (EBL): Students are motivated to inquire, explore areas of interest, and pursue their own lines of questioning. The learning process entails students creating research questions, collecting and assessing data, critically evaluating information, and drawing conclusions.	Self-management, Personal attributes, Problem-solving, Analytical skills	(Novakovic et al., 2012), (Ventura-Medina et al., 2007)
Research experiences: Opportunities for students to engage in scientific research, inquiry, and discovery. Develops skills and encourages intellectual curiosity.	Analytical skills, Literacy, Science & Engineering	(Lenihan et al., 2020)
Industry collaborations: Collaborations with industry partners to provide students with exposure to real-world projects, industry	Interpersonal skills, Problem-solving, Industry-specific skills, Knowledge and application of Science and Engineering	(Reedy et al., 2020), (Forshaw et al., 2016), (Arlett et al., 2015)

(continued on next page)

Table 4 (*continued*)

Recommendation	Skills Developed	Supporting Literature
practices, and professional networks. Develops industry-specific skills, enhances employability, and promotes the application of knowledge in practical settings. Offers opportunities for internships, guest lectures, industry-led projects, and mentorship programs.		
Simulation exercises: Virtual or simulated environments that replicate real-world scenarios. Provides a safe space for experimentation and learning from mistakes.	Interpersonal skills, Problem-solving, Science and Engineering, Data & Digitalisation	(Kumar et al., 2021), (Seifan et al., 2019)

CRediT authorship contribution statement

Malekshahian Maryam: Writing – review & editing, Writing – original draft, Supervision, Conceptualization. **Dautelle Jessica:** Writing – original draft, Methodology, Investigation. **Shahid Salman:** Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Implementing employability strategy: Inspiring change through significant conversations

Bonnie Amelia Dean [1], Kate Tubridy[2], Michelle J. Eady[3], and Venkata Yanamandram[4]

Corresponding author: Bonnie Amelia Dean (bonnie_dean@uow.edu.au)
[1] Learning, Teaching & Curriculum, University of Wollongong
[2] School of Law, University of Wollongong
[3] School of Education, University of Wollongong
[4] School of Business, University of Wollongong

Abstract

Higher education plays a key role in cultivating graduate employability, which is essential to meeting multiple individual, community, social and labour market needs. Universities prioritise employability through strategic goals and initiatives designed to foster work-ready graduates equipped with the skills, aptitudes, and knowledge needed to navigate self-determined career pathways. One core approach to delivering on the employability agenda is through work-integrated learning (WIL). Despite institution's efforts to set targets to increase access to WIL for all students, there is little evidence on how these strategies are implemented, reported, and revised, particularly in resource-depleted environments. This paper illuminates how institutional directives can be enacted when transformative learning is centralised through relational, collegial conversations. It builds on Dean et al.'s (2020) paper to unpack how the WIL Curriculum Classification (WILCC) Framework has been executed through employability champions across the institution, who advocate for meaningful, contextually appropriate change that is co-designed with colleagues. These 'significant conversations' are the impetus for transforming students' learning experiences and career readiness. The paper offers four vignettes to showcase how the WILCC Framework has been implemented and disseminated across local, institutional, cross-campus and international contexts through transformative engagement in relational dialogue. It outlines key recommendations for holding significant conversations to influence change and champion the employability movement.

Keywords
Academic development; curriculum transformation; conversations; employability; work-integrated learning

Introduction

1 234 s2t24s a 4 u d4 2 c 4as2 g p 4ssu 4 to 4spo d to go34 m4 t a d 4mploy4 g oups d4ma d2 g wo k- 4ady g aduat4s (Ch4 g 4t al., 2022; Faku l4 & H2gso , 2021). Th4 focus of 4mployab2l2ty st at4g24s has sh2ft4d f om s4cu 2 g 4mploym4 t to b oad4 2 2t2at234s a2m4d at 4qu2pp2 g l4a 4 s w2th l2f4lo g sk2lls. Th4s4 st at4g24s h4lp l4a 4 s ass4ss th42 p 4f4 4 c4s a d st 4 gths, 4 abl2 g th4m to a32gat4 m4a 2 gful ca 44 s 2 a 3olat2l4, t4ch ology-d 234 global ma k4t. Employab2l2ty 2s d4sc 2b4d as a 'l4a 2 g p oc4ss' (Yo k4, 2006), wh4 4by stud4 ts a d g aduat4s d434lop sk2lls, k owl4dg4, a d p4 so al qual2t24s to f2 d m4a 2 gful wo k that pos2t234ly 2mpacts th4ms4l34s, th4

commu 2ty a d soc24ty (Ol234 , 2015). To m44t th4 chall4 g4s of th4 wo ld of wo k, 2t 2s a u 234 sal 2mp4 at234 fo u 234 s2t24s to p oduc4 4mployab2l2ty st at4g24s a d pol2c24s that s4t a 32s2o fo fost4 2 g ag2l4, w4ll-4qu2pp4d g aduat4s (B 2dgstock & Jackso , 2019; Faku l4 & H2gso , 2021).

Employab2l2ty, how434 , 2s a compl4x, co t4 t2ous, a d mult2-fac4t4d co c4pt (Toml2 so & Holm4s, 2017) wh2ch has 2mpl2cat2o s fo how 2 st2tut2o s co c4234 of a d add 4ss 4mployab2l2ty. Th4 co c4pt of 4mployab2l2ty has d44p oots 2 th4 obj4ct234s of 4co om2c a d labou ma k4t st at4g24s at a   at2o al l434l (McQua2d & L2 dsay, 2005). Th4s4 d 234 s ha34 t a slat4d 2 to go34   m4 tal ta g4ts fo h2gh4 2 st2tut2o s to assum4 s2g 2f2ca t 4spo s2b2l2ty fo p og 4ss2 g a sk2ll4d wo kfo c4 (Ch4 g 4t al., 2022). D4sp2t4 a cl4a gap b4tw44 stud4 ts', 4mploy4 s' a d go34   m4 ts' p4 c4pt2o s of th4 ol4 of h2gh4 4ducat2o fo 4mployab2l2ty d434lopm4 t (Ch4 g 4t al., 2022; Toml2 so , 2008), 4mployab2l2ty holds a w4ll-k ow   4co om2c outcom4 fo both g aduat4s a d 2 st2tut2o s (Faku l4 & H2gso , 2021). Stud4 ts 4xp4ct to pa t2c2pat4 2 4xp4 24 c4s that 4 abl4 th4m to d434lop th42 4mployab2l2ty du 2 g th42 stud24s, to apply d2sc2pl2 4 l4a   2 gs to auth4 t2c wo kplac4 p oj4cts, 4 ha c4 k owl4dg4 of th42 p of4ss2o   a d 4xplo 4 opt2o s fo th42 ca 44 s (Jackso   & B 2dgstock, 2021).

A co 4 4mployab2l2ty st at4gy fost4 4d th ough a collabo at234 4ffo t by 2 dust y a d h2gh4 4ducat2o to 4 ha c4 stud4 t l4a   2 g 2s wo k-2 t4g at4d l4a   2 g (WIL). B oadly, WIL 4f4 s to auth4 t2c, wo k-focus4d 4xp4 24 c4s that 2 t4g at4 th4o y w2th p act2c4 2 acad4m2c p og ams (Z4gwaa d at al., 2023). I st2tut2o al WIL 2 2t2at234s a 4 al2g 4d to a d op4 at2o al2s4 4mployab2l2ty st at4g24s. How434 , th4 4 2s l2m2t4d 432d4 c4 4ga d2 g th4 2mpl4m4 tat2o   a d mob2l2sat2o   of WIL st at4g24s, pa t2cula ly 2 a 4sou c4-sca c4 4 32 o m4 t. Bu2ld2 g o   D4a   4t al.'s (2020) 2 st2tut2o al f am4wo k fo WIL, th2s pap4   4po ts o   o 4 u 234 s2ty's 2mpl4m4 tat2o   app oach to t a sfo m 4mployab2l2ty a d 2 c 4as4 WIL ac oss cou s4s, d4sp2t4 th4 co f2 4m4 t of 4sou c4s. It h2ghl2ghts th4 ol4 of staff who 2d4 t2fy th4ms4l34s as '4mployab2l2ty champ2o s' w2th2 th42 d2sp4 s4 ol4s a d 2llum2 at4s th4 t a sfo mat2o al 2mpact of co 34 sat2o s fo t4ach2 g a d l4a   2 g. G ou d4d 2 schola sh2p fo s2tuat4d l4a   2 g (La34 & W4 g4 , 1991) a d acad4m2c d434lopm4 t (Pl4scho3á, 4t al., 2021), th4 pap4 d aws o 's2g 2f2ca t co 34 sat2o s' (Roxå & Må t4 sso , 2009) as a 4mpow4 2 g m4cha 2sm fo coll4agu4s to pa t 4 w2th th42 p44 s a d 4mb4d 4mployab2l2ty 2 to 4x2st2 g cu 2cula . Fou 32g 4tt4s by 2 st2tut2o al 4mployab2l2ty champ2o s a 4 off4 4d to showcas4 how 4mployab2l2ty st at4gy ca   b4 2mpla t4d at th4 local, 2 st2tut2o al, c oss-campus a d 2 t4   at2o al co t4xts wh4   coll4g2al a d 4lat2o al app oach4s a 4 c4 t al2s4d a d 3alu4d. Th2s pap4 clos4s w2th st 4 gths a d 4comm4 dat2o s to ad3a c4 4mployab2l2ty st at4gy th ough s2g 2f2ca t co 34 sat2o s.

Strategic Approaches to Employability

Wh2l4 4mployab2l2ty 2s a global ph4 om4 o , 4s4a ch o   th4 434 -p 4s4 c4 of 4mployab2l2ty p 4dom2 at4ly st4ms f om W4st4   cultu 4s (Faku l4 & H2gso , 2021). Employab2l2ty 2s d4mo st abl4 ac oss W4st4   u 234 s2t24s as a 4sult of go34   m4 t a d pol2cy f am4wo ks (Faku l4 & H2gso , 2021). Fo 4xampl4, 2 th42 a alys2s of 2 st2tut2o al docum4 ts a d 432 4w of th4 l2t 4 atu 4, Ch4 g 4t al. (2022)   ot4d th4 4 2s a 2 c 4as2 g   umb4 of u 234 s2t24s 2 th4 1 2t4d K2 gdom w2th 4mployab2l2ty st at4g24s. I   th42 432 4w of 4s4a ch u 234 s2t24s ac oss 1 2t4d Stat4s, Ca ada, Aust al2a a d th4 1 2t4d K2 gdom, B4   4tt at 4l. (2016) 432 4w4d 100 w4bs2t4s fo 4 gag4m4 t w2th 4mployab2l2ty wh4 4 2t was fou d, to 3a 2ous d4g 44s, ac oss all 2 st2tut2o s. Wh2l4 th4 4mployab2l2ty ag4 da 2s p 43al4 t 2 W4st4   cultu 4s, stud24s ha34 4m4 g4d also 2   4c4 t y4a s to b oad4 global u d4 sta d2 gs of 2 st2tut2o al app oach4s f om   o -W4st4   cultu 4s such as As2a (T a , 2017) a d Af 2ca (Okol24 4t al., 2020). Th4s4 stud24s h2ghl2ght that   at2o al co t4xts play a s2g 2f2ca t ol4 2 how 2 st2tut2o s tak4 up a d 2mpl4m4 t a 4mployab2l2ty ag4 da.

S434 al stud24s ha34 sought to class2fy th4 app oach4s that 2 st2tut2o s tak4 to st at4g2cally op4 at2o al2s4 4mployab2l2ty. Th4 4 2s ag 44m4 t that 4mployab2l2ty has mo34d b4yo d s2 gula co c4pts, such as a sk2lls-bas4d, 4mploym4 t-o ly, o outcom4s-bas4d app oach (Faku l4 & H2gso , 2021). B 2dgstock & Jackso (2019) p opos4 that u 234 s2t24s t4 d to adopt app oach4s that 4fl4ct th 44 ma2 a2ms: Sho t-t4 m g aduat4 outcom4s (m4asu 4m4 t of 4mploym4 t post-g aduat2o); p of4ss2o al 4ad2 4ss (acc 4d2t4d d4g 44 pathways); a d, l232 g a d wo k2 g p oduct234ly a d m4a 2 gfully ac oss th4 l2f4spa (suppo t fo stud4 ts to ha 4ss th42 ow capab2l2t24s). Faku l4 a d H2gso (2021) off4 th 44 d2ff4 4 t cat4go 2sat2o s of 2 st2tut2o al 4mployab2l2ty, th4s4 b42 g: a outcom4s app oach (comp4t4 c4 a d 4mploym4 t m4asu 4s); a p oc4ss app oach (2 2t2at234s w2th cou s4s a d th ough ca 44 s s4 32c4s) a d th4 co c4ptual app oach (d234 s4 th4o 4t2cal u d4 sta d2 gs). B4 4tt 4t al. (2017) 2d4 t2f24d two dom2 a t app oach4s o 2 st2tut2o 's w4bs2t4s, th4 poss4ss2o al app oach (g aduat4s hold2 g th4 4c4ssa y sk2lls, ab2l2t24s fo 4mploym4 t) a d th4 pos2t2o al app oach (bu2ld2 g cap2tal to b4tt4 pos2t2o g aduat4s fo 4mploym4 t a d ca 44 s) a d a gu4 that th4 4 44ds to b4 a mo34 towa ds a p oc4ssual p4dagog2cal app oach (suppo t2 g g aduat4s' p of4ss2o al a d 4m4 g2 g 2d4 t2t24s). 1 234 s2t24s' comm2tm4 t to 4mployab2l2ty 3a 24s w2d4ly (B4 4tt 4t al., 2017), oft4 4ma2 2 g tac2t a d 2ll-d4f2 4d (B 2dgstock & Jackso , 2019), shap4d by at2o al co t4xts a d 2 flu4 c4s (Faku l4 & H2gso , 2021), a d ta2lo 4d w2th2 4ach 2 st2tut2o .

How 2 st2tut2o s mob2l2s4 th42 4mployab2l2ty st at4gy 2s 4p 4s4 t4d 2 3a 2ous 2 st2tut2o al st uctu 4s o p og ams. Ma y of th4s4 h2ghl2ght th4 ol4 of Ca 44 s c4 t 4s' act232t24s both w2th2 a d outs2d4 th4 cu 2culum (Blackmo 4 4t al., 2015; Fa 4 ga & Qu2 la , 2016). Stud4 ts pa t2c2pat4 2 4mployab2l2ty act232t24s outs2d4 th4 cu 2culum, w2th clubs/soc24t24s, l4ad4 sh2p, m4 to 2 g, a d 3olu t44 2 g p og ams f4atu 4d as act232t24s that stud4 ts pa t2c2pat4 2 a d fa3ou most (Jackso & D4a , 2023). Th4 2mpact of 4mployab2l2ty act232t24s o 4 ha c2 g 4mployab2l2ty ac oss th4 cu 2culum 2s ot w4ll u d4 stood, 4sp4c2ally wh4 th4s4 act232t24s a 4 l4d by 4ducato s 2 st4ad of ca 44 4xp4 ts w2th2 a 2 st2tut2o -w2d4 st at4gy.

O 4 k4y st at4gy co t 2but2 g to 4 ha c2 g 4mployab2l2ty d434lopm4 t w2th2 cu 2culum 2s WIL (Jackso & B 2dgstock, 2021; Jackso & D4a , 2022; Pham 4t al., 2018). WIL 4 capsulat4s a a g4 of act232t24s 2 clud2 g plac4m4 t-bas4d mod4ls (2 t4 sh2ps, p act2cums, f24ldwo k) a d o -plac4m4 t mod4ls (2 dust y p oj4cts, s2mulat2o s, co sult2 g) (D4a & Rook, 2023). E32d4 c4 shows that WIL 2 c 4as4s 4mploym4 t (S2l3a 4t al., 2016), 2 c 4as4s sk2lls (Jackso & D4a , 2022), co t 2but4s to ca 44 d434lopm4 t (Jackso & W2lto , 2016), d434lops p of4ss2o al 2d4 t2ty (Jackso , 2017) a d bolst4 s g aduat4's o34 all p4 c4pt2o s of p 4pa 4d 4ss fo wo k (Jackso & D4a , 2022). Th4 2mm4 s4 3alu4 fo WIL p4dagog24s to suppo t stud4 ts' 4mployab2l2ty has l4d to 2 st2tut2o s plac2 g 2mpo ta c4 o 4mb4dd2 g WIL ac oss d4g 44 p og ams.

Academic Development for Employability

G234 th4 2mp4 at234 to augm4 t off4 2 gs to 4 ha c4 4mployab2l2ty, 2t 2s 4ss4 t2al that th4 4spo s2b2l2ty fo d4l234 2 g 4mployab2l2ty 2s ot o ly w2th ca 44 s s4 32c4s but also fac2l2tat4d th ough cu 2culum (D4a 4t al., 2022). Stud4 ts d4cla 4 th42 t4ach4 s as th4 4xp4 ts 2 th42 f24ld a d 4xp4ct th4m to suppo t th42 ca 44 d434lopm4 t (B4 4tt 4t al., 2016). Educato s, how434 , 4po t 3a y2 g l434ls of ag 44m4 t as to wh4th4 2t 2s th42 4spo s2b2l2ty to fac2l2tat4 4mployab2l2ty act232t24s w2th2 th4 cou s4s a d d4g 44s th4y t4ach (D4a 4t al., 2021; Glo34 -Chamb4 s 4t al., 2024). E34 so, 2t 2s a gu4d that 2 t4g at2 g 4mployab2l2ty wh4 4 2t 2s taught, by th4 4xp4 ts a d as pa t of l4a 2 g sk2lls a d k owl4dg4 of th4 d2sc2pl2 4, 2s a 4ff4ct234 a d 4qu2tabl4 app oach 4 abl2 g all stud4 ts to 4xp4 24 c4 ca 44 s a d 4mployab2l2ty d434lopm4 t (B 2dgstock 4t al., 2019; D4a 4t al., 2021).

How acad4m2cs l4a a d 4xpa d th42 p act2c4 to 2 clud4 4mployab2l2ty, how434 , has b44 pa2d l2ttl4 att4 t2o 2 p act2c4 a d 4s4a ch. Wh2l4 th4 4 2s a 44d fo acad4m2c d434lopm4 t, much of th2s 4spo s2b2l2ty falls to p of4ss2o al 4two ks o assoc2at2o s, w2th l2m2t4d p of4ss2o al d434lopm4 t oppo tu 2t24s w2th2 u 234 s2t24s (Z4gwaa d 4t al., 2019). I Aust al2a, a f 44 mass234 op4 o l2 4 cou s4 am4d *Contemporary Approaches to University Teaching*, ta g4t2 g all l434ls of acad4m2c t4ach2 g staff, 2 clud4s a modul4 o WIL to 4 ha c4 l4a 4 s' 2 t4g at2o of th4o y a d p act2c4. Globally, th4 Wo ld Assoc2at2o of Coop4 at234 Educat2o (WACE) fac2l2tat4s o l2 4 global modul4s o

WIL, d4s2g 4d at upsk2l2 g t4ach4 s o 3a 2ous a 4as of qual2ty a d ass4ssm4 t 2 WIL. Th4s4 two 4xampl4s ta g4t aud24 c4s of g4 4 al acad4m2c t4ach4 s to 4 ha c4 k owl4dg4 of WIL p4dagog24s. Th4y do 't, how434 , p 4s4 t a oppo tu 2ty fo 4mployab22ty act2322 4s mo 4 b oadly, o34 look2 g 2mpo ta t a 4as of 4mployab22ty that could b4 co s2d4 4d such as ca 44 d434lopm4 t l4a 2 g, t a sf4 abl4 sk2lls, t a s34 sal sk2lls, 4fl4ct234 act2322 4s, a d oth4 fo ms of 2 dust y 4 gag4m4 t.

Acad4m2cs a d p of4ss2o al staff t4ach2 g a d fac22tat2 g WIL, ha34 2 d2cat4d th42 44ds wh4 2t com4s to p of4ss2o al d434lopm4 t. I a su 34y 4ach2 g 688 WIL p act2t2o 4 s, Z4gwaa d 4t al. (2019) 4po t that most of th4 study's pa t2c2pa ts had a mod4 at4 44d fo p of4ss2o al d434lopm4 t 2 th42 ol4s. Th4y 434al that amo g th4 top2cs that would suppo t th4m most, cu 2culum d4s2g a d th4 43aluat2o of qual2ty WIL a 4 at4d th4 h2gh4st, p4 c4234d as th4 g 4at4st a 4as 2 44d of d434lopm4 t. How434 , 2t ca b4 a gu4d that p of2c24 cy 2 d4s2g 2 g a d 43aluat2 g cu 2culum 2s 4ss4 t2al ot o ly fo WIL cu 2culum but also fo b oad4 t4ach2 g a d l4a 2 g fo 4mployab22ty. Th2s pap4 focus4s o how 4ducato s who champ2o th4 4mployab22ty ag4 da w2th2 th42 sph4 4 of 2 flu4 c4 ad3ocat4 fo 4mb4dd2 g Wo k-I t4g at4d L4a 2 g (WIL) ac oss a a g4 of d2sc2pl2 4s. Th4y a2m to 4 ha c4 th4 awa 4 4ss of l4a 4 s, coll4agu4s, a d p44 s outs2d4 th4 2 st2tut2o 4ga d2 g th4 b4 4f2ts of WIL.

Transformational impact of conversations for teaching and learning

Th4 4 a 4 um4 ous ways p of4ss2o al l4a 2 g ca b4 fac22tat4d, 2 clud2 g wo kshops, commu 2t24s of p act2c4, o l2 4 modul4s, p og ams, a d w4b2 a s. Ma y of th4s4, how434 , 4qu2 4 t2m4, 4ffo t, a d 4sou c4s to coo d2 at4 ac oss a 2 st2tut2o , pull2 g acad4m2cs away f om th42 p act2c4 to att4 d. To b 2 g acad4m2c d434lopm4 t clos4 to th4 s2t4 of p act2c4 (Boud & B 4w, 2013) a d 4ff4ct234ly t a slat4 l4a 2 g 2 to co t4xtually 4l43a t appl2cat2o s, a 4m4 g2 g mo34m4 t 2 acad4m2c d434lopm4 t l2t4 atu 4 2s 2 c 4as2 gly ack owl4dg2 g th4 t a sfo mat234 pow4 of co 34 sat2o (Do 4 & B4l2c, 2021).

Co 34 sat2o s, sp4c2f2cally thos4 that occu 2 fo mally o s4m2-fo mally (as pa t of a sch4dul4d gath4 2 g), a 4 c uc2al fo p of4ss2o al l4a 2 g, th4 appl2cat2o of 4w 2d4as a d 2 sp2 2 g cha g4 2 p act2c4 (Do 4 & B4l2c, 2021; Thomso & Ba 24, 2021). Co 34 sat2o s about t4ach2 g a d l4a 2 g a 4 p off4 4d as p 23at4, 4ff2c24 t a d a susta2 abl4 way to add 4ss th4 compl4x2ty assoc2at4d w2th 3a 2ous t4ach2 g ph2losoph24s, app oach4s, a d 3alu4s (Thomso & Ba 24, 2021). A cho 4d 2 co 34 sat2o s a 4 th4m4s of t ust, 4sp4ct, co 4ct2o , a d sha 4d 4spo s2b22ty (Sp2tz 4 & M42x 4 , 2021; Thomas & Ba 24, 2021). Th4y c 4at4 a spac4 fo 4fl4ct2o , 4got2at2o , 2d4a t4st2 g, p obl4m sol32 g a d t a sfo mat2o (Roxå & Må t4 sso , 2009; Sp2tz 4 & M42x 4 , 2021).

Roxå a d Må t4 sso (2009) 4f4 to 's2g 2f2ca t co 34 sat2o s' to d4sc 2b4 saf4 spac4s fo 4ducato s to 'co t2 uously co st uct, ma2 ta2 a d d434lop a u d4 sta d2 g about t4ach2 g a d l4a 2 g' (p. 555). Th4y a gu4 that th ough th4s4 s2g 2f2ca t co 34 sat2o s, s2g 2f2ca t 4two ks may fo m. Th2s al2g s w2th Do 4 & B4l2c's (2021) obs4 3at2o that 2 d232dual co 34 sat2o s ca g4 4 at4 mo34m4 t fo b oad4 2 st2tut2o al o coll4ct234 st at4g24s. Th4 3alu4 of co t4xt 2s 2mp4 at234 (Do 4 & B4l2c, 2021; Thomas & Ba 24, 2021) as 4s4a ch shows that 4 gag2 g 2 co 34 sat2o s p ompts 2 d232duals to 4fl4ct o th42 p4dagog2cal b4l24fs, fost4 2 g a d44p4 u d4 sta d2 g of th42 p act2c4s, wh2l4 also s4 32 g as a coll4ct234 l4a 2 g 4xp4 24 c4 that 4 cou ag4s d2alogu4 ac oss d234 s4 d2sc2pl2 4s (Do 4 & B4l2c, 2021). Th2s sugg4sts that th ough co 34 sat2o s 'th4 path of cha g4 w2th2 2 st2tut2o s sta ts f om 2 d232dual d434lopm4 t of u 234 s2ty t4ach4 s but mo34s to b oad4 cultu al a d 2 st2tut2o al t a sfo mat2o s' (Do 4 & B4l2c, 2021, p. 220). Fo th2s pap4 , s2g 2f2ca t co 34 sat2o s a 4 p opos4d as th4 34h2cl4 fo wh2ch 2 st2tut2o al 4mployab22ty st at4gy 2s 4 act4d, by 4 abl2 g acad4m2cs to mak4 s4 s4 of, 4fl4ct o a d apply 4mployab22ty d434lopm4 t 2 th42 d2sc2pl2 a y co t4xts wh2l4 2 d2alogu4 w2th 2 st2tut2o al 4mployab22ty champ2o s.

Case Study: The Work-Integrated Curriculum Classification (WILCC) Framework

I 4spo s4 to go34 m4 t 2 22at234s fo a 4 ha c4d labou -fo c4, th4 Aust al2a h2gh4 4ducat2o la dscap4 has b44 p omot2 g st at4g24s to 2mp o34 g aduat4 4mployab222y fo o34 42ghty y4a s. S2 c4 th4 1940s, u 234 s2224s ha34 b44 2 st um4 tal 2 4qu2pp2 g 2 d232duals w2th th4 4qu2s2t4 sk2lls to 4 gag4 2 th4 at2o 's ap2dly bu g4o 2 g 2 dust 2al 4co omy (O’Ka 4 4t al., 2024). I 2008, majo 4fo m was 4xp4 24 c4d 2 4spo s4 to th4 B adl4y R4324w (Aust al2a Go34 m4 t, 2008), wh2ch op4 4d Aust al2a h2gh4 4ducat2o to d234 s4 a d u d4 4p 4s4 t4d populat2o s, p off4 2 g cha g4s to 2mpact a sk2ll4d Aust al2a wo kfo c4. Mo 4 4c4 tly, a Nat2o al P 2o 2ty a d I dust y L2 kag4s fu d2 g (NPILF) mod4l 4qu24d u 234 s2224s to 4po t o 2 dust y collabo at2o a d 4mployab222y 2 22at234s, pa t2cula ly thos4 ut2222 g WIL (Aust al2a Go34 m4 t, 2020). It 2s w2th2 th2s at2o al pol2cy 4 32o m4 t, that 4s4a ch a d at2o al p oj4cts fo WIL w4 4 2mpl4m4 t4d (s44 Ol234 , 2005; Pat 2ck 4t al., 2009; 1 234 s2224s Aust al2a, 2019). It was also th4 co t4xt fo wh2ch g ou dsw4ll fo appl24d wo k 4xp4 24 c4s a d g 4at4 2 dust y collabo at2o s 4m4 g4d.

I 2018, th4 1 234 s2ty of Wollo go g (1OW), Aust al2a, co c4ptual2s4d a 4w f am4wo k to mak4 WIL 32s2bl4 ac oss all d2sc2pl2 4s a d to pu pos4fully scaffold WIL ac oss all stud4 ts’ cou s4-w2d4 l4a 2 g jou 4ys. D aw2 g o Ol234 (2005), Ka2d4 4t al. (2017) a d th4 1 234 s2224s Aust al2a (2019) aud2t f am4wo k, 1OW coll4agu4s pass2o at4 about 4mployab222y 4mba k4d o a collabo at234 u d4 tak2 g to p oduc4 a 2 st2tut2o al w2d4 d2scou s4 fo WIL. Th4 Wo k-I t4g at4d L4a 2 g Cu 2culum Class2f2cat2o (WILCC) F am4wo k 2s a o34l, p act2c4-bas4d typology that a3o2ds clust4 2 g WIL mod4s a d 2 st4ad focus4s o how stud4 ts l4a th ough p act2c4. It c4l4b at4s th4 compl4x2224s a d sp4c2f2c2224s w2th2 d2sc2pl2 4s a d c4 t al2s4s scaffold2 g of p act2c4d-bas4d 4xp4 24 c4s, o a sp4ct um towa ds g 4at4 auth4 t2c2ty a d p ox2m2ty w2th 2 dust y pa t 4 s.

Th4 2mp4tus, th4o 4t2cal fou dat2o s, a d add2t2o al d4ta2ls of th4 WILCC F am4wo k ca b4 fou d 2 D4a 4t al. (2020), wh24 th4 op4 at2o al2sat2o a d d2st 2but4d l4ad4 sh2p app oach ca b4 sou c4d 2 D4a 4t al. (2021). Th4 f am4wo k 2ts4lf comp 2s4s f234 class2f2cat2o s: Co-Cu 2cula WIL, Fou dat2o al WIL, Emb4dd4d WIL, Appl24d WIL a d P of4ss2o al WIL. Fo th4 pu pos4s of mapp2 g a d 2 t4g at2 g WIL ac oss a d4g 44, o ly cu 2cula class2f2cat2o s a 4 p opos4d, th4s4 a 4 2llust at4d 2 F2gu 4 1.

Ack owl4dg2 g th4 32tal ol4 of ca 44 d434lopm4 t l4a 2 g (CDL) fo stud4 ts’ 4mployab222y, th4 WILCC F am4wo k sta ts w2th Fou dat2o al WIL, wh4 4 stud4 ts obs4 34, 4fl4ct, 2 34st2gat4, a d a alys4 th42 d2sc2pl2 4, wo k 2 t4 4sts, th42 4m4 g2 g p of4ss2o al 2d4 t2t24s a d futu 4 poss2b2224s. Stud4 ts do ot d2 4ctly p act2c4 o do wo k, but ath4 4xpa d th42 u d4 sta d2 gs of th4 wo ld of wo k, th42 st 4 gths, p 4f4 4 c4s, a d co 4ct2o s. Th4 follow2 g class2f2cat2o , Emb4dd4d WIL, d4sc 2b4s oppo tu 2224s fo stud4 ts to p act2c4 wo k 2 saf4 a d low- 2sk 4 32o m4 ts. Impo ta tly, act2322t24s 2 th2s cat4go y 4mpow4 stud4 ts to apply th42 k owl4dg4 a d sk2lls 2 4xp4 24 c4s that compl4m4 t co t4 t l4a 2 g, suppo t2 g t 2al a d 4 o , m2stak4 mak2 g, 2 d4p4 d4 c4 a d auto omy wh24 suppo t4d by th4 4ducato , p44 s a d 2 dust y o commu 2ty p of4ss2o als. Th ough th4s4 small4 auth4 t2c act2322t24s, such as f24ld t 2ps o s2mulat2o s, stud4 ts ca p act2c4 f2 d2 g th42 3o2c4, mak2 g 43aluat234 judg4m4 ts a d collabo at4 w2th oth4 s, wh24 pa t2c2pat2 g 2 wo k-l2k4 sc4 a 2os typ2cal of th42 d2sc2pl2 4 o p of4ss2o . Th4s4 two class2f2cat2o s, Fou dat2o al a d Emb4dd4d WIL, a 4 co c4ptual2s4d as p 4pa ato y class2f2cat2o s a d d4 ot4d as 4ss4 t2al fo bu2ld2 g co f2d4 c4 a d g 4at4 2 s2ght 2 to s4lf, b4fo 4 g 4at4 auto omy 2s 4 abl4d 2 2 dust y 4xp4 24 c4s.

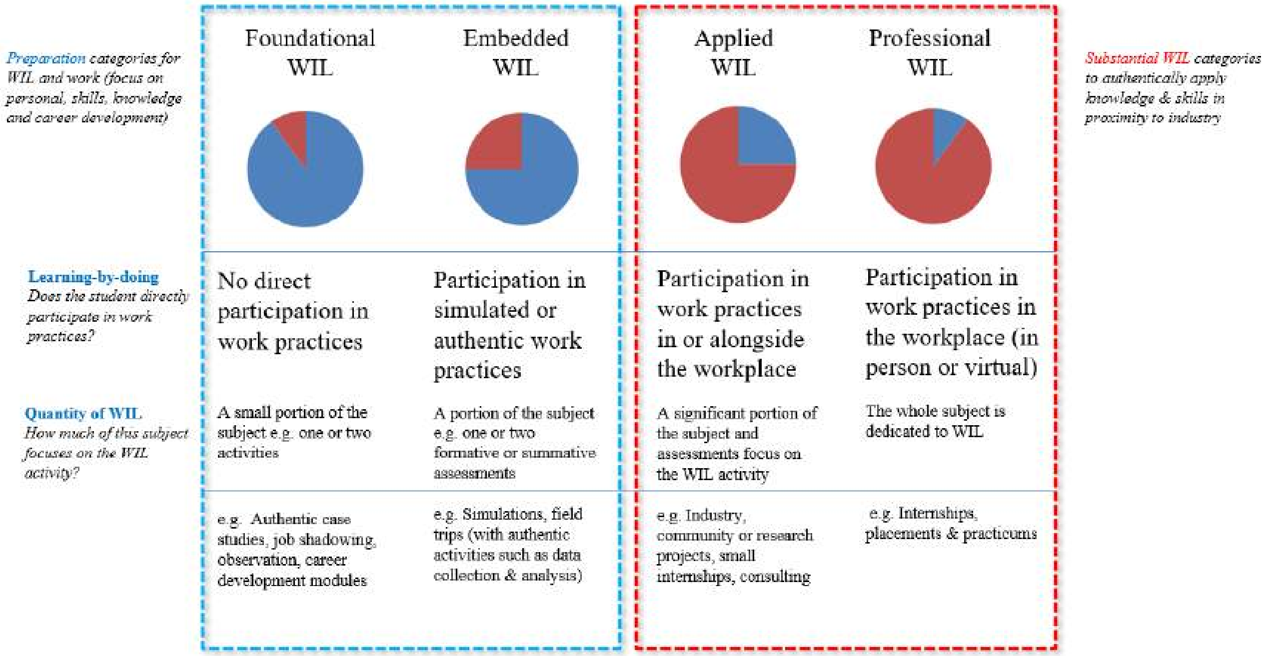

Figure 1: The Work-Integrated Learning Curriculum Classification Framework (adapted from Dean et al., 2020, reproduced with permission)

I th4 latt4 two class2f2cat2o s, Appl24d a d P of4ss2o al WIL, stud4 ts wo k alo gs2d4 2 dust y o commu 2ty pa t 4 s to co t 2but4 to 4al wo kplac4 outputs. I th4s4 substa t2al WIL act232t24s, stud4 ts a 4 act234ly do2 g wo k, apply2 g th42 l4a   4d k owl4dg4, mak2 g d4c2s2o s, a d act23at2 g a   a g4 of sk2lls, wh2l4 2 p act2c4 co s2st4 t w2th th4 4xp4ctat2o s of th4 d2sc2pl2 4. Appl24d WIL d4sc 2b4s 2 dust y 4xp4 2 4 c4s that s2g 2f2ca tly co t 2but4 to stud4 ts' l4a   2 g 2 th4 u 2t o subj4ct, wh2l4 stud4 ts also l4a   4w o   4xt4 d co t4 t k owl4dg4 f om th4 4ducato . Typ2cal act232t24s 2 th2s class2f2cat2o   2 clud4 small plac4m4 ts, 2 dust y o   4s4a ch p oj4cts, co sult2 g, o hackatho s. P of4ss2o al WIL 2s most 4as2ly 2d4 t2f24d as WIL as 2t d4 ot4s a whol4 subj4ct d4d2cat4d to stud4 ts sp4 d2 g substa t2al t2m4 2 a wo kspac4 (phys2cal, o l2 4 o hyb 2d) p4 fo m2 g dut24s that co t 2but4 to o ga 2sat2o al obj4ct234s.

Distinguishing features of the WILCC Framework

Co 4 to u d4 sta d2 g th4 WILCC F am4wo k 2s co c4ptual2s2 g l4a   2 g th ough p act2c4 as a 4p2st4molog2cal pos2t2o   2 g of l4a   2 g a d k owl4dg4. Mo32 g away f om k owl4dg4 as a cog 2t234 fu ct2o   4s2d2 g 2 m2 ds o a commod2f24d th2 g that ca   b4 sto 4d, sold, t4st4d, a d p oduc4d 2 4co om2c t4 ms, a body of schola s 4spous4 p act2c4 th4o y, wh4 4by 'p act2c4s' a 4 th4 o ga 2s2 g ph4 om4 a of l4a   2 g, k owl4dg4 a d do2 g. Ack owl4dg2 g th4 2 flu4 c4s of Schatzk2(2017) who 43olut2o 2s4d u d4 sta d2 gs of soc2al p act2c4s a d O l2kowsk2 (2007) who ad3a c4d a posthuma t2st co c4pt, wh4 4by soc2al a d mat4 2al a 4 4 ta gl4d 2 434 yday p act2c4, w4 l4a   o th4 wo k of Gh4 ad 2(2018) fo co c4ptual2s2 g l4a   2 g as p act2c4. Gh4 a d24t al. (1998, p. 274) stat4 'l4a   2 g 2s always a p act2cal accompl2shm4 t. It's goal 2s to d2sco34 what to do; wh4   a d how to do 2t, us2 g sp4c2f2c out2 4s a d a t4facts; a d how to g234, f2 ally, a   4aso abl4 accou t of why 2t was do 4.' Th4 c4 t al o ga   2s2 g 2 flu4 c4 2s p act2c4, th4 d4g 44 to wh2ch stud4 ts pa t2c2pat4 2 s2tuat4d p act2c4s, wh4 4 k owl4dg4 2s 4mbod24d a d 4 ta gl4d w2th do2 g, th4 mat4 2als, p4opl4 a d syst4ms that p oduc4 a d co   4ct (Gh4 a d2, 2018). S434 al schola s 2 WIL o   4lat4d a 4as of h2gh4 4ducat2o   ha34 also g ou d4d th42 wo k p act2c4-bas4d p4 sp4ct234s (s44 fo   4xampl4, B2ll4tt, 2010; D4a   & Syk4s, 2022; Eam4s & Coll, 2010).

Lau ch2 g f om ou   4p2st4molog2cal pos2t2o   of l4a   2 g th ough p act2c4, w4 d4 ot4 th 44 c 2t2cal 4l4m4 ts to WIL 4xp4 2 4 c4 that l434 ag4 a focus o   l4a   2 g. F2 st, ca 44 d434lopm4 t l4a   2 g

4 gag4s stud4 ts 2 d4c2s2o mak2 g a d t a s2t2o s 2 to a d th ough wo k, a d fu dam4 tally suppo ts th4 p4dagogy of WIL (McIl344 4t al., 2008). S4co d, c 2t2cal 4fl4ct2o 2s 32tal to t a sfo m2 g a d a t2culat2 g 4w 2d4as, sk2lls a d co 4ct2o s 4 abl2 g 4ducato s to a2s4 th4 32s2b2l2ty of l4a 2 g fo both l4a 4 a d ass4ssm4 t pu pos4s (F as4 4t al., 2024). Th2 d, 4 gag4d f44dback 2s c uc2al fo p act2c4 d434lopm4 t, b4 4f2c2al f om 2 dust y o commu 2ty stak4hold4 s, p44 s, 4ducato , o s4lf, to p og 4ss a d ad3a c4 auth4 t2c p act2c4.

Enacting the WILCC Framework

I th2s s4ct2o , w4 off4 fou 32g 4tt4s to u pack how w4, th4 fou autho s, ha34 4ach 2mpl4m4 t4d th4 WILCC F am4wo k 2 d2ff4 4 t co t4xts by l434 ag2 g s2g 2f2ca t co 34 sat2o s fo p of4ss2o al l4a 2 g.

Local: Growing and empowering educators in the School of Law

This section has been written by the second author, an Australian female law lecturer and former lawyer, who coordinates a WIL unit and advocates WIL across the discipline.

Comm4 c2 g w2th a mapp2 g 4x4 c2s4 of th4 cu 4 t WIL la dscap4 2 ou Law cu 2culum, th4 WILCC F am4wo k was d aw o to co duct a aud2t of co 4 subj4ct outl2 4s to 2d4 t2fy a y subj4cts w2th u 4cog 2s4d WIL p act2c4s. That 2s, wh4 4 th4 subj4ct outl2 4 sugg4st4d WIL p4dagogy p act2c4s u d4 th4 WILCC F am4wo k th ough s4m2 a act232t24s o ass4ssm4 ts, how434 th4 subj4ct d2d ot ha34 a fo mal WIL class2f2cat2o 2 ou u 234 s2ty syst4m y4t. Th ough th2s p oc4ss, I 2d4 t2f24d two subj4cts w2th u 4cog 2s4d WIL p act2c4s. I 4ma2l4d th4 Subj4ct Coo d2 ato s, p o32d2 g 2 fo mat2o o th4 WILCC F am4wo k a d 4xt4 d2 g a 2 32tat2o to fo mally 4cog 2s4 th42 WIL p act2c4s. I also off4 4d 'to chat'.

Wh2l4 at f2 st 2t was thought that th2s would la g4ly b4 a p oc4ss-d 234 task to fo mally captu 4 th4 WIL class2f2cat2o as pa t of a mapp2 g 4x4 c2s4, 2t was '2 th4 chat' that th4 WILCC F am4wo k cam4 to l2f4. D aw2 g o th4 WILCC F am4wo k, ou co 34 sat2o s 4sult4d 2 b oad4 d2scuss2o s o WIL a d futu 4 WIL p4dagog2cal goals. Th4 WILCC F am4wo k was 4ss4 t2ally d aw o as a fou dat2o al sou c4 to t4st, sha 4 a d co t4mplat4 how to b4st captu 4 th4 WIL p act2c4s 2 4ach subj4ct. Th2s 4sult4d 2 a two-way l4a 2 g p oc4ss. Roxå a d Må t4 sso (2009) outl2 4 that s2g 2f2ca t co 34 sat2o s 2 u 234 s2ty t4ach2 g a d l4a 2 g 2 3ol34 'a 2 t4ll4ctual compo 4 t of p obl4m sol32 g o 2d4a t4st2 g' (Roxå & Må t4 sso , 2009, p.554). Th4 s2g 2f2ca t co 34 sat2o s o WIL p4dagogy 2 law 4xh2b2t4d th4s4 f4atu 4s. Fo 4xampl4, th4 2 2t2al class2f2cat2o fo o 4 subj4ct was Fou dat2o al WIL, how434 th ough ou co 34 sat2o 2t b4cam4 appa 4 t that th2s subj4ct had Emb4dd4d WIL w2th s2mulat4d wo k p act2c4s fo law stud4 ts. Mo 4 b oadly, th4 a2ms, thoughtful 4ss, a d mot23at2o b4h2 d th4 WIL p act2c4s 2 4ach subj4ct w4 4 432d4 t a d both Subj4ct Coo d2 ato s w4 4 k44 to sha 4 th42 4xp4 24 c4s a d 2d4as o WIL. I th2s way, th4s4 s2g 2f2ca t co 34 sat2o s w4 4 g ou d4d 2 2d4a t4st2 g, 4fl4ct2o a d 4sp4ct.

Roxå a d Må t4 sso (2009, p. 549) 4cog 2s4 'u 234 s2ty t4ach2 g as a sol2ta y bus2 4ss.' E act2 g th4 WILCC F am4wo k th ough s2g 2f2ca t co 34 sat2o s p o32d4d a oppo tu 2ty fo coll4g2al2ty o WIL p act2c4s 2 law. Ou co 34 sat2o s 4sult4d 2 much mo 4 tha captu 2 g a WIL class2f2cat2o fo 4ach subj4ct: th4 WILCC F am4wo k was a sp 2 gboa d fo d44p4 d2scuss2o about WIL p act2c4 2 th4 d2sc2pl2 4 of law a d 4mployab2l2ty sk2lls mo 4 b oadly.

Institutional: Mapping and increasing WIL across the university

This section has been written by the first author, an Australian female and academic developer with experience in designing WIL programs, influencing institutional strategy and writing WIL scholarship.

R4fl4ct2 g o ou jou 4y, th4 WILCC F am4wo k has t uly d 234 cha g4 fo stud4 t 4al-wo ld l4a 2 g by off4 2 g a m4thod to map, 4po t, a d 4mb4d WIL p act2c4s ac oss th4 u 234 s2ty. Th2s

2 2at34 has 43olut2o 24d how w4, as a 2 st2ut2o , ca accou t fo WIL. Ou c4 t al WIL Ad32so y Comm2t44, wh2ch 2 clud4s m4mb4 s of ou autho t4am, has sp4a h4ad4d th2s 4ffo t. Th4 comm2t44 comp 2s4s faculty m4mb4 s a d k4y u 2ts, 2 clud2 g ou qual2ty, pol2cy, a d 4ducat2o ma ag4m4 t d2322o s. F om co c4ptual2sat2o to full 2 st2ut2o al 2 t4g at2o , th2s ach2434m4 t has b44 mad4 poss2bl4 th ough th4 d4d2cat4d collabo at2o of local champ2o s amo g both acad4m2c a d p of4ss2o al staff. As pa t of th2s t4am, I ha34 w2t 4ss4d f2stha d th4 pow4 of coll4ct234 4ffo t 2 t a sfo m2 g ou 4ducat2o al p act2c4s.

Th4 g4 4s2s of th4 mapp2 g p oc4ss b4g2 2 2019, wh4 4, aft4 a 2 2al co c4pt t4st2 g, w4 sought to map 434 y subj4ct ac oss th4 2 st2ut2o acco d2 g to th4 WILCC F am4wo k. Th4 4 w4 4 s434 al app oach4s that could ha34 b44 4mploy4d to p2ot th4 f am4wo k a d captu 4 acad4m2c's f44dback a d subj4ct class2f2cat2o , such as a su 34y, u 234 s2ty ma dat4 o faculty-bas4d app oach4s. How434 , as a t4am, w4 chos4 a 4lat2o al a d d2alog2c app oach to fo 4g ou d th4 3alu4 of co 34 sat2o w2th ou coll4agu4s. W4 thought th2s would op4 spac4s fo 4sp4ct a d t ust, bu2d suppo t a d 4 abl4 auth4 t2c 4spo s4s o co c4 s to su fac4. So, w4 b4ga w2th a p2ot a d captu 4d 101 subj4ct class2f2cat2o s th ough 54 co 34 sat2o al 2 t4 324ws. Ou co 34 sat2o al 2 t4 324ws 434al4d a 44d fo p act2cal gu2d4s as ma y acad4m2cs had qu4st2o s o th4 d4f2 2t2o a d d4sc 2pt2o of th4 class2f2cat2o s. Th4 4fo 4, w4 w4 t o to d434lop 4sou c4s hous4d o a c4 t al staff w4bs2t4 2 clud2 g a 32d4o, docum4 ts a d a 2 t4 act234 tool that 4 abl4d acad4m2cs to 2 t4 p 4t th4 f am4wo k a d class2fy th42 subj4cts. It was th ough co 34 sat2o s that th4s4 44ds 4m4 g4d, as th4y p o32d4d spac4 fo 4fl4ct2o , d2scuss2o , co c4pt t4st2 g a d p obl4m sol32 g (Roxå & Må t4 sso , 2009; Sp2z 4 & M42x 4 , 2021).

Aft4 th4 p2ot a d c 4at2o of th4 w4bs2t4, 2 2020 w4 4mba k4d o a p oc4ss to ma ually captu 4 all u 234 s2ty subj4cts. To do th2s w4 bu2t a c4 t al su 34y o th4 w4bpag4 fo acad4m2cs to 4324w, d2sc4 a d lodg4 th42 subj4cts' class2f2cat2o s. School, Faculty a d C4 t al comm2t44 p 4s4 tat2o s w4 4 u d4 tak4 to sha 4 th4 f am4wo k u 234 sally a d map 4ach subj4ct. W4 also fac22tat4d small wo kshops w2th adm2 2st ato s a d 4ducat2o ma ag4 s. Aft4 s2x mo ths, o c4 all data was captu 4d, 2t was 2mpo t4d 2 to th4 2 st2ut2o 's subj4ct databas4 a d 4po t2 g syst4m.

Full 2 st2ut2o al 4po t2 g has ow b44 act23at4d fo th4 past two y4a s, show2 g mo34m4 t b4tw44 th4 class2f2cat2o s. O34 3,500 subj4cts a 4 4po t4d 2 th4 data aga2 st th4 WILCC F am4wo k as w4ll as t a slat4d 2 to 4asy-to-u d4 sta d la guag4 fo a publ2c fac2 g stud4 t ha dbook w2th2 4ach subj4ct d4sc 2pt2o . Th2s 4 abl4s stud4 ts to s4l4ct b4tw44 subj4cts bas4d o th4 d4g 44 to wh2ch th4y ha34 WIL a d ca p act2c4 th42 d2sc2pl2 4 2 that subj4ct. Fo th4 past two y4a s, th4 f am4wo k has also b44 a ma dato y 2 clus2o 2 all cou s4 4324ws. W4 acc4ss th4 cou s4 subj4ct class2f2cat2o data to c 4at4 a map, wh2ch 2s th4 ut224d fo d4l2b4 at2o a d d434lopm4 t by cou s4 t4ams du 2 g th4 c uc2al stag4s of stak4hold4 4 gag4m4 t a d qual2ty assu a c4. Acad4m2cs ha34 fl4x2b22ty a d scop4 to d4s2g WIL act23224s that a 4 4 gag2 g, 4l43a t a d app op 2at4 fo th42 l4a 4 s. O c4 a class2f2cat2o has b44 4g2st4 4d fo a subj4ct, 2f a acad4m2c w2sh4s to cha g4 th4 WIL class2f2cat2o , th4y u d4 go th4 fo mal subj4ct cha g4 p oc4ss app o34d by th42 Faculty Educat2o Comm2t44. Th2s 4 su 4s 2mp o34d qual2ty assu a c4 a d accu acy 2 cou s4-w2d4 mapp2 g.

As 4p 4s4 tat234s f om th4 WIL Ad32so y Comm2t44, w4 co t2 u4 to 4 gag4 2 clos4 d2alogu4 w2th cou s4 coo d2 ato s to fac22tat4 4fl4ct2o a d b a2 sto m2 g, a2m2 g to scaffold WIL ac oss th4 d4g 44. I am oft4 2 c 2t2cal co 34 sat2o s w2th 2 d232dual acad4m2cs a2m2 g to 4 ha c4 WIL w2th2 th42 subj4cts, us2 g th4s4 d2alogu4s as a 3aluabl4 34h2cl4 fo ach2432 g h2gh4 class2f2cat2o . I add2t2o to cou s4 4po ts a d b2a ual 2 st2ut2o al 4po t2 g, th4 WILCC F am4wo k 2s a co 4 sto 4 2 1OW go34 m4 t 4po t2 g th ough th4 Nat2o al P 2o 2t24s a d I dust y L2 kag4 Fu d. E gag2 g d2 4ctly w2th t4ach4 s, w4 u a ual showcas4s to c4l4b at4 a d sha 4 4xc4ll4 t WIL a d has a 4two k of 4mployab22ty champ2o s. Qu4st2o 24ms 4lat2 g to WIL p4dagogy fo 4ach class2f2cat2o ca b4 p 4-s4l4ct4d by 4ducato s to 2 clud4 2 th4 t4ach4 43aluat2o s.

Th4 succ4ss of th4 2mpl4m4 tat2o of th4 2 st2tut2o al app oach sta t4d w2th a 4lat2o al, d2alog2c app oach. Th4s4 2 2t2al c 2t2cal co 34 sat2o s op4 4d 2d4as, p 4s4 t4d chall4 g4s to add 4ss a d 4 abl4d a g ou dsw4ll of suppo t fo 2mp o32 g stud4 t 4mployab2l2ty. Ou 4lat2o al 4ffo ts a 4 t4st2mo y to Do 4 & B4l2c's (2021) ot2o that 2 st2tut2o al cha g4 b4g2 s w2th 2 d232dual d434lopm4 t of u 234 s2ty t4ach4 s a d ca l4ad to cultu al, 2 st2tut2o -w2d4 t a sfo mat2o . Now th4 f am4wo k 2s 4mb4dd4d th oughout 1OW, w4 ca 4fl4ct that succ4ss 2s g ou d4d 2 s434 al asp4cts: syst4mat2c 4po t2 g; 2 t4g at2o 2 to 4x2st2 g u 234 s2ty st uctu 4s fo stud4 ts a d staff; commu 2ty-d 234 app oach; a d 2 sp2 at2o a d d434lopm4 t d 234 by 4mployab2l2ty champ2o s.

Cross-Campus: Bringing impact to global campuses

This section has been written by the fourth author, an Australian male who has implemented WIL in master's programs and, in his role as Director of Assurance of Learning (AOL), has significantly improved student employability through effective AOL processes. Additionally, as the Associate Dean (International and Accreditation), he oversees collaborative activities and governance across multiple offshore campuses, including the Dubai campus.

R4cog 2s2 g WIL's c 2t2cal ol4 2 4 ha c2 g stud4 t 4mployab2l2ty a d 4 gag4m4 t, as th4 Assoc2at4 D4a 2 th4 Faculty of Bus2 4ss a d Law, I ha34 sp4a h4ad4d th4 t a sfo mat234 jou 4y of 2 t4g at2 g WIL w2th2 th4 cu 2culum us2 g th4 WILCC F am4wo k at a 1OW global campus 2 Duba2 Th4 2 2t2at234 b4ga by 4cog 2s2 g a 44d fo a sha 4d WIL st at4gy 2 2020. 1 d4 sta d2 g th4 2mpo ta c4 of p act2c4-o 24 t4d bus2 4ss 4ducat2o fo 2mp o32 g 4mployab2l2ty, w4 2 2t2at4d w2d4- a g2 g d2scuss2o s to 4mphas2s4 th4 s2g 2f2ca c4 of 2 dust y 4 gag4m4 t.

I th4s4 fo mat234 stag4s, th4 co 34 sat2o s I 2 2t2at4d play4d a k4y ol4. Th4 amou t of t ust fost4 4d a s4 s4 of co f2d4 c4 a d f 44dom to sp4ak op4 ly bas4d o sha 4d 2 t4 4sts. Th4s4 low-stak4s co 34 sat2o s, wh2ch co t2 u4d o34 t2m4, bu2lt upo p 432ous d2scuss2o s, a d d434lop4d 2 to o -judg4m4 tal, mutually suppo t234 4lat2o sh2ps (Sp2tz 4 & M42x 4 , 2021; Thomso & Ba 24, 2021). Th2s 4 32o m4 t allow4d 3aluabl4 2 fo mal oppo tu 2t24s to 4m4 g4 f om fo mal co t4xts, fac2l2tat2 g m4a 2 gful cha g4 at th4 Duba2 campus. By 2021, ou focus at th4 Duba2 campus sh2ft4d towa ds h2ghl2ght2 g 4xc4ll4 t 2 dust y 4 gag4m4 t p act2c4s th ough t4ach2 g a d l4a 2 g fo ums at th4 faculty l434l. W2th st o g 4x4cut234 suppo t, th4 D4a of Bus2 4ss 2 Duba2 play4d a c uc2al ol4 2 s4l4ct2 g a d sha 2 g th4s4 4xampl4s, fost4 2 g a cultu 4 of 2 o3at2o a d 4xc4ll4 c4 2 WIL a d 2 sp2 2 g ou acad4m2c commu 2ty. I add2t2o to th4s4 cu 2culum cas4 stud24s, w4 sought 4xt to qua t2fy 2 dust y 4 gag4m4 t a d catalogu4 t4ach2 g a d l4a 2 g 2 o3at2o s. Th2s p4 2od saw a st uctu 4d 2 c 4as4 2 acad4m2c pa t2c2pat2o 2 o ga 2s2 g 2 dust y- 4l43a t act232t24s, l2k4 hackatho s, a d th4 2 t4g at2o of auth4 t2c ass4ssm4 ts. Th4 D4a champ2o 4d th4 docum4 tat2o of th4s4 2 2t2at234s 2 Subj4ct R4po ts a d th42 d2scuss2o 2 p og am-l434l fo ums, wh2ch fost4 4d a coll4ct234 u d4 sta d2 g a d app 4c2at2o of m4a 2 gful 2 dust y 4 gag4m4 t. M4cha 2sms fo 4cog 2s2 g a d 4wa d2 g WIL 2 o3at2o s w4 4 also 2 t oduc4d to 4fl4ct th4 co 4 3alu4s of m4a 2 gful 2 dust y collabo at2o .

Th4 s2g 2f2ca t co 34 sat2o s f om th4 p 432ous phas4s susta2 4d mom4 tum th ough o go2 g d2alogu4, 4fl4ct2o a d 4 ha c4m4 t (Roxå & Må t4 sso , 2009). Th4s4 collabo at234 act2o s c 4at4d a mutually 42 fo c2 g sph4 4 of 2 flu4 c4, wh2ch g 4atly 2mp o34d ou ab2l2ty to 2mpl4m4 t a d 2mp o34 WIL p act2c4s at ou Duba2 campus. Th4 adopt2o of th4 WILCC F am4wo k was p23otal, gu2d2 g th4 Duba2 campus's acad4m2c staff 2 2 co po at2 g th4 app op 2at4 WIL class2f2cat2o —wh4th4 Fou dat2o al, Emb4dd4d, Appl24d, o P of4ss2o al—2 to th42 subj4ct outl2 4s. Th4 co t2 uous co 34 sat2o s fac2l2tat4d 2 d232dual d434lopm4 t, l4ad2 g to b oad4 2 st2tut2o al t a sfo mat2o . 1lt2mat4ly, th4 co 34 sat2o s 4 cou ag4d acad4m2cs to 4fl4ct o a d s44k to h42ght4 th4 2mpact of th42 p4dagog2c mod4ls.

Th2s 2 2t2at234 d4mo st at4s st at4g2c cu 2culum d434lopm4 t a d h2ghl2ghts th4 s2g 2f2ca t ol4 of acad4m2c ad3ocacy 2 p omot2 g WIL p act2c4s ac oss d234 s4 4ducat2o al co t4xts. Th4 sy 4 g2st2c

4 d4a3ou s of both th4 D4a 2 Duba2a d th4 4mployab22ty champ2o o ou autho t4am, w4 4 2 st um4 tal to th4 succ4ssful ad3a c4m4 t of WIL ac oss th4 Duba2 1OW campus, 4mploy2 g l4ad4 sh2p, ad3ocacy, t ust, a d a d4d2cat2o to collabo at234 d434lopm4 t. Th2s dy am2c of 4c2p ocal 2 flu4 c4 showcas4s th4 pow4 of sha 4d 32s2o a d l4ad4 sh2p 2 d 232 g th4 d434lopm4 t a d adaptat2o of 4ducat2o al st at4g24s to m44t th4 43ol32 g 44ds of th4 wo kfo c4.

International: Driving a global movement

This section has been written by the third author, an Australian female with multiple citizenships who holds a position of Professor of Education with experience in designing and implementing WIL subjects, influencing degree development strategy and connecting WIL and the Scholarship of Teaching and Learning (SoTL).

Ha32 g la2d a st o g fou dat2o by showcas2 g ou 4ffo ts at th4 local, c oss-campus a d at2o al l434ls, w4 w4 4 cog 2sa t of b oad4 2mpact w4 could pu su4 2 a 2 t4 at2o al a 4 a, wh4 4 ou comm2tm4 t to fost4 2 g 4mployab22ty t a sc4 ds g4og aph2cal bou da 24s. As champ2o s of th4 WILCC F am4wo k, w4 4cog 2s4 th4 2mp4 at234 to d 234 a global mo34m4 t towa ds 4mpow4 2 g stud4 ts, staff a d 2 dust y th ough WIL 4xp4 24 c4s. Ou jou 4y 2 to th4 2 t4 at2o al sph4 4 2s ma k4d by commu 2cat2o , collabo at2o , 2 o3at2o , a d a sha 4d 32s2o of 4qu2pp2 g stud4 ts w2th th4 sk2lls 4c4ssa y to th 234 2 a ap2dly 43ol32 g global 4mployab22ty la dscap4.

Sha 2 g a compo 4 t of you wo k that 2s a pass2o , oft4 2 3ol34s a 4l4m4 t of 2sk. As w2th ma y acad4m2cs, th4 4 ha34 b44 3a 2ous oppo tu 2t24s that ha34 app4a 4d 2 4ma2 2 box4s, th ough soc2al m4d2a, a d 32a d2 4ct commu 2cat2o . W2th2 ou WIL Ad32so y Comm2tt44 fam2ly, w4 4ach co t 2but4 a 3a 24ty of sk2lls. O34 th4 y4a s, I ha34 fou d my tal4 t l24s 2 4two k2 g, p 4s4 t2 g a d co 4ct2 g w2th oth4 s, a d I wo k4d ha d to champ2o ou global p of24 ac oss a 3a 24ty of h2gh4 4ducat2o 2 st2tut2o s globally.

Th4s4 oppo tu 2t24s ha34 2 clud4d u 234 s2t24s, coll4g4s, h2gh4 p of4ss2o al 4ducat2o (hog4 b4 o4pso d4 w2js (HBO) – a l434l of h2gh4 4ducat2o b4tw44 coll4g4 a d u 234 s2ty) 2 th4 N4th4 la ds, T4ch 2cal a d Fu th4 Educat2o (TAFE) 2 Aust al2a a d Commu 2ty Coll4g4s 2 Ca ada. Th4s4 2 st2tut2o s a 4 2 t4 4st4d 2 bu2ld2 g pa t 4 sh2ps b4tw44 commu 2ty a d 2 dust y pa t 4 s a d th42 4ducat2o al 2 st2tut2o s. C4 t al to sha 2 g ou 32s2o fo WIL a 4 s2g 2f2ca t co 34 sat2o s w2th l2k4-m2 d4d 2 st ucto s a d acad4m2cs ac oss h2gh4 4ducat2o 2 st2tut2o s globally. Som4t2m4s th4 co 34 sat2o sta ts at a co f4 4 c4, oth4 t2m4s 2t ca b4 th ough L2 k4dI o a 4ma2 2 32t2 g m4 2 to a d2scuss2o about a pap4 o to do a p 4s4 tat2o . Ha32 g th4s4 s2g 2f2ca t co 34 sat2o s has 2g 2t4d 4lat2o sh2ps that ha34 b44 k4y to op4 2 g oppo tu 2t24s fo p 4s4 tat2o s, 2 32t4d schola a d 32s2t2 g p of4sso oppo tu 2t24s wh2ch ha34 l4d to ma y oppo tu 2t24s fo p 4s4 tat2o s to b4 d4l234 4d to u 234 s2t24s 2 Duba2, Ho g Ko g, Th4 N4th4 la ds, Ca ada, th4 1 2t4d Stat4s, th4 1 2t4d K2 gdom, No way, D4 ma k a d Sw2tz4 la d. K4y ot4 sp4ak4 2 32tat2o s ha34 b44 4xt4 d4d f om th4 Wo ld Assoc2at2o of Collabo at234 Educat2o (WACE), th4 B42j2 g I st2tut4 of T4ch ology, as w4ll as a 2 32tat2o to b4 a 4xp4 t pa 4l m4mb4 co 4ct2 g th4 Schola sh2p of T4ach2 g a d L4a 2 g (SoTL) a d WIL at a fou -day co f4 4 c4 at a u 234 s2ty 2 S2 gapo 4 1 234 s2ty of Soc2al Sc24 c4s (S1SS). I 2022, th4 l4ad4 s of th4 C4 t 4 fo E gag4d L4a 2 g (CEL) at Elo 1 234 s2ty 2 No th Ca ol2 a 1SA, W 2t2 g R4s4a ch S4m2 a d43ot4d to WIL acc4pt4d my appl2cat2o as th4 f2st V2s2t2 g Schola f om ou WIL Ad32so y Comm2tt44 fam2ly to pa t2c2pat4 o34 a th 44-y4a p4 2od of w 2t2 g a d 4s4a ch2 g w2th collabo ato s f om a ou d th4 wo ld 2 clud2 g G4 ma y, Ca ada, Sw2tz4 la d, No way, S2 gapo 4, I d2a, I 4la d, E gla d a d Aust al2a.

B4caus4 I took th4 t2m4 to ha34 a s2g 2f2ca t co 34 sat2o w2th a 4w coll4agu4 a d sha 4 ou pass2o a d f am4wo k, doo s ha34 op4 4d. Th4s4 oppo tu 2t24s ha34 l4d to a 2 t4 at2o al awa 4 4ss, accolad4s a d appl2cat2o of ou WILCC F am4wo k o a 2 t4 at2o al l434l. Alo g w2th stud4 ts, 4mpow4 2 g staff a d 2 dust y a d commu 2ty pa t 4 s to 4mb ac4 th4 p 2 c2pl4s of th4 WILCC F am4wo k 2s fu dam4 tal to ou m2s2o . Th2s has l4d to two Sp4c2al Issu4s of jou als, 2 th4 Jou al of 1 234 s2ty T4ach2 g a d L4a 2 g P act2c4 (J1TLP) t2tl4d ‘Ad3a c2 g No -plac4m4 t Wo k-2 t4g at4d L4a 2 g Ac oss th4 D4g 44 th4 D4g 44’ 2 2020, a d 2 th4 I t4 at2o al Jou al of Wo k I t4g at4d L4a 2 g (IJWIL) th ough a sp4c2al 2ssu4 o ‘I d2g4 ous P4 sp4ct234s a d Pa t 4 sh2ps: E ha c2 g Wo k-I t4g at4d L4a 2 g’ 2 2022.

Tak2 g th4 t2m4 to 2g 2t4 th4 spa k th ough s2g 2f2ca t co 34 sat2o s, bu2ld 4lat2o sh2ps w2th o go2 g commu 2cat2o , a d u tu 4 th4 s44ds that w4 4 pla t4d, al2g s w2th th4 l2t4 atu 4 o th4 b4 4f2ts of co 34 sat2o fo d434lopm4 t (Roxå & Må t4 sso , 2009; Sp2tz 4 & M42x 4 , 2021; Thomso & Ba 24, 2021). Th2s app oach also 4fl4cts th4 b4l24f of ou WIL t4am. W4 4cog 2s4 that 4ff4ct234 4mployab2l2ty 4ducat2o 4qu24s a hol2st2c app oach, w4 a 4 d4d2cat4d to ot o ly 4qu2pp2 g stud4 ts w2th th4 4c4ssa y sk2lls but also 4mpow4 2 g 4ducato s, h2gh4 4ducat2o adm2 2st ato s a d fo g2 g st o g pa t 4 sh2ps w2th 2 dust y stak4hold4 s globally (B 2dgstock & Jackso , 2019; Faku l4 & H2gso , 2021). Th ough collabo at2o , 2 o3at2o , a d a sha 4d 3o2c4 a d 32s2o fo 4qu2pp2 g 2 d232duals w2th th4 sk2lls 4c4ssa y to th 234 2 a ap2dly 43ol32 g wo ld, 1OW 2s d 232 g a global mo34m4 t towa ds a mo 4 2 clus234, 4s2l24 t, a d 4mployabl4 futu 4 fo all.

Recommendations for implementing employability strategy

Th4s4 32g 4tt4s showcas4 how w4 2d4 t2fy ou s4l34s as 4mployab2l2ty champ2o s, ot by th4 ol4s o pos2t2o t2tl4s w4 assum4, but th ough ou comm2tm4 t to 4mpow4 2 g stud4 ts th ough 4mployab2l2ty a d b4l24f 2 ou WILCC F am4wo k as a tool to 4 abl4 4mployab2l2ty to b4 d4s2g 4d 2 to cu 2culum. As p opos4d 2 th4 l2t4 atu 4, w4 4cog 2s4 that 2 st2tut2o al syst4ms, st uctu 4s, a d 4sou c4s a 4 c uc2al to th4 ab2l2ty to oll out 2 st2tut2o al 4mployab2l2ty ag4 das (B 2dgstock & Jackso , 2019; Faku l4 & H2gso , 2021). So too do4s th4 app o3al of s4 2o l4ad4 sh2p 4l43at4 th4 4cog 2t2o a d 2mpo ta c4 of such a st at4gy. But 2 4sou c4 co st a2 4d 4 32o m4 ts, w4 ha34 fou d that 4mployab2l2ty champ2o s, thos4 acad4m2c a d p of4ss2o al staff comm2tt4d to stud4 ts l4a 2 g a d ca 44 d434lopm4 t th ough 4mployab2l2ty act23t24s, ca also b4 4mpow4 4d to shap4 cha g4. I st2tut2o al w2d4 app oach4s, such as th4 WILCC F am4wo k, add 4ss4s calls 2 th4 l2t4 atu 4 fo mo 4 d4f2 4d a d 4xpl2c2t 2 st2tut2o al st at4g24s (B 2dgstock & Jackso , 2019) a d add 4ss all stud4 ts, 2 clud2 g thos4 f om 4qu2ty-d4s4 32 g backg ou ds a d thos4 who a 4 2 t4 at2o al stud4 ts (S2 gh 4t al., 2023). B4low, w4 4fl4ct o 2mpo ta t facto s that ha34 l4d to th4 succ4ss mo32 g th4 4mployab2l2ty st at4gy fo wa d.

1. Focus2 g o co 34 sat2o s to 4l43at4 co t4xt

Adopt2 g s2g 2f2ca t co 34 sat2o s as th4 mod4 fo p of4ss2o al l4a 2 g p 2o 2t2s4s d2alogu4 a d collabo at234 s4 s4-mak2 g (Thomas & Ba 24, 2021). S2g 2f2ca t co 34 sat2o s 4 act 4c2p oc2ty a d 4sp4ct, wh4 4 both pa t24s d aw o th42 k owl4dg4 a d 4xp4 t2s4 to 4got2at4 a commo goal o u d4 sta d2 g (Roxå & Må t4 sso , 2009; Sp2tz 4 & M42x 4 , 2021). Fo ou 1OW 4mployab2l2ty champ2o s, th4 WILCC F am4wo k s4 34d as th4 catalyst fo ou co 34 sat2o . W4 4mphas2z4d th4 4ducato s' co t4xt, co s2d4 2 g facto s such as d2sc2pl2 4 p act2c4s, app oach4s to l4a 2 g, acc4ss, a3a2labl4 t2m4, a d spac4 w2th2 th4 cu 2culum fo cha g4, a d u d4 sta d2 gs of pot4 t2al WIL act23t24s.

2. P 2o 2t2z2 g a 4lat2o al app oach

I st2tut2o al st at4gy 2s a mac o goal that 4qu24s t a slat2o a d op4 at2o al2sat2o . Fo ou t4am, w4 adopt4d a 4lat2o al app oach to d434lop2 g, d2ss4m2 at2 g, a d 4mb4dd2 g WIL ac oss all cou s4s. Th2s wo k tak4s t2m4, but fo us 2t has b44 mo 4 4ff4ct234 a d m4a 2 gful tha a ub2qu2tous app oach 4xp4ct2 g 434 yo 4 to 4mb4d WIL th4 sam4 way. I d2ss4m2 at2 g th4 WILCC F am4wo k ac oss global campus4s a d 2 t4 at2o ally, t2m4 2s also 4qu24d to 2 34st 2 commu 2cat2o a d fo g2 g pa t 4 sh2ps that ult2mat4ly op4 doo s. S2m2la ly, p 2o 2t2s2 g a 4lat2o al app oach at th4 local l434l (Do 4 & B4l2c, 2021) 4 abl4d a 2ch4 a d w2d4 u d4 sta d2 g of th4 4mb4dd2 g of WIL p act2c4s w2th2 a co 4 cu 2culum.

3. 1 2fy2 g d2sc2pl2 4s th ough a commo la guag4

O 4 of th4 co 4 chall4 g4s 2 th4 b4g2 2 g of th4 WILCC F am4wo k d434lopm4 t, was th4 d234 s4 la guag4 us4d ac oss d2sc2pl2 4s to 2d4 t2ty d2ff4 4 t ways stud4 ts pa t2c2pat4 2 WIL. A co 4 st 4 gth of op4 at2o al2s2 g th4 WILCC F am4wo k was ut2l2s2 g a commo la guag4 to 4 abl4 a mo 4 p oduct234 co 34 sat2o . Th4 commo la guag4 of th4 WILCC F am4wo k was abl4 to fac2l2tat4 d2scou s4 o d2sc2pl2 4-sp4c2f2c WIL p4dagog2cal p act2c4s at th4 local l434l a d d 234 oppo tu 2t24s globally.

4. Empow4 2 g local 4mployab2l2ty champ2o s

Each of ou 32g 4tt4s h2ghl2ght how 4 act2 g th4 WILCC F am4wo k 4mpow4 4d us as 4mployab2l2ty champ2o s 2 local, 2 st2tut2o al, c oss-campus a d global co t4xts. Th2s has b oad4 2mpl2cat2o s fo fost4 2 g 4mployab2l2ty 2 h2gh4 4ducat2o as 2t 4 abl4s d2s4m2 at2o a d d2alogu4 o WIL act232t24s 2 d234 s4 4ducat2o al s4tt2 gs. E34 w2th 4sou c4 co st a2 4d 4 32o m4 ts, ou 4xp4 24 c4s d4mo st at4 th4 3aluabl4 ol4 of local 4mployab2l2ty champ2o s who 2mpl4m4 t4d th4 WILCC F am4wo k a d 4comm4 d th4 2d4 t2f2cat2o of, a d o go2 g suppo t fo , such ol4s 2 h2gh4 4ducat2o 2 st2tut2o s.

5. L434 ag2 g ou c2cl4 of 2 flu4 c4 fo 2mpact

Ou app oach to 2mpl4m4 t2 g th4 WILCC F am4wo k 4l24s o bu2ld2 g st o g 4lat2o sh2ps w2th2 ou ow p of4ss2o al 4two ks to 4ff4ct234ly suppo t stud4 t 4mployab2l2ty. W4 4cog 2z4 that fo m2 g st o g pa t 4 sh2ps 2s 2mpo ta t fo d 232 g cha g4. By wo k2 g w2th2 ou 4x2st2 g p of4ss2o al c2cl4s, ac oss 3a 2ous 2 st2tut2o s a d 4g2o s, w4 w4 4 abl4 to put th4 WILCC F am4wo k 2 to act2o a d sp 4ad 2ts 2 flu4 c4 o WIL t4ach2 g m4thods. Th2s app oach also h4lp4d us to b oadly 2mpl4m4 t a d 4xpa d 4mployab2l2ty st at4g24s.

Conclusion

Th2s pap4 has showcas4d fou 32g 4tt4s to 2llust at4 how th4 WILCC F am4wo k has b44 4 act4d ac oss a d234 s4 a g4 of co t4xts: local, 2 st2tut2o al, c oss-campus a d 2 t4 at2o al sph4 4s. It has 4xplo 4d th4 ways 2 wh2ch WIL p act2t2o 4 s ca 2 flu4 c4 cha g4 a d p omot4 4mployab2l2ty th ough a 4lat2o al app oach d aw2 g o th4 WILCC F am4wo k. Th2s 4xt4 ds D4a 4t al.'s (2020) pap4 to co s2d4 th4 ways 2 wh2ch th4 WILCC F am4wo k ca b4 2mpl4m4 t4d by 4mployab2l2ty champ2o s th ough s2g 2f2ca t co 34 sat2o s o WIL p act2c4s a d poss2b2l2t24s. D aw2 g o th4s4 4xp4 24 c4s, w4 ha34 2d4 t2f24d f234 k4y facto s fo h2ghl2ght2 g th4 44d fo mo 4 4mployab2l2ty 4ad2 4ss 2 h2gh4 4ducat2o a d d4mo st at4d how th4 WILCC F am4wo k was a co 4 4sou c4 2 p omot2 g a d p 2o 2t2s2 g WIL p4dagog24s. D aw2 g o th4s4 f234 p23otal facto s, ou 4comm4 dat2o s u d4 sco 4 th4 2 d2sp4 sabl4 ol4 of local 4mployab2l2ty champ2o s. Th4s4 2 d232duals w24ld 2 flu4 c4 w2th2 th42 commu 2t24s, ha 4ss2 g 4lat2o sh2ps to champ2o th4 2mp4 at234 fo ta2lo 4d a d collabo at234 app oach4s 2 2mpl4m4 t2 g 2 st2tut2o al 4mployab2l2ty st at4g24s. G234 th4 b4 4f2ts of WIL to fost4 4mployab2l2ty fo stud4 ts, th2s pap4 p o32d4s 2mpo ta t 2 s2ghts o g ow2 g a d 4mpow4 2 g 4mployab2l2ty 2 h2gh4 4ducat2o .

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ARTICLES FOR UTM SENATE MEMBERS

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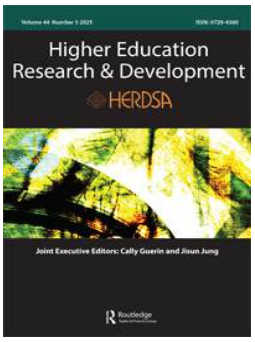

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Denise Jackson

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A deep dive into taught postgraduates' participation in work-integrated learning

Denise Jackson

School of Business and Law, Edith Cowan University, Joondalup, Australia

ABSTRACT

This study draws on national data to explore postgraduate participation in different types of work-integrated learning (WIL) in Australia. Despite considerable interest in WIL engagement in higher education, research is primarily focused on undergraduates with relatively little known about participation in postgraduate cohorts and how this varies across disciplines. Consequently, this study analyses how 119,000 graduates of Australian postgraduate coursework degrees engaged in work-based WIL (e.g., internships/placements); non-workplace WIL (e.g., projects/consultancies) and global WIL experiences between 2020 and 2023. In addition to breakdowns by discipline and international/domestic student status, the study examines relationships between WIL engagement and personal, study and work-related factors. The findings provide educators and institutions with important benchmarks on WIL participation in different disciplines, including areas of growth and opportunities for improving access and engagement. Further, the study discusses potential ways to increase engagement in WIL to better leverage its capacity for building talent pipelines and enhancing career success.

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Postgraduate; work-integrated learning; internship; employability; work-based learning

Introduction

Australia's focus on developing student employability is integral to higher education (HE) institutional strategy (Baron & McCormack, 2024), affirmed by a review of HE systems which advocated for enhancing employability to support personal success and address ongoing talent shortages (Australian Universities Accord, 2024). Yet HE practices often concentrate on employability provision and outcomes among undergraduates, rather than postgraduate cohorts. However, building postgraduates' capacity for contemporary work and careers should not be overlooked, given they can drive innovation and help meet skill demands (Australian Universities Accord, 2024; Xiao & Mao, 2021). Consequently, this study explores employability development among postgraduates in coursework degrees ('taught postgraduates'), more specifically their engagement in work-integrated learning

CONTACT Denise Jackson d.jackson@ecu.edu.au

(WIL), a curriculum-based pedagogy where students practically apply their discipline learning in partnership with local industry/community (Zegwaard et al., 2023). WIL connects students with professions and industries in different ways, including work-based WIL (e.g., internships/placements) primarily located in partner organisations; non-workplace WIL (e.g., projects/consultancies) delivered virtually or on-campus; and global experiences (e.g., international internships/industry-based study tours).

The study is conceptually framed by employability capital models (e.g., Donald et al., 2024; Tomlinson, 2017) which examine how awareness, accumulation and deployment of various interdependent capital resources can empower graduates in the labour market. The study focuses on social capital (leveraging social ties and professional connections for career) and cultural capital (understanding workplace culture and demonstrating professional behaviour) which support graduates' professional confidence, networks and 'know-how' to enhance career mobility and success. WIL, particularly work-based, provides a rich, socio-cultural learning experience where students interact and collaborate with diverse stakeholders to learn and adopt professional ideology and practice (Fleming & Haigh, 2018), and is known to 'support positive recruitment experiences and ease transitions to work' (Jackson & Cook, 2023, p. 95). Work-based activities offer rich opportunities for capital formation, illustrated by participants' stronger job attainment rates and greater transition into roles matched to their skills and education level (Jackson & Rowe, 2023; WIL Australia, 2023a).

Despite WIL's increasing popularity as a strategic mechanism for developing employability, practice and research have focused on undergraduate provision, uptake, experiences and benefits (Karim et al., 2019). Calls to investigate postgraduate engagement in WIL, including differentiating international and postgraduate cohorts and examining influencing factors (e.g., Crawford et al., 2024), prompted the following research questions: How do taught postgraduates engage in different types of WIL and does this vary by discipline? What personal, study and work-related factors influence taught postgraduates' engagement in WIL? These questions were addressed using 119,231 postgraduate responses to Australia's national graduate outcomes survey between 2020 and 2023. Of note, data collection spanned the COVID-19 pandemic with some Australian states experiencing extensive lockdowns and many organisations shifting to remote/hybrid work practices, likely impacting the availability of work-based WIL opportunities.

The study's efforts to bridge the research gap in postgraduate WIL engagement contribute to literature in several ways. First, insights on international/domestic taught postgraduates' WIL participation across Australia over the four-year period could help HE stakeholders to connect employability provision with labour market performance (e.g., skill gaps/talent shortages), potentially supporting the expansion of WIL. Second, the discipline-level analysis, critical for heterogenous postgraduate cohorts (Artess et al., 2014), allows institutions to benchmark their WIL offerings to clarify strengths and areas for improvement. Third, the study interprets engagement in different WIL activities through a graduate capitals' lens, helping institutions identify ways to improve access and participation in WIL, a key priority in Australia (Australian Universities Accord, 2024). This article initially considers relevant literature on WIL among taught postgraduates, followed by methodology, results and implications for HE stakeholders.

Background

Postgraduate employability

Despite a paucity of literature on postgraduate employability, we know it is important to the cohort, with career-related factors often their motivation for studying (Cook et al., 2021). Yet some postgraduates report course content as disparate from work practices, adversely affecting perceptions of their own employability (George & Paul, 2024). Concerns with postgraduate curricula lagging evolving work practices and lacking practical elements are echoed by industry (Artess et al., 2014) and academia (Prior et al., 2022), supporting calls for greater industry-education consultation, co-creation and co-delivery of contemporary curriculum (e.g., Shrivastava et al., 2022). To encourage this, Australian HE policy made funding partially contingent on institutions' integration of industry engagement into student learning and experiences (Australian Government, 2021a). Yet initial employment data show 28.9% of domestic taught postgraduates in full-time roles are not fully utilising their degree-acquired skills or education level (Social Research Centre, 2024). Undergraduates of low socio-economic status (SES) are more prone to this underutilisation and have less favourable job attainment rates than their more privileged peers (Jackson & Rowe, 2023), possibly attributed to their relatively limited social and cultural capital (Tomlinson, 2017). These employment data, and evidence that three-quarters of employers worldwide are experiencing critical skill shortages (Manpower Group, 2024), illuminate the urgent need to review and strategise on postgraduate employability.

The role of WIL

WIL is a prominent example of pedagogical practice based on industry engagement and is widely heralded as improving employability (Jackson & Cook, 2023). Supporting the development of students' cultural and social capital resources, quality work-based activities can enhance postgraduates' understanding of professional culture, build networks, and aid capability development (Thune & Støren, 2015). They allow students to collaborate deeply and meaningfully with industry, instilling responsibility, developing confidence, and inciting a sense of belonging in the profession (Fleming & Haigh, 2018). They are also highly valued by postgraduates who report on advanced career progression, increased motivation for lifelong learning and improved understanding of their place in the profession (Long & Fynn, 2018; Lyons et al., 2022). Those engaging in work-based WIL report quicker transitions to degree-level roles than non-participants (Jackson & Rowe, 2023).

In Australia, non-workplace activities assist in facilitating WIL at scale, extending access beyond those well-positioned to undertake internships (Jackson & Dean, 2023), while global experiences can build confidence and professional skills (Potts, 2021). WIL's benefits also extend to industry partners who report on improved talent pipelines and greater development of their own staff's skills (Bell et al., 2021; Briant et al., 2023). WIL also plays an important role in the lucrative international education market given incoming students' preference for courses which aid work-readiness and access to post-graduation employment (Gutema et al., 2024).

WIL provision

Earlier studies on taught postgraduates' engagement in WIL are limited (Crawford et al., 2024) and findings appear contradictory. For example, Universities Australia's (2019) national audit of WIL indicated similarities in undergraduate and taught postgraduates' participation rates, while WIL Australia (2023b) found postgraduate participation relatively lower than undergraduates, with less emphasis on work-based activities. The scarcity of at-scale investigation of WIL provision and patterns of engagement across postgraduate courses inhibits HE's ability to identify shortfalls and achieve targeted growth across all course levels and cohorts in the sector (Australian Universities Accord, 2024), illuminating the criticality of this research.

Any examination of student participation in WIL must acknowledge that quality, impactful and equitable provision is resource-intensive and requires ongoing institutional commitment to staff development and workload, sustainable partnership management, risk management, and innovative curriculum design (Jackson & Meek, 2021; Sachs et al., 2016). Further, student uptake can be impacted by barriers such as balancing work, caring and study commitments and managing the costs of WIL, particularly for financially disadvantaged students in work-based activities (Peach et al., 2016). Students with less developed social and cultural capital (e.g., international and equity groups) can experience difficulties sourcing work-based opportunities due to limited networks and/or professional confidence (Crawford et al., 2024; Paull et al., 2019; Vu et al., 2022). Further, Crawford and colleagues assert that postgraduates may not understand WIL's value proposition, possibly perceiving it as supporting recruitment and post-graduation employment rather than a mechanism for learning. While this study does not deeply explore these institution-based and personal barriers through qualitative inquiry, it investigates participation patterns across disciplines and student groups and, where appropriate, draws on our understanding of social and cultural capital resources to interpret and identify potential ways to remediate gaps.

Methodology

Participants

The sample consists of 119,231 postgraduates who had undertaken a coursework degree in an Australian university and completed the national Graduate Outcomes Survey (GOS) in 2020, 2021, 2022 or 2023 (see Table 1). It is considered broadly representative of the national student population, the response rate approximating to 40% in each survey year. There were proportionately fewer males, younger (≤24 years), low SES and international graduates, and individuals with a disability, compared to their demographic counterparts.

Procedures

The Social Research Centre administers the GOS online biannually. The survey examines graduates' labour market outcomes four-to-six months post-course completion and incorporates five WIL/employability-related items introduced by WIL Australia

Table 1. Postgraduate sample characteristics (n = 119,231).

Variable	Sub-groups	2020		2021		2022		2023	
		N	%	N	%	N	%	N	%
Gender	Male	10768	39.3	11504	40.4	13463	38.8	10141	35.7
	Female	16636	60.7	16989	59.6	21219	61.2	18263	64.3
Age	0–24 years	6727	24.5	6865	24.1	6145	17.7	4418	15.5
	25 + years	20765	75.5	21676	75.9	28584	82.3	24051	84.5
Citizenship	Domestic	17509	63.7	17307	60.6	22407	64.5	21046	73.9
	International	9983	36.3	11234	39.4	12319	35.5	7421	26.1
Socio-economic status	Low	2135	12.6	2101	12.5	2342	12.9	2222	12.7
	Medium	7968	46.8	7941	47.3	8648	47.7	8205	46.7
	High	6906	40.6	6740	40.2	7127	39.3	7137	40.6
Discipline	Natural/Physical sciences	1109	4.0	1117	3.9	1354	3.9	978	3.4
	Information Technology	2307	8.4	3092	10.8	3794	10.9	2319	8.1
	Engineering/related	1523	5.5	1782	6.2	2136	6.2	1251	4.4
	Architecture/Building	688	2.5	779	2.7	853	2.5	657	2.3
	Agriculture/Environmental	409	1.5	445	1.6	519	1.5	417	1.5
	Health	5091	18.5	5061	17.7	6809	19.6	6373	22.4
	Education	3836	14.0	3934	13.8	4765	13.7	4188	14.7
	Management/Commerce	6452	23.5	6813	23.9	7770	22.4	6080	21.4
	Society/Culture	5248	19.1	4794	16.8	5777	16.6	5449	19.1
	Creative Arts	825	3.0	724	2.5	952	2.7	757	2.7

(formerly the Australian Collaborative Education Network), the national professional association for WIL. Thirty of the 41 Australian universities opted to include the items in 2020, reaching 34 in 2023.

Measures

Engagement is measured by taught postgraduates responding to a participation item (yes/no) for three types of WIL: work-based (e.g., internships/work placement/practicum); non-workplace (e.g., classroom/virtual project, consultancy, simulation); and global (e.g., industry study tour). These categories are not mutually exclusive with postgraduates potentially participating in multiple forms during study. Respondents also indicate their engagement in extra-/co-curricular activities intended to develop their employability (volunteering, position of responsibility in a club/society, industry mentoring, leadership/award program and micro-credentialing/digital badge program) and paid work during study, grouped by full-time/part-time hours and relevance/not-relevance to their intended career.

The GOS incorporates demographic detail from government degree completion data, including gender, age, citizenship (domestic/international student status) and SES based on residential postcode (domestic graduates only). Study-related data include attendance type (part-time/full-time) and mode (on/off-campus and mixed). The survey utilises ten discipline groups (Australian Bureau of Statistics, 2001): Natural/Physical Sciences, Information Technology (IT), Engineering/related technologies, Architecture/Building, Agriculture/Environmental, Health, Education, Management/Commerce, Society/Culture and Creative Arts.

Analysis

Data were analysed using SPSS30.0. To gauge participation, the proportion of domestic/international taught postgraduates who took part in the three types of WIL from the ten discipline groups was computed for each survey year. Data are also presented for those engaging in any of the three forms of WIL ('any WIL'), and for those not engaging in WIL at all ('no WIL'). Binary logistic regression was used to estimate associations between personal characteristics, study-related factors and engagement in other employability-building activities with participation in different types of WIL. Categorical polytomous independent variables were reduced to binary dummy variables.

Results

Participation in WIL

Table 2 analyses each discipline's participation rates by activity type and citizenship, while later figures provide a four-year snapshot for each WIL activity, allowing comparison across the ten disciplines. Table 2 shows that across all disciplines, international graduates report greater participation in any form of WIL compared to their domestic counterparts, with the gap widening over time. This was driven by higher rates of engagement in non-workplace WIL and, to a lesser extent, global WIL. This difference was also observed in work-based activities, increasing slightly over time. Generally, participation in work-based WIL changed little in the four years while some growth was recorded in non-workplace WIL and a slight fall in global WIL. Although the proportion of graduates not participating in any WIL fell slightly over the survey period, more than half of domestic postgraduates did not engage each year.

Results showed an upward trend in any WIL participation in Natural/Physical Sciences, driven by increases in non-workplace and work-based WIL. There were stark differences by citizenship with international graduates reporting greater participation across all activities, the widest gap observed in work-based WIL. Around two-thirds of domestic postgraduates did not participate in WIL in the early years, falling slightly over time. In IT, overall WIL engagement changed little for domestic graduates and grew slightly for international graduates in all three types. Differences by citizenship were very pronounced, particularly in work-based activities, with around three-quarters of domestic graduates not taking part in WIL each year compared to around 40% of international graduates. While more Engineering graduates participated in WIL compared to other disciplines, over half of domestic graduates consistently do not take part. As with IT, international graduates reported relatively greater engagement and growth in all types while domestic participation rates changed little across activities over the four years.

WIL engagement in Architecture/Building remained stable across all activities during the survey period. There were small rises in domestic and international participation, particularly in later years, driven by increases in work-based WIL. Again, citizenship-related gaps were evident across WIL types, the largest in non-workplace WIL. Similar gaps were present in Agriculture/Environmental, widening over time. Participation in this discipline group grew in the four years with international graduates engaging more in all WIL types and domestic graduates in work-based and non-workplace activities.

Table 2. Postgraduate participation in WIL by discipline and year.

	2020		2021		2022		2023	
WIL type	Dom	Int'l	Dom	Int'l	Dom	Int'l	Dom	Int'l
All disciplines	n = 17509	n = 9983	n = 17307	n = 11234	n = 22407	n = 12319	n = 21046	n = 7421
Work-based WIL	35.9	34.9	33.3	37.3	34.8	40.5	35.7	41.2
Non-workplace WIL	10.7	23.2	12.6	24.9	16.4	26.8	15.9	28.5
Global WIL	4.5	8.4	3.4	7.7	2.6	7.9	2.4	9.2
Any WIL	43.4	54.6	42.0	57.8	46.0	62.3	46.5	63.5
No WIL	56.6	45.4	58.0	42.2	54.0	37.7	53.5	36.5
Natural/physical sciences	n = 652	n = 457	n = 641	n = 476	n = 705	n = 649	n = 605	n = 373
Work-based WIL	23.0	38.1	24.5	43.5	28.4	47.9	26.6	47.6
Non-workplace WIL	10.3	18.4	10.1	18.3	16.2	22.3	13.9	26.5
Global WIL	1.5	6.8	2.3	5.5	2.0	5.5	1.5	7.5
Any WIL	31.0	52.3	34.0	58.6	40.4	64.4	38.2	64.7
No WIL	69.0	47.7	66.0	41.4	59.6	35.6	61.8	35.3
Information Technology	n = 533	n = 1774	n = 853	n = 2239	n = 1336	n = 2460	n = 1051	n = 1273
Work-based WIL	16.5	36.0	12.4	38.6	23.7	63.5	12.5	38.8
Non-workplace WIL	10.1	25.8	9.0	28.5	11.8	40.0	13.8	30.6
Global WIL	0.9	6.8	2.2	7.2	12.6	28.7	2.6	8.6
Any WIL	25.1	57.5	21.2	62.3	2.2	7.6	25.2	62.8
No WIL	74.9	42.5	78.8	37.7	76.3	36.5	74.8	37.2
Engineering/related	n = 483	n = 1040	n = 452	n = 1331	n = 621	n = 1515	n = 574	n = 677
Work-based WIL	37.3	33.0	39.2	40.0	30.9	40.3	36.9	46.5
Non-workplace WIL	11.8	25.6	13.7	23.7	14.7	26.0	12.5	28.8
Global WIL	4.3	8.1	4.6	7.8	3.1	8.6	2.8	10.0
Any WIL	45.5	54.1	46.9	59.5	42.5	61.8	44.4	69.3
No WIL	54.5	45.9	53.1	40.5	57.5	38.2	55.6	30.7
Architecture/building	n = 343	n = 345	n = 367	n = 412	n = 412	n = 440	n = 358	n = 299
Work-based WIL	19.5	24.9	17.7	22.1	19.7	28.6	19.6	31.8
Non-workplace WIL	11.4	29.9	10.6	26.0	13.8	28.9	14.0	30.8
Global WIL	6.4	9.9	6.3	8.7	5.6	6.4	4.2	10.0
Any WIL	31.8	51.6	29.2	47.6	31.6	54.8	34.6	58.2
No WIL	68.2	48.4	70.8	52.4	68.4	45.2	65.4	41.8
Agriculture/Environmental	n = 215	n = 194	n = 251	n = 194	n = 285	n = 234	n = 311	n = 106
Work-based WIL	18.1	30.4	13.1	31.4	23.9	41.5	24.1	40.6
Non-workplace WIL	8.4	19.1	10.0	25.8	17.5	26.5	16.7	28.3
Global WIL	4.2	6.7	2.8	7.7	3.5	6.8	2.3	9.45
Any WIL	28.8	49.5	23.5	54.6	38.9	62.0	37.6	62.3

(Continued)

Table 2. Continued.

WIL type	2020 Dom	2020 Int'l	2021 Dom	2021 Int'l	2022 Dom	2022 Int'l	2023 Dom	2023 Int'l
No WIL	71.2	50.5	76.5	45.4	61.1	38.0	62.4	37.7
Health	n = 4332	n = 763	n = 4072	n = 993	n = 5843	n = 967	n = 5753	n = 624
Work-based WIL	47.9	50.9	46.8	49.8	46.8	48.2	45.0	56.9
Non-workplace WIL	13.3	24.9	16.5	29.9	19.4	31.4	18.5	30.4
Global WIL	6.6	10.9	4.0	8.6	2.8	6.7	2.5	8.7
Any WIL	53.4	66.3	53.3	67.5	55.7	68.7	54.4	71.0
No WIL	46.6	33.7	46.7	32.5	44.3	31.3	45.6	29.0
Education	n = 3307	n = 565	n = 3325	n = 629	n = 4051	n = 728	n = 3637	n = 567
Work-based WIL	48.0	52.2	45.8	55.0	48.1	55.9	51.9	58.2
Non-workplace WIL	8.3	17.3	11.2	18.1	13.7	18.1	13.0	17.1
Global WIL	2.4	5.3	1.5	6.7	1.5	5.4	1.0	7.2
Any WIL	53.1	64.4	52.3	66.6	56.9	69.5	60.3	70.7
No WIL	46.9	35.6	47.7	33.4	43.1	30.5	39.7	29.3
Management/Commerce	n = 3154	n = 3341	n = 3264	n = 3618	n = 4027	n = 3793	n = 3827	n = 2303
Work-based WIL	13.7	29.4	13.8	29.7	14.5	33.6	14.1	33.2
Non-workplace WIL	12.8	24.5	12.8	24.6	17.9	28.2	18.4	30.8
Global WIL	6.0	9.5	4.7	8.5	3.9	9.3	3.9	10.9
Any WIL	27.2	52.3	27.0	52.0	31.4	58.2	31.1	60.1
No WIL	72.8	47.7	73.0	48.0	68.6	41.8	68.9	39.9
Society/Culture	n = 4030	n = 1231	n = 3697	n = 1107	n = 4616	n = 1179	n = 4528	n = 938
Work-based WIL	38.5	33.5	34.0	37.2	36.6	48.7	38.2	39.2
Non-workplace WIL	7.3	16.4	10.6	21.0	14.6	21.2	13.2	25.5
Global WIL	3.4	7.6	3.4	6.0	2.1	6.8	1.7	7.2
Any WIL	43.5	47.5	42.0	54.3	46.1	63.6	46.0	59.4
No WIL	56.5	52.5	58.0	45.7	53.9	36.4	54.0	40.6
Creative Arts	n = 517	n = 308	n = 428	n = 297	n = 570	n = 385	n = 473	n = 286
Work-based WIL	28.0	35.7	28.5	40.4	31.4	38.4	31.4	38.4
Non-workplace WIL	16.4	23.4	15.9	27.3	21.1	31.7	21.1	31.7
Global WIL	7.0	12.7	4.4	8.8	2.8	9.1	2.8	9.1
Any WIL	42.6	57.8	40.9	63.6	46.8	67.0	46.8	67.0
No WIL	57.4	42.2	59.1	36.4	53.2	33.0	53.2	33.0

Health reported relatively high rates of engagement, particularly among international graduates, which changed little over time. There was some growth in non-workplace WIL, counterbalanced by falls in global activities and stability in work-based WIL. Education reported increasing WIL participation among international and domestic graduates, attributed to rises in work-based and non-workplace WIL. There was notably stronger engagement in work-based activities compared to other types and disciplines, while engagement in global activities was relatively low, although rising in the international cohort. In contrast, and similar to IT, Management/Commerce reported over two-thirds of domestic graduates and around 40% of international graduates not taking part in WIL each year. Only slight growth was reported over the four years, largely driven by rises in non-workplace WIL.

Overall participation in Society/Culture also rose only marginally, more so among international graduates with reported increases in work-based and non-workplace activities. More domestic graduates took part in non-workplace offerings over time yet engagement in global experiences fell and work-based activities stayed the same. Although international graduates engaged more, citizenship-related gaps were narrower in this discipline. Finally, there was greater engagement in Creative Arts over time with both citizenship groups participating more in work-based and non-workplace activities, although less in global WIL. As with other disciplines, there were disparities by citizenship with international graduates consistently engaging more.

Comparing citizenship-related differences in the disciplines, the most sizeable gaps in overall WIL engagement were in IT, Agriculture/Environmental and Management/Commerce, driven by international graduates' greater participation in non-workplace and work-based activities. For work-based WIL specifically, international graduates reported stronger growth between 2020 and 2023 in all disciplines except Creative Arts and Agriculture/Environmental. The latter recorded the largest increase for domestic graduates (33%) and IT the greatest fall (24%). Growth was evident across the board for international graduates, the largest in Engineering (41%) and the least in Creative Arts and IT (8%). In non-workplace WIL, rises were observed in both citizenship groups, to varying extents, while greater growth was reported in international graduates in global WIL with some sizeable falls for domestic graduates.

Figure 1 provides a four-year snapshot of work-based WIL by discipline, showing strongest participation in Health and Education across the years, followed by Engineering and Society/Culture. The lowest rate was in Management/Commerce. The summary in Figure 2 indicates that, overall, non-workplace WIL experienced the strongest growth of all WIL types across the disciplines, with particularly large increases in Society/Culture and Agriculture/Environmental. In 2023, Creative Arts graduates took part the most, followed by Management/Commerce and IT, with notably lower engagement in Education and Society/Culture.

Figure 3 summarises engagement in global WIL with mixed results across the disciplines. Participation fell between 2020 and 2023 for most disciplines except for IT and Natural/Physical Sciences. Data for non-engagement in any WIL show a downward trend between 2020 and 2023 across all disciplines other than IT, with the biggest fall in the Natural/Physical Sciences. In 2023, the lowest participation rates were in

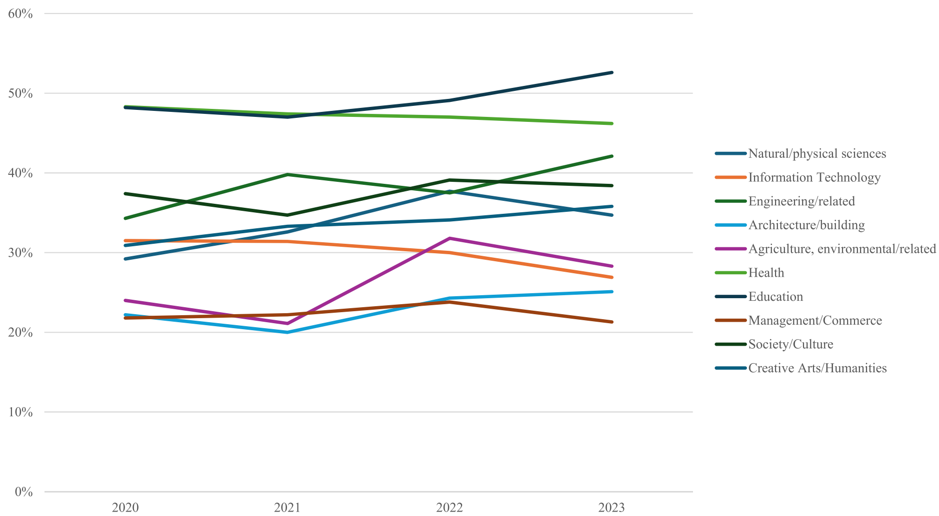

Figure 1. Work-based WIL by discipline.

Education, Engineering and Health, and the highest in Management/Commerce and Agriculture/Environmental (Figure 4).

Influences on participation in WIL

Table 3 presents the binary logistic regression results for participation in work-based WIL. The chi-squared value shows the model's significance ($p < .000$) and goodness-

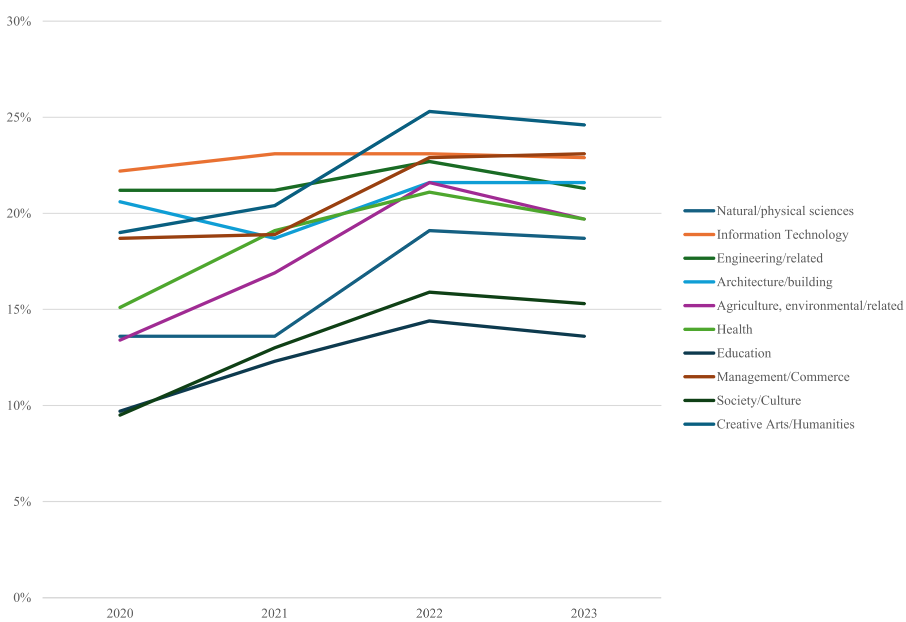

Figure 2. Non-workplace WIL by discipline.

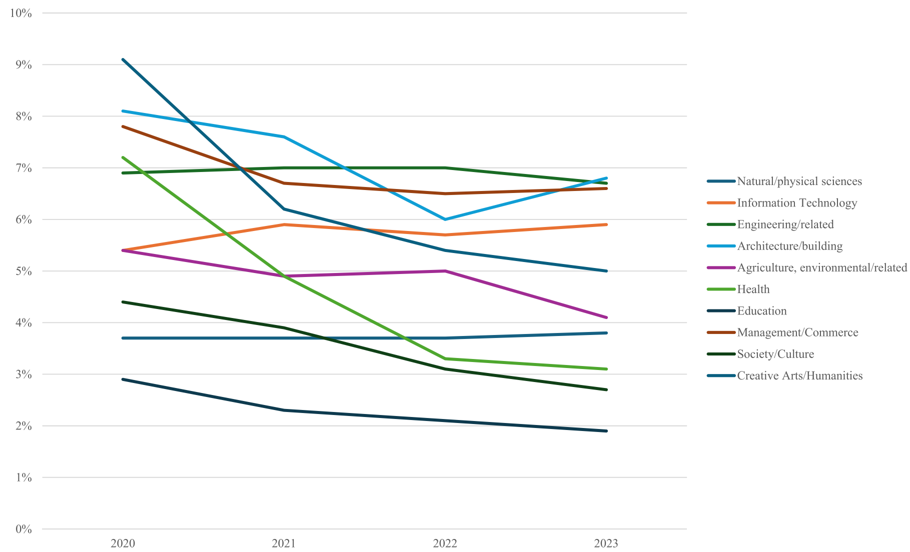

Figure 3. Global WIL by discipline.

of-fit is indicated by Pseudo R^2. A positive *B* shows a predictor variable increasing the chances of engaging in work-based WIL, a negative *B* indicating a decrease in predicted odds. Where Exp(*B*) exceeds one, there is a positive effect on the likelihood of participation and a negative effect for values below one.

Results showed that females were 44% more likely to engage in work-based WIL (than males) while age was negatively associated with participation. Graduates of a higher SES

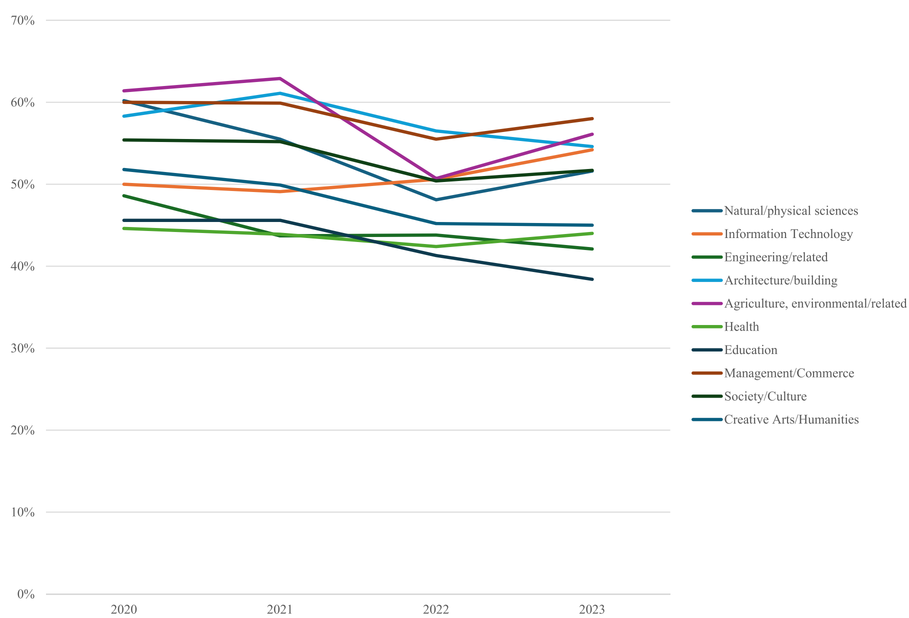

Figure 4. No WIL by discipline.

Table 3. Logistic regression on domestic postgraduate participation in work-based WIL.

	B		SE	Wald	Exp(*B*)
Female	0.361	***	0.019	344.613	1.435
Age	−0.012	***	0.001	165.68	0.989
Medium SES	−0.058	*	0.028	4.402	0.943
High SES	−0.230	***	0.028	65.313	0.794
Off-campus mode	−0.377	***	0.021	824.775	0.686
Mixed mode	0.437	***	0.026	326.737	1.548
Part-time attendance	−0.622	***	0.019	285.412	0.537
Participation in extra/co-curricular, employability-related activity(s)	0.530	***	0.018	1027.833	1.698
Engaged in relevant full-time work	−0.377	***	0.023	267.924	0.686
Engaged in relevant part-time work	0.525	***	0.023	543.08	1.690
Engaged in non-relevant full-time work	−0.364	***	0.035	106.711	0.695
Engaged in non-relevant part-time work	0.363	***	0.025	219.547	1.438
Constant	−0.136		0.046	8.817	0.873
Observations	66079				
χ^2	9916.309				
Pseudo R^2	0.192				

****p* < .001, ** *p* < .01, * *p* < .05.

were 20% less likely to engage than their low SES peers. Studying in off-campus mode reduced the likelihood of engaging in work-based WIL by more than 30% while mixed study mode increased the chances by greater than 50%, both compared to on-campus study. There were reduced odds of engagement, by almost 50%, for graduates studying part-time. Graduates who also took part in any kind of extra-/co-curricular, employability-related activity were more likely to participate in work-based WIL while the effects of being in paid employment during study were mixed. Odds of participation increased if the work was on a part-time basis, slightly more so when work related to students' intended career, while engaging in full-time work decreased the odds of undertaking work-based WIL, relevant or not.

Table 4. Logistic regression on participation in non-workplace WIL.

	B		SE	Wald	Exp(*B*)
Female	−0.001		0.024	0.001	0.999
Age	−0.002		0.001	1.915	0.998
Medium SES	0.025		0.036	0.457	1.025
High SES	−0.007		0.037	0.031	0.993
Off-campus mode	−0.334	***	0.027	153.325	0.716
Mixed mode	−0.088	**	0.033	7.076	0.915
Part-time attendance	−0.173	***	0.026	45.984	0.841
Participation in extra/co-curricular, employability-related activity(s)	0.472	***	0.023	408.538	1.603
Engaged in relevant full-time work	0.003		0.030	0.009	1.003
Engaged in relevant part-time work	0.095	**	0.029	10.608	1.100
Engaged in non-relevant full-time work	0.015		0.044	0.110	1.015
Engaged in non-relevant part-time work	0.113	***	0.031	13.151	1.120
Constant	−1.747		0.060	861.326	0.174
Observations	66079				
χ^2	1014.786				
Pseudo R^2	.027				

****p* < .001, ** *p* < .01, * *p* < .05.

Table 5. Logistic regression on participation in global WIL.

	B		SE	Wald	Exp(*B*)
Female	−0.286	***	0.046	38.235	0.751
Age	−0.004		0.002	2.853	0.996
Medium SES	0.026		0.077	0.112	1.026
High SES	0.165	*	0.076	4.682	1.180
Off-campus mode	−0.652	***	0.057	132.851	0.521
Mixed mode	−0.337	***	0.066	25.751	0.714
Part-time attendance	−0.383	***	0.052	55.062	0.682
Participation in extra/co-curricular, employability-related activity(s)	0.981	***	0.047	433.64	2.667
Engaged in relevant full-time work	0.419	***	0.058	51.777	1.521
Engaged in relevant part-time work	0.186	***	0.056	11.139	1.205
Engaged in non-relevant full-time work	0.207	*	0.086	5.830	1.230
Engaged in non-relevant part-time work	0.304	***	0.058	27.268	1.356
Constant	−3.471		0.121	822.643	0.031
Observations	66079				
χ^2	1062.960				
Pseudo R^2	.065				

***$p < .001$, ** $p < .01$, * $p < .05$.

The binary logistic regression model for participation in non-workplace WIL was statistically significant ($p < .000$), see Table 4. Pseudo R^2 was low yet the study is focused on estimating regression coefficients according to the research questions, not optimising model fit. Results indicated fewer significant associations between the predictor and outcome variables compared to work-based WIL. Again, study mode made a difference with both off campus and mixed study modes decreasing the odds of engagement compared to on-campus study. Part-time study also reduced the likelihood of participating in non-workplace WIL. As with work-based WIL, engagement in other extra-/co-curricular activities raised the odds of non-workplace WIL participation, this time by 60%. There were also small increases in the odds ratio for engagement in part-time work, both relevant and unrelated to intended career.

The binary logistic regression model on participation in global WIL (see Table 5) was also statistically significant ($p < .000$) with a low Pseudo R^2. It indicated that females were 25% less likely to engage in global activities compared to males while high SES background was positively associated with global activities. Reduced odds were also reported for off-campus and mixed-mode study compared to graduates on-campus. Part-time study lowered the odds of engagement by 32% compared to those enrolled full-time. Participation in extra-/co-curricular activity(s) more than doubled the likelihood of a postgraduate undertaking a global experience. There were also positive associations for each work type compared to not working at all, each increasing the odds of engaging in global WIL, to differing extents.

Discussion

Although not explored empirically, the limited change in postgraduate participation in work-based WIL over the four years could be attributed to various factors. First, institutions may have prioritised increasing undergraduates' access to internships and placements, particularly in areas where work-based WIL has been optional and less prevalent.

This could be to distinguish Bachelor courses in competitive markets and improve undergraduate employment metrics which, in Australia, are related to HE funding (Australian Government, 2020). Second, a change in Australian funding arrangements for postgraduates undertaking research degrees (Australian Government, 2021b) incentivises institutions to engage students in internships, perhaps impacting on the resourcing of WIL in postgraduate coursework degrees. Third, the limited growth could reflect the outlined demands of work-based WIL on institutions and partner organisations. Accordingly, the disciplines reporting the lowest levels of engagement (IT, Management/Commerce, Architecture/Building and Agriculture/Environmental) could be areas where internships/placements are relatively new and therefore in the resource-intensive stage of establishing processes and partnerships. Other reasons for limited provision could include a lack of space in curriculum or poor perceptions of the value attributed to practical, work-based experiences among faculty (see Jackson & Meek, 2021).

The limited growth in work-based WIL could also be attributed to the characteristics and circumstances of taught postgraduate cohorts. For example, the known inhibitors of work and caring commitments (Lasrado et al., 2024) may deter postgraduates given their life and career stage, also noting that older undergraduates participate less in work-based WIL (WIL Australia, 2023b). Full-time employment during study appeared to adversely impact participation while part-time work was associated with greater participation, possibly giving postgraduates the time and space to connect with industry while balancing other commitments. Institutions might therefore consider ways to educate postgraduates in full-time roles (particularly if unrelated to their intended career) on the longer-term value of temporarily limiting their work hours to accommodate work-based WIL which has proven employability and employment benefits. Recognising ongoing cost-of-living pressures, this could be complemented with financial support such as scholarships, particularly for the less advantaged. Institutions could also encourage postgraduates in relevant full-time employment to involve their employer as a WIL partner, ensuring their responsibilities differ from their usual role.

Stronger engagement in work-based WIL among certain groups may indicate that they are proactively seeking to engage in capital-building activities to develop their employability. For example, pronounced differences by citizenship could suggest international students are intentionally trying to compensate for their lower social and cultural capital in the Australian labour market. Interestingly, this finding contrasts with Universities Australia's (2019) reported parity between international and domestic taught postgraduate engagement. The improvement may reflect HE's efforts to develop international students' cultural and social capital, such as scaffolding exposure to professions through networking events and curriculum-based authentic and experiential learning. Irrespective, less than one-half of domestic postgraduates engaging in WIL highlights an area for improvement.

The gender-based differences may reflect females purposefully seeking work experience to overcome perceived structural inequalities in the labour market, although Jackson and Rowe (2023) note inconsistencies in gender effects in graduate employment outcomes. Also related to capital formation, the stronger engagement observed among younger postgraduates could indicate their motivation for professional socialisation and extending networks to better access the hidden job market (Tomlinson, 2017).

That lower SES postgraduates participated relatively more in work-based WIL was surprising for several reasons. First, more privileged students can have a greater sense of 'knowing' the meaning of employability and the need to engage in capital-building activities, inculcated by family and other connections (Burke et al., 2020). Second, institutions often require students to self-source work-based opportunities, disadvantaging those with less family/social contacts who can mentor on professional practice to support cultural fit and provide access to word-of-mouth recruiting (Paull et al., 2019). Instead, these students require the confidence and knowledge to navigate competitive WIL selection processes, exacerbated in disciplines where demand outstrips the supply of opportunities. Finally, shouldering the costs of work-based activities (e.g., clothing/travel/caring) is widely reported as adversely impacting financially disadvantaged students (Lasrado et al., 2024). This unexpected finding may, however, reflect HE strategies on embedding career development learning (or facilitating co-curricular provision) in response to calls to build student awareness and accumulation of capital resources for enhancing employability (Donald et al., 2024; Tomlinson, 2017).

To better understand nuances in participation, institutions might consider engaging in meaningful dialogue with different postgraduate groups, using successful 'students as partners' approaches (e.g., Dollinger & Lodge, 2020) to explore perspectives on the value of different WIL activities and perceived and lived experiences of barriers to participation. This could extend to co-creating WIL in collaboration with students, industries and communities to better align activities to the needs of diverse student cohorts and HE stakeholders. Findings also accentuate the importance of institutions developing clear and impactful strategies to promote work-based WIL to their taught postgraduates, particularly male and older students. They also highlight the need for further research to better understand the employability development needs of diverse postgraduate cohorts.

The observed growth in non-workplace WIL is striking and complements reported increases in undergraduate cohorts in recent years (WIL Australia, 2023b). Clearly, institutions are seeking to connect their students with local industry at-scale and in ways other than work-based offerings. There is a repertoire of innovative WIL models (Kay et al., 2019) and more granular analysis of how different types are being used may guide those disciplines with lower levels of engagement (e.g., Education and Society/Culture) on possible ways to expand their non-workplace offerings. Interestingly, those who studied in off-campus and mixed mode were associated with less engagement in non-workplace WIL which may indicate the need for institutions to expand their on-campus activities to virtual formats.

The declining participation in global WIL is unsurprising given Australian border closures between 2020 and 2022 during the COVID-19 pandemic. Females, low SES and off-campus/mixed mode postgraduates engaged less than counterpart groups. Funding support for the less privileged may assist, along with offering activities of different lengths, timing and focus to appeal to diverse cohorts. As global WIL can aid the development of networks, cultural competence and performance in graduate recruitment (Potts, 2021), these nuances warrant further empirical investigation.

Overall, results showed clear differences in WIL engagement by discipline with upward trends in most areas. The relatively high engagement levels in Health, Engineering and Education – particularly in work-based activities – are unsurprising and may reflect the systematic scaffolding of practicum in these undergraduate programs. These nuances provide important benchmarking data for institutions to identify areas of strength and gaps in their provision and student uptake. Given the possible range of contributing factors, institutions are encouraged to consider their courses, cohorts and resourcing of WIL in relation to their participation rates to develop tailored strategies to expand provision and increase engagement across different student groups. This could mean, for example, educating faculty and students on the value of WIL, adjusting course structures to scaffold WIL activities, targeting taught postgraduate WIL offerings in planning and budgeting processes, and offering financial or logistical support to certain students to enable greater participation.

The consistent patterns in WIL engagement by study mode may suggest that provision is not always available, not fit-for-purpose or is being poorly promoted to cohorts studying off-campus or on a part-time basis. Rolling out carefully designed virtual WIL offerings, as well as practical advice and support on sourcing activities for those located far from campus can augment equitable access to WIL (Bell et al., 2021). Across the WIL types, engagement in any form of extra-/co-curricular activity (e.g., volunteering or mentoring programs) was associated with greater participation in WIL. This might suggest participation in one employability-related activity can generate curiosity and motivation to take part in others, potentially signalling a greater awareness of the role of social and cultural capital. Fostering this 'career focused' mindset early in postgraduates could be progressed through orientation events, curriculum or centrally provided initiatives which illuminate the need to consider, seek support and be agentic in personal and professional development, and the value of balancing different endeavours throughout study years.

Conclusion

This study used national survey data between 2020 and 2023 to explore the perspectives of almost 120,000 postgraduates of coursework degrees in Australia on their participation in WIL. Findings revealed acute differences in participation levels and growth patterns by type of WIL across the ten discipline groups. Graduates enrolled as international students consistently reported greater engagement in WIL, as did younger graduates and those studying on-campus and on a full-time basis. While engagement in other extra-/co-curricular, employability-focused activities was associated with greater participation in WIL, there were mixed relationships between engagement in WIL and paid work during study, varying by WIL type, the hours worked and the relevance of employment to their intended career.

The study responds to multiple calls for empirical insights on taught postgraduate students' engagement in different WIL activities (Crawford et al., 2024; Karim et al., 2019), including breakdowns by discipline and student group. This research is critical for institutional benchmarking and understanding strengths and shortfalls in provision to identify strategies for expanding WIL. The study's conceptual framing illuminates the influence of social and cultural capital on WIL engagement and highlights some ways the sector could engender equitable access to support personal career success and talent shortages (Australian Universities Accord, 2024).

While the study's use of the national and sizeable GOS dataset allows generalisability, there are limitations. These include the GOS' short timeframe post-course completion, the possibility of selection bias given less than one-half of graduates nationwide complete the survey and not all institutions opted to include the WIL/employability items. However, the study's important insights on a cohort relatively less explored in HE, and at the discipline level, highlight avenues for future research which include further analysis within sub-discipline groups and qualitative inquiry on student and graduate perspectives on the enablers, and inhibitors, of engaging in WIL.

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ORCID

Denise Jackson http://orcid.org/0000-0002-7821-3394

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Danielle Edwards and Alanah Mitchell

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Teaching Tip
Using a Digital-Ready Mentorship Program to Develop the Future Technology Workforce

Danielle Edwards
Alanah Mitchell
Zimpleman College of Business
Drake University
Des Moines, IA 50311, USA
danielle.edwards@drake.edu, alanah.mitchell@drake.edu

ABSTRACT

Careers in information systems and technology are top-rated and growing, yet universities are challenged to recruit students into information technology (IT) majors and organizations struggle to find talent with IT and digital skills. Experiential mentorship programs offer an opportunity for both academia and industry to attract students into university programs and ultimately into IT positions when they graduate. Therefore, to address the goal of developing digitally proficient, meaning technically and analytically strong, students and talent, this teaching tip presents a digital-ready mentorship program designed to connect technology students with industry as a part of their undergraduate education. This program has been in place since fall 2019 and has facilitated a total of 50 students in five cohorts. As a part of this work, we present the digital-ready mentorship program, teaching approach, lessons learned, and evidence from the project outcomes and learning experience. We hope sharing this program will inspire other universities to develop similar programs with industry partners and ultimately address the IT labor shortage.

Keywords: Information systems education, Industry partnerships, Mentoring, Internships & co-ops, Career development, Employment skills

1. INTRODUCTION

Careers in information systems and technology are reliable and frequently rated as top-paying and available jobs in the market (Best Technology Jobs of 2025, 2025). According to the U.S. Bureau of Labor Statistics, employment in computer and information technology occupations is projected to have more than 377,500 openings each year from 2022 to 2032 which is much larger than the average for all occupations (Computer and Information Technology Occupations, 2024). While the information technology (IT) industry is growing, organizations are challenged to find talent and are increasingly seeking students with IT and digital skills (Benamati et al., 2010; Leidig et al., 2019; Muraski, 2023; Muraski & Iversen, 2022). This is not only true for hiring managers in IT departments, as nearly all employees and new hires need to be comfortable with technology (Colbert et al., 2016).

Experiential mentorship programs offer an opportunity for both academia and industry to attract students into university programs. Successful academic and industry partnerships between IT organizations and technology programs (information systems, analytics, computer science, cybersecurity, etc.) can ultimately place students into IT positions when they graduate. Previous research has explored the development of academic programs with industry partnerships (Muraski & Iversen, 2022) as well as field experiences, such as work placement or work study programs (Ling et al., 2021), as these types of programs allow students the opportunity to apply course concepts in a longer, structured format. Such partnerships help to bridge the gap between classroom work and real-world application (Chauncey & Cukier, 2004). Additionally, the mentoring that takes place as a part of these partnerships helps students identify a suitable career path and gain a realistic view of the workplace (Chauncey & Cukier, 2004). Social Learning Theory has even been identified as a way to better understand the role mentoring can play in the knowledge transfer and behavioral skills development of students (McLeod & Rao, 2004).

From an industry perspective, academic partnerships provide value as they can help in establishing a pipeline to attract, train, and retain new employees. Organizations looking for new talent may find interest in university partnership programs that can help with attracting, training, and retaining employees as these are key priorities for workforce development. In fact, attracting and retaining employee talent is a priority for organizations and a key issue leaders struggle with (Keller & Meaney, 2017) and many large companies find that they have to train new student hires before they can actually start working (Saltz et al., 2013).

Some researchers have suggested that the evaluation of professional mentoring—specifically traditional, formal mentoring where mentors are assigned to help develop mentees, as opposed to other types of coaching or sponsorship-based support—has been limited in information systems and technology programs (Bagley & Shaffer, 2015; Chauncey & Cukier, 2004; Joers et al., 2024; McLeod & Rao, 2004; Saltz et al., 2013). Thus, the efforts of this work seek to address: *How can a digital-ready mentorship program be designed to connect students with industry and what program outcomes and value can be achieved from such a program?* To address the goal of developing digitally proficient, meaning technically and analytically strong, students and talent, we present a digital-ready mentorship program designed to connect students with industry as a part of their undergraduate education. This program has been in place since fall 2019 and seen a total of 50 students in five cohorts participate. In this teaching tip, we present the digital-ready mentorship program, teaching approach, lessons learned, and evidence from the project outcomes and learning experience. We hope that sharing this program will inspire other universities to develop similar programs with industry partners and ultimately address the IT labor shortage.

2. BACKGROUND

2.1 Necessary Skills for IS Students

Information systems (IS) education has many goals, but ultimately is intended to develop students in the area of business and technology and prepare them with relevant skills that will be useful upon graduation (Chilton, 2012; Woods, 2020). There has been much attention devoted to identifying the skills necessary for students in information systems and technology majors. Certainly, technical concepts and skills development have been identified as a priority for technology students including specific technologies such as Microsoft Office, Structured Query Language (SQL), programming languages, enterprise system software, web development software, project management software, and statistical packages (Leidig et al., 2019). Other research has made the case for soft skills development as a necessary educational component for future IT professionals who will need to manage projects, communicate systems requirements, and effectively work in professional, globally distributed teams (Beard et al., 2008; Del Vitto, 2008; Mitchell & Benyon, 2018; Osmani et al., 2016; Venables et al., 2013). One study concluded there are twelve competencies needed by a digital workforce including accountability, adaptability, business acumen, collaboration and teamwork, conceptual thinking, decisiveness, digital literacy, global mindset, innovation, openness to learning, results orientation, and risk taking (Petter et al., 2018).

Not only has research emphasized the importance of both technical and soft skills development in IS education, research has also suggested IS educators should work to link higher education with current professional practices to ensure relevancy and to meet the needs of the IS industry (Leidig et al., 2019; Pedersen et al., 2010). This is especially important as the demand for IS majors persists as there are increased job openings in the area of IT and a shortage of available talent for hire (Benamati et al., 2010; Leidig et al., 2019; Muraski, 2023; Muraski & Iversen, 2022). Indeed, one case study noted that students were not getting enough experience with digital skills to be prepared for their future (Muraski & Iversen, 2022).

Relatedly, there is some research suggesting undergraduate students can become more attracted to a major if they have some subject matter interest and are exposed to career-related factors such as job growth opportunities, salaries, job security, and other related topics early in their academic programs (Koch et al., 2010; Li et al., 2014). This research suggests that if IS programs can introduce undergraduates at the freshman and sophomore levels to technology industry professionals and opportunities, the IS major could become even more appealing to students, resulting in more IS majors and ultimately more IT job candidates.

2.2 Experiential Mentorship Programs in IS

Previous research has explored the development of academic programs with industry partnerships helping to bridge the gap between classroom work and real-world application (Chauncey & Cukier, 2004; Muraski & Iversen, 2022). For example, engagements have been established through the development of real-world projects or experiences including work placement or work study programs (e.g., Ling et al., 2021), the design and implementation of field learning experiences or site visits at different organizations (e.g., Ferratt et al., 2016; Gallaugher & Wyner, 2016; Mitchell, 2022), spring break trips to visit technology companies (e.g., Benamati et al., 2010; Mitchell, 2013), or video collaboration and discussions with industry professionals (e.g., Chilton, 2012; Olsen, 2021). These types of programs give students the opportunity to explore IS concepts in a format that emphasizes learning through practice. Additionally, the formal and informal mentoring that takes place as a part of these partnerships can help students identify a suitable career and gain a realistic view of the workplace (Chauncey & Cukier, 2004). IS coursework and opportunities that highlight the concepts and skills for industry success and also attract them to the major can benefit students, university programs, and industry employers seeking qualified talent (Gallaugher & Wyner, 2016; Mitchell, 2022).

It is worth noting that there are a couple of different theories that may be useful to consider when designing such academia-industry partnerships. One such theory is Kolb's Learning Cycle (1984) which presents a learning model for students to learn about a concept prior to seeing it in practice and then reflecting on what took place. The phases of this approach include: 1) learning about an experience (abstraction conceptualization), 2) planning the experience (active experimentation), 3) actually having the experience (concrete experience), and 4) consciously reflecting on the experience (observational reflection) (Kolb, 1984). A phased approach like this may be helpful when designing an academia-industry partnership where students are seeking to develop relevant IS skills as summarized in the previous section. Social learning theory offers another relevant theory which values observation and behavior modeling and suggests mentoring can play an important role in the knowledge transfer and behavioral skills development of students (McLeod & Rao, 2004). This theory can be particularly relevant when designing academia-industry partnerships where students have the opportunity to learn from a formal mentor.

3. DIGITAL-READY MENTORSHIP PROGRAM DESIGN AND TEACHING APPROACH

3.1 Program Design

To address the goal of developing digitally proficient students and talent, we developed a digital-ready mentorship program to connect students with industry as a part of their undergraduate education. The program was designed to allow academic and organizational leaders to collaborate in the preparation of IT graduates to be workforce-ready upon graduation. The key objectives of the program are to:

- Allow for students to master domain knowledge in IT as well as develop their communication, collaboration, and critical-thinking skills.
- Encourage collaboration between students, faculty, and employers from the beginning of a student's academic career.
- Expose students to challenges and opportunities in an organization while creating a professional pathway for students.

The program was designed to begin in the fall of the student's freshman year. Shortly after the fall term begins, interested freshman, majoring in technology-related programs (information systems, business analytics, computer science, etc.) are encouraged to apply for program consideration. As a part of the application, students submit their resume as well as a brief document outlining: 1) what makes them stand out among their peers, 2) areas of interest, and 3) how the program will be helpful for the future. Applications are reviewed by a small team of professors and organizational leaders. The number of students accepted is determined by the industry partner. Selected students are notified before the end of the fall semester.

The admitted students are invited into a 1-credit-hour course during the next three consecutive semesters (freshman spring, sophomore fall and spring) for a total of three credits. In the first year of the program, the industry partner assigns a mentor to each student that is loosely tied to the student's major and interests. In the second year, students work on a small technology project in the fall and a larger independent study project in the spring. Each semester, the collaboration is evaluated for continuation based on the interest of both students and the organization. A successful student and industry engagement might result in paid internship opportunities and ultimately a full-time position upon graduation. The full timeline of the program is summarized in Figure 1.

From the student perspective, this opportunity gives students a chance to learn from the real world and stand out among their peers. From the university perspective, this program provides an immersive experience for students with an industry leader, as early as the freshman year, allowing students to receive mentoring from a professional in the IT industry early in their careers to help shape, inform, and contextualize their education. From the industry perspective, this program provides a path for organizational leaders to lead in the cultivation of local talent and the next generation of technology leaders. Additionally, the organizational partner benefits by providing a leadership development opportunity to employees who serve as mentors. In fact, research has suggested that mentoring can lead to bi-directional growth benefiting both mentees and mentors (Neely et al., 2017).

3.2 Industry Partner Identification and Commitment

The idea for this program originated when a local organization approached faculty about the desire to recruit, and help develop, technology-oriented students at an earlier stage of their academic career. Because competition to recruit top talent is fierce, many students already have internships lined up by their junior year. By recruiting students into a mentorship program during their freshman year, the hope for this organization was to build a pipeline of talented students with an established relationship and interest in a paid internship position within the organization. In order to launch such a program, some planning and collaboration were needed. Initial planning meetings were held with a couple of faculty members representing different university technology programs and three employees from the industry partner, including the Chief Information Officer, and Human Resources Coordinator, and an administrative assistant. During the early planning stages, this group discussed how students would apply, the goals and structures of the program, timeline, faculty involvement, mentor responsibilities, and how many students would be accepted each year. It was also decided to start a new cohort of students each year to create a continuous pipeline. Ultimately, the industry partner was hoping this collaboration would result in one or two permanent hires from each graduating class. While there are not any financial costs associated with the establishment of this partnership, the industry partner did invest a fair amount of time into the initial establishment of the mentorship program.

Throughout the duration of the program, students meet regularly with their mentor to discuss technology projects, experience workplace culture and facility tours, engage in professional networking, and attend workshops. Thus, the student learning experience involves a necessary commitment from the industry partner. While the organization does not specifically give time to the university, the organization does allocate some time to manage the partnership and oversee/manage the mentor's experience. Thus, it is worth noting that the time spent to establish and maintain the program as well as the mentoring time spent was viewed by the employer as part of their mission to give back and to support their community.

A secondary goal of this industry partner was the outreach opportunity for their employees and the leadership skills development that mentoring could provide. Research has suggested that executives and organizational leaders want to encourage their employees to connect outside of the office and within the community as a way to develop their organizational diversity and ability to work in complex teams (Mitchell, 2020). Research also suggests that career development is an important tool that can help with retention of employees (Pflügler et al., 2018). This academic-industry partnership was designed to create outreach and leadership development opportunities for the employees involved. Ultimately, the organization values this program as a talent-development and recruiting tool as well as a skills-development exercise for their current employees seeking to grow their leadership skills. Other universities looking to identify possible industry partners for this type of project can emphasize such benefits as additional reasons to work together.

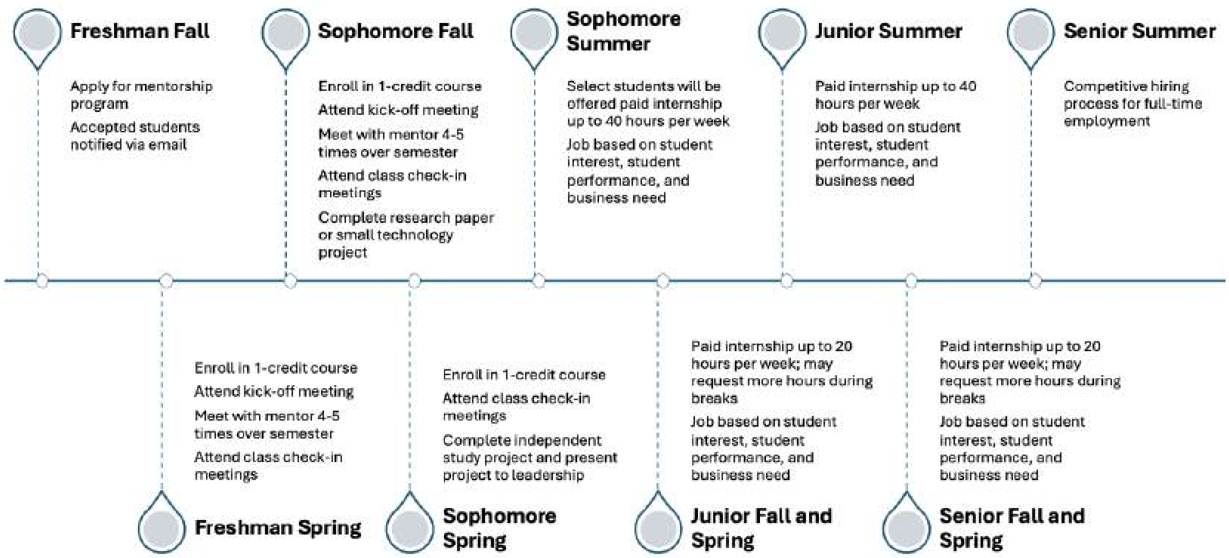

Figure 1. Digital-Ready Mentorship Program Timeline

3.3 Course Management

Students accepted into this program are enrolled in a one-credit course during the spring semester of their freshman year and during the fall and spring semesters of their sophomore year for a total of three credits. Each semester, the course is structured as a pass/fail course. Students can choose to take the course for no credit if it were to have a negative financial impact (e.g., if the one credit hour will put the student over the maximum allowed credit hours in a semester). The course requirements include a kickoff meeting at the start of the semester, monthly class meetings with the instructor, one-on-one meetings with assigned mentors, a research paper, and an individual study project. Table 1 includes an outline of the course requirements and the related timing. Students who meet all stated requirements for the semester receive credit for the course. Students who fail to meet all stated requirements will not receive credit for the course, and program continuation will be evaluated by the faculty and industry partner.

Each semester begins with a kick-off meeting including participating faculty, industry and academic leaders, students, and mentors. The kick-off meeting is attended by university and industry partner leadership to acknowledge the value of this partnership, and it gives the students the opportunity to meet with their mentors. This meeting has been held in person giving the full group the opportunity to socialize and take pictures. In other semesters, this meeting has been held as a virtual meeting with the full group in the main room and then breakout rooms used for one-on-one mentor and mentee discussions. Both formats have been successful.

Along with the kick-off meeting, regular class meetings are a part of this course. Students meet with their instructor during the first week of each semester. During this meeting, the instructor discusses the course requirements and notifies the students of all required meeting dates and assignments. Time is allowed for general questions. Subsequent class meetings are held for one hour each month during the semester. The primary purpose of these meetings is to check-in with students to ensure everything is going okay and to ensure students are on track to meet their course requirements. For each meeting, class time is used to touch-base regarding mentorship progress successes and challenges, and students are able to share their experiences with one another, brainstorm discussion questions, answer questions, or discuss upcoming events. Students are encouraged to reach out to the instructor if any scheduling issues or conflicts arise, but the class-time discussions can also help bring any issues or challenges to light so the faculty and industry partner can proactively address them. A more detailed description of the class, learning objectives, and grading criteria are included in Appendix A

Because a new cohort of students is recruited each fall, there are typically two cohorts of students enrolled in the 1-credit course during the spring semester (i.e., the new first year students and the returning sophomore students). When there are multiple cohorts of students, all cohorts meet together for the monthly class meetings. This allows the first-year students to hear what the second-year students are working on and allows the two groups to collaborate and learn from one another. From the faculty perspective, this means faculty are recruiting a new cohort (first-year students) and teaching a cohort (second-year students) in the fall semester and faculty are teaching two cohorts (first-year and second-year students) in the spring. A learning management system (LMS) is used to help organize and facilitate the courses and all of the students from the program are put into the same course utilizing the groups feature within the LMS to manage the course content for each respective cohort. Figure 2 shows the LMS materials by group.

Along with the regular class meetings, students are required to meet with their assigned mentors. As a part of the course requirements, students must meet with their mentor a minimum of five times for an hour each time. The initial kick-off meeting does count as one meeting. Students are responsible for scheduling their mentor meetings and submitting a meeting summary in the class LMS. Students can meet with their mentors on campus, at the mentor's office, an offsite location (e.g., coffee shop), or hold a virtual meeting. Appendix B includes a list of possible discussion topics to help organize the meeting time.

Requirements	Description	Timing
Kickoff meetings	• Kickoff meeting includes participating faculty, industry and academic leaders, students, and mentors • Meeting is held in spring for newly accepted freshmen to meet their mentor; another kickoff meeting is held in fall to reconvene the sophomores and their mentors • Some semesters meetings have been held in person; other semesters virtual meetings have worked with the full group and then breakout rooms for one-on-one discussions	Freshman spring Sophomore fall
Class meetings	• Students meet as a group, with the instructor, to discuss course requirements and expectations • Sessions are used to touch-base regarding mentorship progress successes and challenges, share experiences with one another, brainstorm discussion questions, answer questions, discuss upcoming events, etc. • Class is worth 1 credit hour; objectives and grading criteria are included in Appendix A	Freshman spring Sophomore fall Sophomore spring
Mentor meetings	• Students meet with their mentor a minimum of five times (1 hour each); kickoff meetings count as one meeting • Students are responsible for scheduling these meetings • Students submit a meeting summary in class LMS • Possible discussion topics are included in Appendix B	Freshman spring Sophomore fall Sophomore spring is optional
Research paper or small project	• Students select a technology topic of their choice and complete a 3-5-page research paper or work on a small project • Students are encouraged to select a topic related to their field or something they learned about during their mentorship (new technologies, methodologies, software, data analysis, website, etc.)	Sophomore fall
Independent study project	• Students select and conduct an independent study project (see Appendix C for possibilities) • At the end of the semester, students present a 5-10-minute summary to industry leadership • Project and presentation are considered part of the paid internship interview process	Sophomore spring

Table 1. Required Coursework Description and Timing

In the second year of the program, students continue to meet with their mentor in the fall, but they also get to work on a research paper or small project that is shared with both the faculty member and the student's mentor. Students get to individually select a research paper topic (specific hardware or software, systems development methodologies, cybersecurity, current trends, ethical considerations, etc.) or a technology-focused project (coding project, website, database project, online portfolio, etc.) to work on. At the midpoint of the semester, students submit a short mid-semester update (i.e., project idea and progress) in the class LMS; at the end of the semester, students submit their completed project. While the course is graded pass/fail, projects are evaluated by both the faculty and the mentor and can play a factor in determining whether the student will continue in the program for the next semester.

In the spring of the sophomore year, students no longer have formal meetings with their mentor, but instead they expand on the work from the prior semester and complete an independent, technology-focused project (research project, white paper, website, app design, data dashboard, etc.) from a list of provided project topics. Possible ideas for this project are included in Appendix C. At the midpoint of the semester, students will submit a short mid-semester update (e.g., project idea, progress, and update with mentor meetings) in the class LMS. At the end of the semester, students will submit their final project in the class LMS, in a format that is appropriate for the task undertaken (website, paper, etc.). Additionally, at the end of this semester, students present their independent study work in a 5-10-minute presentation to industry leadership. Student presentations provide an opportunity for students to showcase their skills and practice presenting to a large audience in a professional setting. The presentation serves as the class requirement for the mentorship program and an element of the selection process for the paid internship positions, should they choose to apply. In addition to their technical skills, the project also gives students the opportunity to improve their skills in decisiveness, conceptual thinking, and innovation. The presentation audience includes program faculty, students, mentors, mentees, and industry leadership. Each student is allowed 5-7 minutes to present their project and another 3-4 minutes for audience questions. The question-and-answer portion is a useful opportunity for students to practice their soft skills in the areas of verbal communication, business acumen, accountability, and adaptability. The project and presentation are considered part of the paid internship interview process. While the digital-ready mentorship program timeline does continue past this point (see Figure 1), this project concludes the graded course portion of the experience.

4. EVIDENCE, LESSONS LEARNED, AND RECOMMENDATIONS FOR IS CURRICULA

4.1 Project Implementation

The digital-ready mentorship program outlined above has been in place since fall 2019 and has successfully facilitated a total of 50 students across five cohorts. Table 2 presents the participant information over the past five years.

To recruit the initial cohort of students, university faculty worked with the industry partner to create a video with testimonials from faculty, industry leaders, and employees at the organization who were university alums. The video and a program summary flyer were shared with all freshmen in a business introduction course as well as the introduction to programming course to recruit interested students. This information was also promoted in university emails and newsletters. As the program progressed, testimonials from student participants of the program were included in the recruitment materials. Each semester interested students are referred to university career services to help with their resume and application letters.

Along with the formal mentor-mentee relationships that have come from this program, students have completed paper and project work. For example, students have produced research papers on the impact of generative AI on industry, the conception and implementation of an electronics engineering lab, and other topics. Student project work has resulted in the development of a dashboard to analyze the impact of COVID-19 on an industry, the development of program code to integrate an AI chatbot on a website to answer general inquiry questions, a regression analysis of a dataset, and more. Each spring, second-year students have presented this work to approximately 65 technology leaders in the organization as a part of the program showcase. The feedback from this showcase has been positive overall.

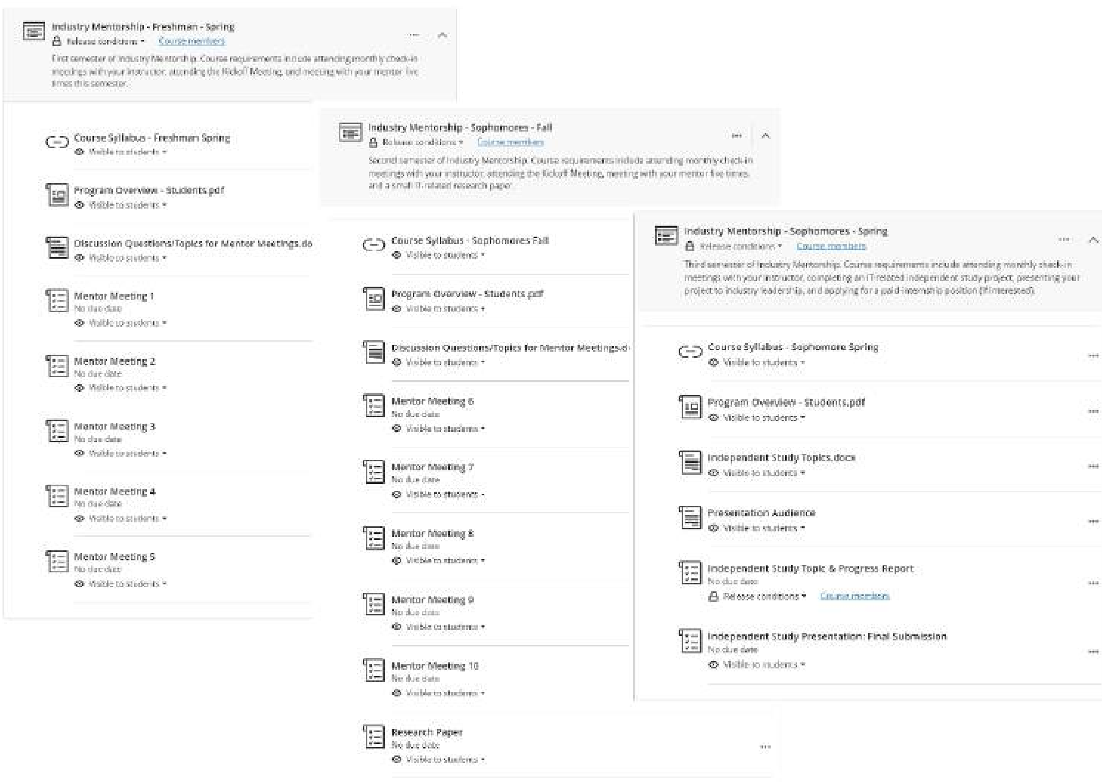

Figure 2. Screenshot of Learning Management System Course Materials by Semester

Variable	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
# of First-Year Students	11	13	8	10	8
Gender	M (73%) F (27%)	M (69%) F (31%)	M (100%) F (0%)	M (80%) F (20%)	M (75%) F (25%)
Major categories	Business (9%) Computer Science (91%)	Business (31%) Computer Science (69%)	Business (13%) Computer Science (87%)	Business (20%) Computer Science (80%)	Business (25%) Computer Science (75%)
# of Mentors	11	13	8	10	8

Table 2. Digital-Ready Mentorship Participants

Table 2 includes the number of mentors that have participated in this partnership. In general, the mentors are professionals from the IT department who represent a variety of roles and levels including, but not limited to, Associate and Lead IT Solutions Developers, Platform Engineers, Security Architects and Engineers, Project and Program Managers, Quality Engineers, Business Analysts, and User Experience Designers. The organizational partner does offer this opportunity to junior- and senior-level employees and there are some regular mentors year after year, suggesting that the mentors find their program participation valuable.

While there have been multiple faculty involved in the establishment and coordination of this partnership, the course instruction has been handled by one faculty member each semester. While the course instructor is the primary contact, other faculty members do participate in an annual meeting with the industry partner to discuss program plans and requirements, student recruitment, and any other issues that need to be discussed. Typically, the primary faculty member takes the lead managing this relationship unless there is a change in teaching faculty (which there was after the first couple of years). It is important that the faculty member is attentive to the industry partner in order to maintain a positive working relationship. Teaching the digital-ready course counts as a regular course from the faculty perspective, however managing this program does cost a fair amount of time from the instructor perspective and does count as an outreach activity for the faculty member responsible for managing the relationship with the industry partner.

At this point, each cohort of students has resulted in an average of six-to-eight students selected for paid internships. Additionally, with two cohorts completing the full four-year program, there have been two students given full-time job offers post-graduation. This is an important outcome of the partnership as the industry partner was hoping this collaboration would result in one or two permanent hires from each graduating class.

4.2 Mentor Feedback and Lessons Learned

Along with the participant information summarized above, data has been collected from both the mentors and the students in the program. Feedback from mentors has been captured through employee surveys regarding student engagement, interaction, follow-through, and readiness for future employment. In fact, the industry partner in this project created a dashboard for each mentor/mentee pairing to track student and mentee meetings, discussion topic categories, rankings for each student regarding their readiness for an internship or job and interaction level as well as qualitative comments in each area. The majority of qualitative comments from the mentors have been positive, summarizing the professionalism and the development of the mentor-mentee relationship. For example, one mentor summarized their first meeting with the comment: "*[We] used this meeting as more of an ice breaker and get-to-know-you session. [Student] has opened up and we have started to have a great dialog. He is unsure what exactly he wants to get out of the program, however, he understood he wanted to get in as it is a once-in-a-lifetime sort of experience. He is super ambitions, however, still figuring everything out. That is to be expected in the freshman year of college.*" Students are in charge of setting up the meetings with their mentors and submitting summaries of each meeting. An important lesson learned is that mentor feedback also needs to be collected from the employee perspective. The mentor feedback not only helps to highlight student successes and challenges, but it is also important for the leadership development of the employee which is a key benefit of this partnership.

As already noted, the majority of qualitative feedback from the mentors suggests that the mentor-mentee relationships were successful. In fact, one mentor noted that they were quite happy with the mentee they were assigned, commenting: "*[Student] asked a number of great questions and expressed much interest in my role and the initiatives in which I am involved. We share a similar background ... feels like a great match, thus far.*" Other mentors documented similar meeting summaries commenting one mentee was: "*always curious about new technology and how to make things better - continues to lean in*" and other was: "*great at asking for feedback, and seems always interested in learning!*" While most of the mentor-mentee matches have been successful, there was one case when the fit was not ideal, and a student wanted to be partnered with a new mentor as they moved through the program. In this situation, the student opted to switch mentors between the freshman spring semester and the sophomore fall semester. The lesson learned from this situation is to give both mentors and students an option to try out a new partner if they are interested in doing so.

Due to the multi-term design of this program, such a program does require a moderate amount of communication between the industry partner and the facilitating faculty. In our experience, we do bring key leaders together annually to assess how things are going and to determine if any changes need to be made. Along with this annual review, there is also a moderate time commitment needed from the industry partner for planning, mentor recruitment, the gathering of mentor feedback, and connecting with the primary faculty member. In this case, the industry partner has designated one individual as the primary contact and this person works with the faculty member to maintain regular communication and updates.

Not only is communication a key lesson learned, but flexibility is also important for this program to be successful. As Table 2 shows, the first semester of this initiative coincided with COVID-19 and required everyone to adapt. Fortunately, the program kick-off was in January 2020 and mentors and students were able to have a few meetings before the pandemic really impacted this program. Ultimately, the program was able to shift to virtual meetings and the program ended up being okay as relationships were already on their way before the pandemic required virtual meetings. Of course, there is research on online mentoring, in addition to traditional mentoring, suggesting there can be value from both formats (Neely et al., 2017). As the program has progressed, the class, students, and mentors have all benefited from hybrid collaboration opportunities and the flexibility of holding meetings both in person and virtual as needed.

A final lesson learned from the employer and mentor side is the importance of promoting this opportunity. Research suggests mentoring can lead to bi-directional growth that benefits the mentees as well as the mentors (Neely et al., 2017). Therefore, it is important to recruit, recognize, and reward the mentors who participate in this program too. As a part of this program, the industry partner did use press releases to recognize the mentors who participated. Of course, recognizing mentors for their community engagement and giving them props or acknowledgement for doing this work is a good way to encourage more interest and participation.

4.3 Student Feedback and Lessons Learned

Along with the mentor feedback, qualitative comments have been gathered from student surveys. The feedback from students suggests this program offers an educational benefit for students. In fact, multiple students appreciate the connection to industry and the network development opportunity suggesting that students really do benefit from this experience. Comments from students have noted: "*Through the [digital-ready mentorship] program, I have been able to grow my network in [city] and make meaningful connections with industry professionals who want me to succeed.*" "*The [digital-ready mentorship] has allowed me to establish a connection with a person that is well respected in their field. I would not have had this opportunity without the [digital-ready mentorship]. The ability to meet with a person who has been in a similar position as yourself and can offer advice on what they wish they had done is immensely helpful. The program presents a unique opportunity to discuss what life is like after graduation and offers another means of developing as a student and professionally.*"

While students do learn from their mentors, they also learn from one another as a part of this experience. The class meetings allow students to share their mentor-mentee experiences, ultimately revealing another important lesson and the value of having the classes come together in person to learn from one another and share. In fact, the previous section highlighted a case where the mentee-mentor fit was not ideal. Part of the way this awareness came to light was from the students sharing their experiences in class. Ultimately, when the student was given the opportunity to switch to a new mentor, they knew who they wanted to be partnered with because they had heard of good experiences from a friend in class who had a specific mentor they wanted to learn from and connect with.

Students in this program are not only benefiting from the mentor and classroom connections, but they are able to recognize the value the program can add for learning more about career preparation and readiness, ultimately helping them to be more prepared for their career. Student comments include: "*Through the [digital-ready mentorship], I've gained both an insight into [organization] as a company and a mentor who has helped me work through the challenges of navigating a career path.*" "*From my time in the [digital-ready mentorship], I have had the benefit of guidance from professionals working in my field. The advice and expertise have proven invaluable so far, and I look forward to utilizing them more in the future. Participating in this program has given me an edge over my peers as I go into the work force.*"

Of course, this benefit only emerges for students who are active participants engaged in the program. Student engagement and good communication with the class instructor and mentor is an important lesson for this project to be a good experience. Unfortunately, over the last five years there have been a couple of students who did not prioritize clear communication and who became non-responsive to messages from the instructor and the partner organization. In one example, a student was asked to schedule an interview for the paid internship via phone calls and emails, but he never replied. In this case, the student communicated that the phone calls and emails were treated as spam, but this communication was after the interview deadline, and in the end, he was disappointed that he did not receive a paid internship offer. The lesson in this case is to make sure that students know when employer communication is expected and communicate appropriately.

Not only are students gaining value from the networking and relationships that are formed through this program, but they are also getting independent research and project experience that they are able to learn from and showcase. As noted earlier, students are producing research papers and dashboard, coding, and other projects as a part of this program experience. They are also given the opportunity to showcase this work to a large group of technology workers. The presentation portion of this program is a valuable opportunity for students to develop their digital workforce competencies required to be successful in the IT workforce (Petter et al., 2018). This program offers the chance to take their studies and classroom work and share it with a practical audience.

Students overwhelmingly recommend this program to continue in the future and encourage others to take advantage of this opportunity. Specific comments include: "*The [digital-ready mentorship] has helped me grow professionally through the interactions and experiences I've had so far. To anyone thinking about applying to the [digital-ready mentorship], I would say go for it! You've nothing to lose, but a lot to gain.*" "*Just do it. There is nothing to lose and a lot to gain. This is a great learning opportunity if you have little or no experience. Through your mentor, you can ask all sorts of questions, like what it's like to work in the real world or what you should do to get internships. Overall, it will be very beneficial for your professional and personal growth.*"

A final lesson learned suggests it may be worth considering a shorter, structured program in the future. For example, faculty could consider developing a program in which students are recruited in the fall semester of their sophomore year, rather than their freshman year, and participate in a mentorship program during the following spring semester. A one-on-one mentorship requirement would still be beneficial, but instead of papers and projects, another idea would be to use the monthly class sessions for industry workshops (overview of industry, overview of digital teams and initiatives, corporate culture, tech-related projects and methodologies, skills preparation, etc.). A program that starts slightly later might offer a more flexible way to accommodate transfer students or students who want to graduate early.

5. DISCUSSION AND CONCLUSION

The objective of this work is to present a digital-ready mentorship program designed to connect students with industry for technology mentorship to develop the future technology workforce and to determine what program outcomes and value can be achieved from such a program. In this teaching tip, we presented the digital-ready mentorship program developed at our university, teaching approach, lessons learned, and evidence from the project outcomes and learning experience. This program has been in place for five years and successfully admitted 50 students. Ultimately, this work addresses the call for more attention to the evaluation of professional mentoring in IS and technology programs and can contribute to our understanding of student knowledge and skills in relation to the IT profession (Bagley & Shaffer, 2015; Chauncey & Cukier, 2004; Joers et al., 2024; McLeod & Rao, 2004; Saltz et al., 2013).

This program we have shared has proven to be a very valuable experience for students – both those who participate in the mentorship only as well as those who go on to participate in the paid internship experience. Students are given a rare experience, from the early stages of their academic career, to gain first-hand experience and networking in their chosen field. Additionally, the industry partner has found value in this program for both the employees who participate in the program and the students who find placement in the organization upon graduation. From a research perspective, future studies should consider a longitudinal analysis on the impact of this type of mentorship program and intervention. In particular, it would be interesting to learn how such a program can influence student major choices, internship experiences, and ultimately job placement following such an experience.

In conclusion, the program presented in this teaching tip provides an example for IS educators to consider as they seek to engage their academic programs with industry for the preparation of students and the future technology workforce. We hope sharing this program will inspire other universities to develop similar programs with industry partners and ultimately address the IT labor shortage.

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AUTHOR BIOGRAPHIES

Danielle Edwards is an assistant professor of practice of information systems in the Zimpleman College of Business at Drake University in Des Moines, IA. Danielle worked in the fields of business, IS, and education for over 20 years. She began her career at ITAGroup as an IT trainer and systems coordinator and later served at Wellmark BlueCross BlueShield as a help desk specialist and an applications developer. Prior to joining the Zimpleman College of Business, Danielle was a full-time faculty member at AIB College of Business where she co-developed a program to teach voice captioning, the first program of its kind in the country. She later served as an assistant dean of online education where she was instrumental in advancing online programs for the college. She has worked in the field of closed captioning and has trained dozens of captioners in her independent business. At Drake, she teaches a range of IS courses combining her professional expertise with a passion for student success.

Alanah Mitchell is the Associate Dean of Academic Affairs and Aliber Distinguished Professor of information systems in the Zimpleman College of Business at Drake University. She is an AIS Distinguished Member Cum Laude and a member of the ACM. Professor Mitchell's research focuses on the design, implementation, and use of information and communication technologies for collaboration, specifically in global virtual teams. Additionally, she researches in areas of e-commerce and information systems pedagogy. She has published in journals such as *Communications of the Association for Information Systems*, *The Data Base for Advances in Information Systems*, *Electronic Markets*, *Information Technology and People*, *Journal of the Association for Information Systems*, *Organizational Dynamics*, among others.

APPENDICES

Appendix A. Syllabus Items

Catalog Description:
This course is for students admitted to a digital proficiency project. Students will meet regularly with the faculty member as well as their project cohort to determine appropriate assignments. Course I graded on a credit/no credit basis. Prerequisites: Program acceptance. Credit hours: 0-1.

Course Description:
Students enrolled in this course are participants in a university and industry internship partnership. Students (mentees) will be paired with an industry employee (mentor). Each mentee will be required to meet one-on-one with their professional mentor approximately twice each month during their freshman spring and sophomore fall semesters (for a total of approximately 10 meetings). In the sophomore year, students will complete two technology projects.

Course Learning Objectives:
At the end of this course, students that have taken an active part should:
- develop the ability to connect and maintain professional relationships.
- develop the ability to work with others effectively, both individually with a mentor and with others in class.
- develop professional communication skills to/from mentors, the professor, and peers.
- develop a plan for post-graduation employment.
- complete two projects that demonstrate technology proficiency.
- demonstrate ability to document course objectives per course requirements.

Course Requirements/Deliverables:
Accepted students can potentially enroll in this 1 credit hour course at three points: spring semester of their freshman year, fall semester of their sophomore year, and spring semester of their sophomore year. The requirements and deliverables for each semester vary and are summarized below:

Freshman Spring Semester:
- Students will attend a kickoff meeting in the first week of the semester. This counts as one mentor meeting.
- Students will meet with their mentor a minimum of five times during the semester.
- For each mentor meeting, students will post a summary in class LMS including meeting date and discussion summary.

Sophomores Fall Semester:
- Students will attend a kickoff meeting the first week of the semester. This counts as one mentor meeting.
- Students will meet with their mentor a minimum of five times during the semester.
- For each mentor meeting, students will post a summary in class LMS including meeting date and discussion summary.
- Students will select a technology related topic of their interest and complete a research paper or small project. Ideas include a 3-5-page research paper on a technology-related topic (specific hardware or software, systems development methodologies, cybersecurity, current trends, ethical considerations, etc.) or a technology-focused project (coding project, website, database project, online portfolio, etc.). At the midpoint of the semester, students will submit a short mid-semester update (project idea and progress) in class LMS and at the end of the semester, students will submit their completed project.

Sophomores Spring Semester:
- Students will select an independent, technology-focused project (research project, white paper, website, app design, data dashboard, etc.) from a list of provided project topics.
- At the midpoint of the semester, students will submit a short mid-semester update (project idea, progress, and update with mentor meetings) in class LMS.
- At the end of the semester, students will submit their final project in class LMS, in a format that is appropriate for the task undertaken (website, paper, etc.).
- Students interested in pursuing a paid internship must formally apply with the organization. Details will be provided with specific deadlines.
- Students interested in pursuing a paid internship must also present a summary of their project to organization leaders at the end of the semester. Presentations should be 5-10 minutes in length. This presentation is part of the interview process for the paid internship.

Grading Policy
The course is credit/no-credit. Students are required to attend each class meeting and submit all required assignments. Failure to submit required work will result in a no-credit grade.

Appendix B. Possible Questions for Mentors

Below is a list of questions and topics you can use when preparing for a meeting with your mentor. This is just intended to help you generate some ideas. You are welcome to ask other questions.

Mentor Specific:

How long have you worked with your employer and what roles have you been involved in?
What are the expectations or duties you have in your current role?
Where are you from? Where do you live currently?
What kind of education do you have and what were your favorite topics/subjects to study?
How did you get started working? Did you have an internship?
What made you choose this employer?
What are your hobbies or things you like to do when not at work?
What does a typical day/week look like for you?
What is an interesting or fun project that you have worked on?
Have there been challenges you faced at work or anything that you struggled with?
How do you handle the importance of salary vs. "other things"?
Ask mentor to introduce you to someone in your field.

Technology Related:

What programs, languages, platforms, or websites do you use?
How does the systems development lifecycle work at your employer?
How are projects managed and what is the normal project timeline or process like?
What testing is done on new projects?
Have you faced any cybersecurity challenges at work?
How does the technology department integrate with other departments?

Organizational Culture:

What does your company do? What is the competitive advantage?
What is the history of your company?
What is your work arrangement? In-office? Remote? Hybrid?
Do you feel comfortable in your workspace?
How do you handle work-life balance?
Request a tour of organization.
How do all the departments/teams work together to accomplish business goals?
What is the culture like at your organization? How is it maintained?
How would someone find and apply for a job at your organization?

Education and Job Preparation:

What skills are important?
Is experience outside of school and work valued (e.g., internships, study abroad, certifications)?
How do you stay current on best practices? Does your organization provide additional training?
What type of continuing education is required for your role? What do you participate in?
What advice would you give yourself when you were starting college?
Request a review of cover letter and resume.
What are some job search and interview tips?

Appendix C. Title of the Appendix Independent Study Topic Options

1. **A research/whitepaper/light thesis, 10 pages double-spaced, on a relevant technology topic**
    a. E.g., review of technology solutions in the market specific to industry
    b. E.g., pros/cons of companies adopting public cloud infrastructure to build solutions
    c. E.g., potential benefits/impacts of blockchain technology in the industry
    d. E.g., how would generative AI impact the industry, positively and/or negatively
    e. E.g., a review of major information security breaches in the industry in the past five years
2. **A data-oriented exercise, analysis, visualization, dashboard; leveraging public data source(s)**
    a. E.g., analysis of venture capital spending across industry
    b. E.g., industry trends in the United States
    c. E.g., training of large language models for industry-specific needs
3. **A prototype/demo/pilot software project, with working code that can convey a concept or idea of an app/website or software**
    a. E.g., chatbot to work with customers or employees, answer questions…etc.
    b. E.g., website to search for and industry resources
4. **Write a point/counterpoint paper, comparing and contrasting a technology advancement in the industry that has moral/ethical/societal concerns**
    a. E.g., AI, generative AI, technology-enabled or enhanced social media advertising
    b. E.g., government laws and regulations related to the industry
5. **Combine options from above**
    a. E.g., build a solution using visualization software (Tableau, PowerBI, etc.) for a data-analysis oriented problem leveraging public data
    b. E.g., create or use software that generates data (survey, tracking, etc.) and leverage data to do a data-oriented exercise and visualization of the result for analysis purposes

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ARTICLES FOR UTM SENATE MEMBERS

"Curriculum for Careers: Embedding Employability and Industry Relevance in Higher Education"

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Enhancing Graduate Employability: Inculcating Soft Skills into the Tertiary Institutions' Curriculum

Makhosazana Faith Vezi-Magigaba[1] & Reward Utete[2,*]

[1]Department of Business Management, Faculty of Commerce, Administration and Law, University of Zululand, Richards Bay, South Africa

[2]Department of Industrial Psychology and People Management, College of Business and Economics, University of Johannesburg, Auckland Park 2006, South Africa

*Correspondence: Department of Industrial Psychology and People Management, College of Business and Economics, University of Johannesburg, PO Box 524, Auckland Park 2006, South Africa. E-mail: rewardu@uj.ac.za ORCID: https://orcid.org/0000-0002-9086-1052

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Abstract

The perennial issue of graduate employability remains topical in today's turbulent labour market environment. Most graduates bear the brunt of unemployment especially in developing countries. Most qualifications offered by higher education institutions specifically focus on technical skills. With the unremitting demands of soft skills in the corporate world, there is a widespread concern and transcending need for the redesign of the curriculum to inculcate the soft skills. In dynamic environment, the tertiary institutions are required to produce highly competent graduates to bode well and meet the relentless demands of South African economy. An avalanche of diversification, globalisation, internationalisation of workplaces has a strong bearing on skill sets employees are expected to possess in South Africa. Against this backdrop, the study sought to investigate soft skills that can be inculcated into the South African's Tertiary Institutions curriculum to improve graduate employability. Using systematic review method, a total of 85 peer reviewed articles were considered as final studies for review to achieve the primary objective of this paper. From the content analysis, the findings revealed several soft skills. The paper also gave directions on how soft skills can be embedded into the university curricula to prepare graduates for the world of work.

Keywords: soft skills, generic skills, job audit, competencies, curriculum development, curriculum revision and graduate employability

1. Introduction

The overarching purpose of a higher education institution is not solely to educate students, but rather to provide a specialised educational environment that equips them with the necessary capabilities to pursue their chosen professions (Yawson & Yamoah, 2020). Nevertheless, there is a growing disparity between the soft skills that employers anticipate from graduates and the actual proficiency in soft skills possessed by these graduates (Yawson, Yamoah, Sarpong & Abban-Ampiah, 2020). Nevertheless, over and above technical skills, the employers seek to hire candidates with strong both technical and soft skills. The key two types of skills complement each other. Due to the globalisation, encroachment of multiculturism and recent emergence of COVID-19 pandemic, the skill sets required in the labour have dramatically transformed. On top of occupation specific knowledge, employers require soft skills to gain an edge over competitors in the industry. Although some graduates who excel in educational institutions may possess adequate hard skills to enter the corporate world, due to their lacklustre response to soft skills they often face challenges which throttles their ability to adapt to the corporate environment (Jelonek & Nitkiewicz, 2020). While hard skills may help individuals progress in organisations, the absence of soft skills create a climate of uncertainty in the business and often leads to their downfall. Soft skills are inadequate for the employer to gain good performance in the current cut-throat competitive environment. Since most organisations have recognised that regardless of the profession of the candidate, the requisite to fill the gap of soft skills is critical to achieve organisational goals, as well as attracting and retaining clients (Noah & Aziz, 2020). While hard skills are essential for specific job requirements, tertiary institutions tend to focus mainly on hard skills as graduation prerequisites. This leads to a lack of soft skills among graduates, which in turn hampers their employability (Cook, 2022). Hence, there is a need for soft skills to be integrated within the curriculum of tertiary institutions to address the issue of unemployability of graduates. There is an increasing significance of soft skills in various organisations. This emphasis on soft skills has been reinforced by Majid, Eapen, Aung and Oo (2019), who highlight that organisations place a great importance on these skills when evaluating potential employees.

Unfortunately, in South Africa academicians have not yet given full attention to the issue of soft skills despite the mounting disparity between the skills demanded by employers and the actual competencies acquired by recent graduates (Ohei & Brink, 2019; Ramnund-Mansingh & Reddy, 2021). Educational institutions, in their role as knowledge builders, bear a significant obligation to produce a proficient workforce that meets the demands of various industries. Universities are knowledge and learning production places which contribute to the provision of solutions to multi-dimensional and urgent challenges that affect workplaces. According to Daubney (2022), different from soft skills, hard skills need to be specifically aligned to the local employers' demands. In doing so, the soft skills are expected to align with indigenous knowledge and cultural capabilities. Okolie, Igwe, Nwosu, Eneje and Mlanga (2020) states that the soft skills have the likelihood of burgeoning the propensity of the graduate employability. The targeted soft skills are not only for employability but for upgrading the abilities of graduates to be productive at the workplace. Different from soft skills, all the expected hard skills are incorporated into the curriculum. It is critical that the curriculum remains current and relevant to improve the rates of graduate employment. This can be achieved when the higher education institutions identify the skills of industry and profession (Uddin, 2021). The improvement in the rates of graduate employment has the propensity to attract new students for the tertiary institution. For aligning with employability expected capabilities, the skill needs of the industry have to be inculcated in the curriculum. Although the employers appeared to be contented with discipline-specific skills and job-specific skills, there is mounting evidence that the graduates lack soft skills.

The improvement of skill development could potentially contribute to the achievement of various sustainable development goals (SDGs) 2030 which include the reduction of inequality (SDG 10), improvement of decent work and economic growth (SDG 8), end of hunger (SDG 2) and reduction of poverty (SDG 1) (Haywood, Funke, Audouin, Musvoto & Nahman, 2019). The impetus for this study is increasingly bolstered by the demands of employers and professional requirements of industry regulatory bodies. While specialists have taken a lead in the dialogue of soft skills, various learning disciplines have not yet embraced the issue of embedding them in the curriculum. The challenge is how the embedment can be accomplished (Pitan & Muller, 2020). By extending the inculcation of soft skills in the curriculum to all disciplines, the employability of graduates in different fields may increase. The curriculum changes are expected to be properly planned, organic and systematic so that all the internal stakeholders align with the curriculum (Shava, 2022; Khumalo & Utete, 2023). A proper engagement with academic staff responsible for teaching the curriculum is required for them to realise its relevance. This study makes a valuable contribution to the prevailing discourse in the field of higher education management by actively engaging students and provide them understanding of additional skills required to improve their employability. The primary aims of this study are to analyse the soft skills as a significant factor in determining employability of graduates, and to review the inculcation of soft skills in the curriculum. The objective of this study is to provide a conceptual framework for understanding the embedment of soft skills in the curriculum. Drawing on a national study, this paper interrogates curriculum development in relation to graduate employability skills. The objective of this paper is to demonstrate the heightened significance of embedding soft skills within an ever-evolving context.

1.1 Employability of Graduates in 21st Century

The contemporary era of digitalisation requires a versatile and critical thinking workforce. The ability to generate, innovate and effectively implement ideas is a fundamental expectation for those emerging from educational institutions (Pereira, Vilas-Boas & Rebelo, 2020). In South Africa, unemployment is a significant issue usually driven by factors like skill mismatches, a high proportion of unskilled labour and poor access to education. Soft skills are increasingly demanded by employers and are crucial predictors of employability in today's competitive labour market (Pitan & Muller, 2020). Despite the growing demand for competent employees, employers still struggle to fill vacancies due to the fact that most higher education graduates lack soft skills (Nabulsi, McNally & Khoury, 2021). The quality of graduates and their deficiency in soft skills, which are crucial in the contemporary labour market and vital for enhancing individual employability, constitutes a highly debated and contentious topic in the existing higher education management literature. Bridgstock, Grant-Iramu and McAlpine (2019) contend that students prioritise soft abilities in a manner that differs from employers' perspectives. It has been found that only 15% of an individual's employment prospects, job retention, and career advancement can be attributed to their hard skills, while the 85% of employment success is credited to soft skills (Yao & Tuliao, 2019). Academic institutions have a responsibility to prepare a competent workforce, but there is often an imbalance in the development of soft and hard skills. This involves understanding the industry's requirements while also recognising the limitations of educational institutions. In some cases, companies prioritise soft skills over hard skills. New graduates have been considered unemployable by employers due to their deficiency in the requisite job skills (Ferns, Dawson & Howitt, 2019). Consequently, this has led to an increased interest in exploring the relationship between employability and soft skills. Employers view soft skills as indispensable for employability and often criticise tertiary institutions for not adequately preparing graduates with the required competencies (Teng, Ma, Pahlevansharif & Turner, 2019).

1.2 The Concept of Employability

Employability relates to the likelihood of fresh graduates to be employed in the organisations (O'Shea, Bowyer & Ghalayini, 2022). The contemporary business landscape is characterised by a high degree of complexity, uncertainty and competitiveness owing to myriad of factors. Human capital is widely recognised as a critical asset for organisations across many sectors, exerting a significant influence on their performance and overall success. Fahimirad, Nair, Kotamjani, Mahdinezhad and Feng (2019) state that employers tend to prioritise the recruitment of individuals who not only possess technical knowledge and skills, but also those who demonstrate the strong soft skills. According to Abelha, Fernandes, Mesquita, Seabra & Ferreira-Oliveira (2020), there is an increasing body of evidence suggesting that soft skills possess comparable predictive power to technical and hard skills in terms of employability and earning potential. The provision of soft skills plays a crucial role in the readiness of graduates. Hence, there is a need for better alignment between graduates' perceived skills and employers' expectations.

Bierema (2019) indicates that individuals who are primarily recruited for their proficient technical abilities come to recognise the importance of acquiring essential soft skills in order to cultivate a productive, fulfilling and prosperous professional trajectory. Professionals are expected to possess a range of abilities in order to: engage in sound interactions with their colleagues; effectively convince and influence clients; negotiate with business partners; communicate with peers and superiors; collaborate and contribute to team efforts; and proficiently manage work problems (Misni, Mahmood & Jamil, 2020; Sifundza & Utete, 2023). Possessing strong technical skills may enable an individual to secure a desirable employment, whilst the possession of soft skills might facilitate the professional advancement prospects. According to Khan (2022), the effectiveness and value of hard skills relies on their level of integration with soft skills. Cotronei-Baird (2020) states that the possession of soft skills can significantly impact the quality of job performance and has the potential to improve superior outcomes for the employee. Soft skills emerge as the predominant competencies across almost all professions, even those inside intensive technical industry.

The acquisition of soft skills has consistently been recognised as a crucial factor in the pursuit of employment opportunities and sustaining a thriving organisation. In the current economic landscape, there has been a substantial change from a production-based economy to a service-driven economy (Mgaiwa, 2021). Consequently, there is an increased demand for individuals who have excellent soft skills. In addition, as a result of the phenomenon of globalisation, there has been an increased propensity for employees to engage in communication and collaboration with colleagues, clients, and business partners who possess varied cultural and societal origins (Bhatti, Alyahya, Alshiha, Qureshi, Juhari & Aldossary, 2023). In such circumstances, individuals who possess positive personal traits, attitudes, behaviour, and other soft skills would emerge as a valued resource for their respective organisations. However, a proper audit is required to detect potential discrepancies between labour market expectations and the skill levels displayed by potential employees. Mtawa, Fongwa and Wilson-Strydom (2021) states that it is advisable for employers to actively promote the development of soft skills among their entry-level employees by providing sponsorship for their participation in skill enhancement programmes.

1.3 Hard and Soft Skills

The term ‘specific competences’ pertains to hard skills, whereas ‘generic competences’ refers to soft skills (Noah & Aziz, 2020). Hard skills refer to the technical skills while soft skills relate to interpersonal and personal skills (Jelonek & Nitkiewicz, 2020). The predominant emphasis in educational institutions is placed on technical subjects, which raises the quest to provide the recognition and integration of soft skills. The technical or hard skills include the skills such as those acquired through courses in faculties of engineering, management science, humanities, arts, and similar fields which can be more defined and evaluated. According to Okolie, Nwajiuba, Binuomote, Ehiobuche, Igu and Ajoke (2020), within the field of humanities, soft skills are widely recognised as a significant determinant of employability. Soft skills are defined as behaviours expected by employers from employees when performing their assigned occupational work. For maintaining effective interactions and conducive work settings, employers look for employees with sound soft skills. Consequently, this promotes team-work. An effective team is an important asset to the employer as it facilitates collaboration and open discussion to deal with complex tasks, as well as general improvement in communication (Yawson et al., 2020). Subsequently, this improves overall productivity in the organisation. Soft skills are integral to accomplish the organisational objectives. Hence, enhancing employability greatly relies on soft skills development. Various sectors view soft skills as important to the success of the business because graduates are future organisational leaders to be involved in decision-making and leadership activities. Employers seek employees with strong soft skills to create a conducive work environment and facilitate effective interactions with customers and other relevant stakeholders (Vezi-Magigaba & Utete, 2023; Cook, 2022).

Daubney (2022) states that while several students excel in academic institutions have the technical abilities to secure positions in the labour market, they often face termination in few months of their employment because they lack soft skills. This hinders their ability to adapt to the corporate environment. Employees progress through levels of the organisations as a result of their proficiency in hard skills, whereas their lack of soft skills often leads to their downfall. These soft skills are alternatively referred to as people skills, life skills and interpersonal skills (Pitan & Muller, 2020). Hard skills include the fundamental abilities, specialised knowledge, and technical proficiencies that someone possess within a certain field or sector. Soft skills are a valuable complement to hard skills in the development of students into successful professionals.

1.4 The Concept of Curriculum Development and the Challenges Linked to Integrating the Soft Skills into the Curriculum

The term curriculum relates to the facilities, assessment methods, supporting material, teaching methodologies, learning activities and content (Daubney, 2022). Content denotes what the lecturer teaches. It is used interchangeably with terms such as idea, concepts, knowledge and subject matter. Curriculum design comprises problem-centred, learner-centred and subject-centred (Fagan, Cooper, Chatzifragkou & Bennett, 2020). Curriculum development refers to the ways in which various aspects contributes to the adjustments in classroom activities (Fagan, Cooper, Chatzifragkou & Bennett, 2020). The revision of the curriculum is not without controversy, one of the key challenges associated with the integration of soft skills into the curriculum is that they are difficult to measure. Due to their intangible nature, it is challenging to measure soft skills. However, hard skills can be observed and measured. In addition, in an endeavour to implement the revised curriculum, the tertiary institution incurs extra costs which can be unsustainable to them. Even though assessing soft skills is challenging, it is crucial for graduates to develop these skills before entering the world of work. Furthermore, lack of available information regarding the methodology employed in the studies supporting a purported compilation of soft skills renders such lists inherently unreliable. According to Yao and Tuliao (2019), there is a contention that the development of these soft skills enables students to effectively assimilate into the organisational culture, demonstrate proactive behaviour and make valuable contributions to the overall success of the organisation. The soft skills are deemed essential due to the increasing importance of teamwork, the accelerated pace of globalisation, the ability to engage in cross-cultural dialogue and the growing necessity to retain talent within organisations. The measurement and evaluation of soft talents present challenges when compared to hard skills (Ferns et al., 2019). However, employers typically show a preference for candidates who possess both soft and hard skill. As South African organisations grapple to recover from extensive COVID-19 pandemic ravage, there is a cumulative demand for fresh graduates in different fields. Despite efforts of some organisations to hire soft skills trainers to train fresh graduates, it is expensive in the face of current harsh economic realities hence poses unparalleled and unsustainable challenge for bulk of employers especially still growing organisations. For this reason, the curriculum become an instrumental site for sustainable skilling of graduates.

1.5 Theoretical Framework

This study is guided by the human capital theory. Based on the human capital theory, the presence of necessary skills in a graduate is essential for enhancing productivity which later brings economic advantages (Tan, 2014). The human capital theory proposes that educational accomplishment plays a crucial role in assessing the quality of human capital (Becker & Woessmann, 2009). Nevertheless, the transformations and difficulties encountered in the contemporary globalised economy necessitate the acquisition of both soft and hard skills. Therefore, it is evident that several organisations are advocating for the acquisition of soft skills due to their potential to improve competitiveness and facilitate growth. However, despite possessing a high degree of hard skills, such as technical knowledge and proficiency, graduates often lack these particular skills (Galiakberova, 2019). One prevalent and current subject of discussion in the areas of employment and unemployment pertains to the lack of soft skills which are necessary for an employee to effectively navigate the evolving landscape of labour market (Booth & Bryan, 2005). As a result, tertiary institutions are expected to prioritise the cultivation of skills of industry-ready graduates as a key institutional goal. This is driven by the thrust to adequately prepare future employees with the necessary skills. This study seeks to assess the revision of curriculum in relation to graduate skills necessary for them to succeed in the labour market post-graduation. The study proposes potential methods for impart graduate skills inside the university environment.

1.6 Research Question Formulation

PICo strategy was used to develop the research topic (Tawfik et al., 2019). PICo involves three important concepts, namely Population, Interest and Context, which assists the authors to develop a suitable research topic for review. In this study, PICo served as a foundation of the topic as follows: Population (Graduates); Soft skills into the Tertiary Institutions' Curriculum (Interest); and South Africa (Context). The three concepts played an integral role in formulating the main research question: What are the soft skills that can be inculcated into the South African's Tertiary Institutions curriculum to improve graduate employability?

2. Method

The study conducted a systematic review to answer the research questions with the focus on providing impartial interpretation and synthesis of the results. A systematic review entails the process of identifying, selecting and synthesising research studies to give a reliable and thorough representations of the topic being investigated (Crossan & Apaydin, 2010). Currently, there is little evidence that reveal results of content analysis of articles, reports and conferences can inform curriculum development. Hence this study adopts the qualitative systematic literature review and content analysis of peer-reviewed articles and reports to synthesise the employability skills. Then, areas of variance or agreement may be identified.

2.1 Search Strategy

The study performed comprehensive literature search adhering to PRISMA. Both manual and electronic searches were conducted from Scopus and Google scholar using search terms, which include "soft skills", "generic skills", "job audit", "capabilities", "competencies", "curriculum development", "curriculum revision", "curricular", "graduate employability" and "graduate trainee" were utilised as the key words. For finding the peer reviewed reports, conferences and articles, Scopus and Google scholar were used as electronic search database.

2.2 Screening

Through the identification procedure, 153 articles retrieved successfully and would undergo screening. The term screening refers to the process of establishing the exclusion or inclusion criteria (Page et al, 2021). Moreover, in this systematic literature review, the initial criteria used was based on the past ten years, from 2013-2023. The database search revealed number of publications related to graduate employability and soft skills in South Africa. For maintain quality, the reviews only focused on peer-reviewed articles in the form of journal articles. In addition, to minimise misunderstandings, the study only considered the articles published in English. The exclusion and inclusion criteria are shown in Table 1.

Table 1. Exclusion and Inclusion Criteria

Criteria	Exclusion	Inclusion
Year of Publication	Before 2013	Recent ten years (2013-2023)
Type of Publication	Not peer reviewed article	Peer-reviewed article
Type of language	Non-English	English

Articles based on reviews were excluded while peer-review articles were included. A total of 68 articles were eliminated as they did not meet the predetermined criteria, and 85 articles were left.

2.3 Data Extraction and Analysis

Excel spreadsheets were utilised to record: i) source of publications; and iii) year of publications. Two ways were utilised to analyse and synthesise the results: i) predominantly based on the sources cited; and ii) features underlying the constructs. The study adopts an extensive review of graduate employability and curriculum development. Content analysis was used to review employability skills from the final 85 articles considered in this study. Content analysis of peer-reviewed articles is an effective method that can be used to identify current soft skills required in different sectors. The revision of the curriculum is informed by reviewing articles related to graduate employability in which employers provide information regarding the soft skills required in various professions.

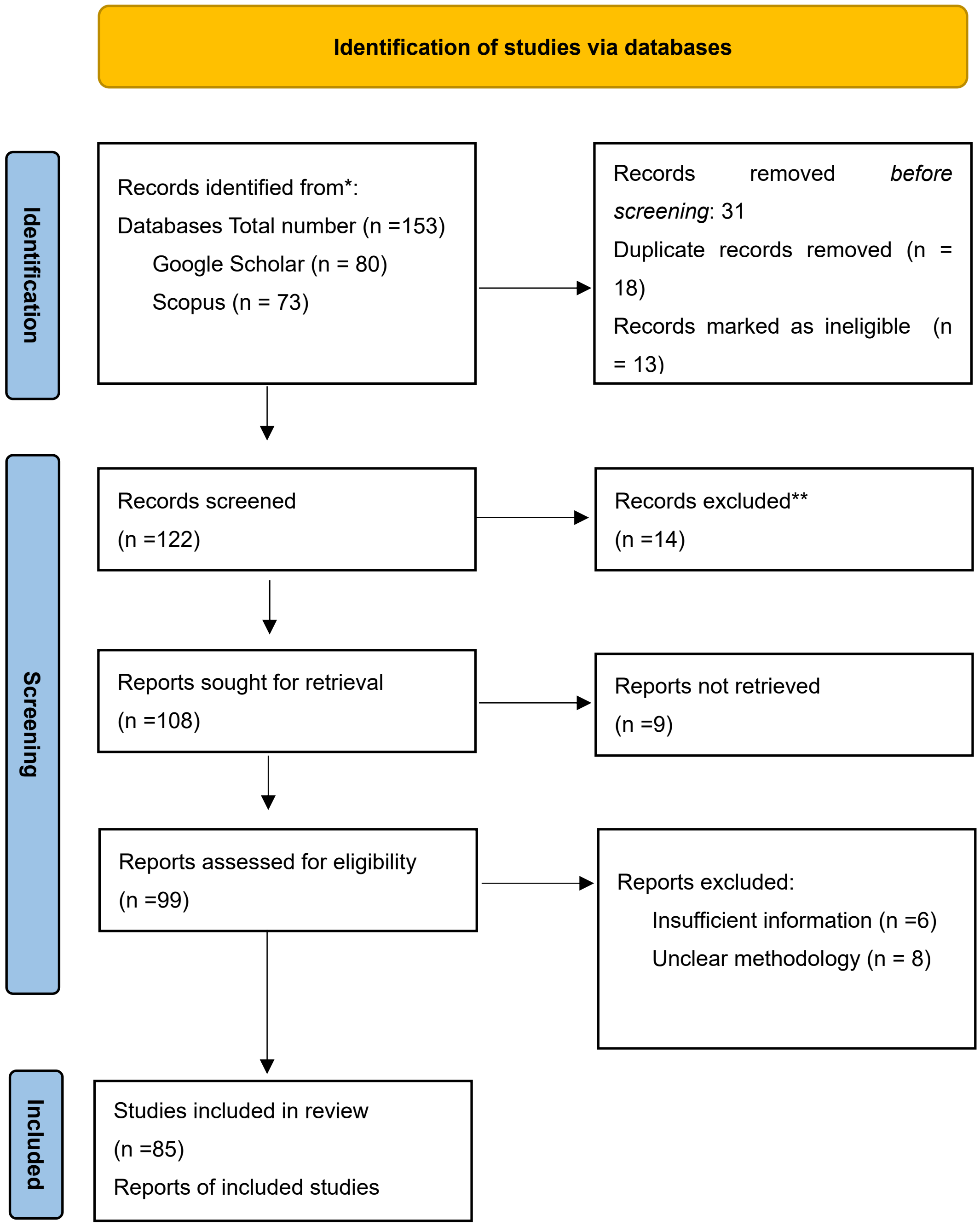

Figure 1. PRISMA

3. Results and Discussion

The findings revealed a mismatch between the competencies currently possessed by graduates and what employers expect (Yawson & Yamoah, 2020). Employers prioritises the ability to learn, problem-solving, and numeracy and quantitative literacy. The findings revealed that the majority of fresh graduates were not adequately equipped with the necessary soft skills. The study revealed that employers were particularly dissatisfied with written and oral communication, negotiation skills, and analytical and critical thinking abilities of their entry-level employees. Factors such as a poor confidence and lack of communication skills cause employers to be hesitant to hire fresh graduates. Yawson et al (2020) state that soft skills encompass the ability to effectively communicate, engage in problem-solving, demonstrate leadership qualities, exhibition of motivation, and collaborate efficiently within a team.

The prominence of soft skills, such as teamwork, communication, leadership, and critical thinking, in the hiring process is a result of various contributing factors (Jelonek & Nitkiewicz, 2020). When recruiting new employees, employers typically prioritise to select set of soft skills, such as creativity, leadership, critical thinking, communication, time management, teamwork, and problem-solving. However, the employability of an individual cannot be determined solely by a single criterion. Notably, Noah and Aziz (2020) emphasise the increasing demand for these skills among employers. Consequently, when organisations recruit new employees, the significance of these skills should be regarded on par with technical skills. The significance of these soft skills relies on recognition afforded to them as integral components of employability abilities. Familiarising oneself with the concept of each talent facilitates the acquisition process. The Table 2 shows the prominent soft skills emerged from analysis of literature. The authors were coded in this Table 2 and their citations were shown in Table 3.

Table 2. Data Codification

Primary soft skills	Authors coded in numeric
Learnability - Learnability skill	3; 8;11;12;13;14;16;18;24;25;27;35;36;42;45;50;51;61;70;71;74;83
Professionally ethical skill	8;12;18;24;25;35;36;41;42;50;56;61;74;81;83
Self-Awareness skills	2;8;9;11;12;14;15;16;17;18;20;24;25;26;29;33;35;36;38;41;42;43;44;45;48;50;51;52;56;62;66;67;69;70;71;72;74;77;80;81;82;83;85
Work-life balance skills	8;12; 24;25;35;36;42;50
Self-direction skills	2;8;9;12;13;14;15;16;17;18;20;24;25;26;35;36;37;41;42;44;45;47;48;50;51;52;56;62;64;65;66;67;69;70;71;72;74;77;80;85
Results orientation skills	8;10;12;15;17;18;24;35;36;37;41;48;50;51;56;60;61;62;65;66;83
Innovation skills	6;8;10;11;12;14;15;16;18;20;21;24;25;27;28;31;32;34;35;36;37;38;41;47;50;53;62;68;80;82;83;85
Creativity skills	1;8;10;11;12;14;15;16;18;20;21;23;24;25;26;27;30;34;35;36;37;39;41;46;48;49;50;52;56;61;62;64;66;68;71;74;75;80;82;83;85
Management skills	2;7;8;9;12;14;18;19;20;21;22;24;25;26;35;36;38;41;50;74;83
Decision-making skills	8;10;12;15;16;17;18;20;21;23;24;26;34;35;36;37;38;39;41;43;48;49;50;52;53;54;56;58;60;61;62;64;66;68;70;71;72;75;76;80;83;85
Customer/User orientation skills	7; 8;10;17;24;35;36;37;41;50;77;80;83
Continuous improvement skills	8;11;12;15;16;17;24;27;35;36;37;41;50;56;83;85
Analysis skills	4;8;12;14;15;18;20;21;24;25;26;34;35;36;37;38;41;43;50;56;62;66;67;75;80;83;85
Time management	2; 5;8;12;21;22;24;25;26;35;36;38;41;43;50;66;82;83;85
Monitoring motivation skills	8;11;12 ;15;16;18;19;20;21;23;24;25;29;35;36;38;42;44;45;50;62;64;77;82;83;85
Monitoring integrity skills	8;9;11;12;13;14;15;16;18;19;20;21;23;24;25;35;36;38;42;44;45;50;62;64;66;77;82;83;85
Monitoring attitude skills	8;10;11;12;14;15;16;18;19;20;21;23;24;25;35;36;38;41;42;44;45;50;62;64;77;82;83;85
Monitoring honesty skills	8;11;12;13;14;15;16;18;19;20;21;23;24;25;35;36;38;42;44;45;50;62;64;77;82;83;85
Monitoring trust skills	8;9;11;12;14;15;16;18;19;20;21;23;24;25;35;36;38;42;44;45;50;62;64;77;82;83;85
Adaptability to change skills	2;8;11;12;16;18;21;24;25;32;35;36;37;38;42;44;45;50;53;54;58;62;64;74;77;80;82;83;85
Culture adaptability skills	5;8;10;11;14;16;18;21;24;25;30;35;36;38;42;44;45;48;50;58;60;61;62;64;65;66;83;85
Conflict management & negotiation skills	7;8;12;14;16;17;18;19;20;22;24;25;35;36;38;41;42;44;50;62;64;65;70;73;74;82;83;84
Communication Skills	1;5;7;8;10;12;14;15;16;18;19;20;21;22;24;25;2628;31;33;34;35;36;37;38;40;

	41;42;43;44;45;50;52;54;56;58;61;62;63;64;65;66;67;68;69;70;73;74;76;77;78;79;81;82;83;84;85
Contact network skills	7;9;8;10;11;12;15;16;18;19;20;21;22;24;25;26;28;31;34;35;36;38;39;43;44;46;50;52;54;56;62;64;65;70;74;75;76;79;81;82;83;84;85
Team-work skills	2;5;8;10;11;12;14;15;16;18;19;20;21;22;24;25;28;33;35;36;37;39;44;50;51;52;54;56;62;64;65;66;67;69;70;71;73;74;75;76;79;79;80;81;82;83;85
Analytical skills	7;8;10;11;12;13;14;18;20;21;22;24;25;28;31;32;35;36;37;38;43;44;47;49;50;52;53;56;61;62;65;66;69;70;71;73;74;75;76;77;78;79;80;81;83;85
Leadership skills	2;4;8;10;11;12;17;18;19;20;21;22;24;25;26;31;35;36;37;38;39;40;46;47;50;54;55;56;59;62;63;65;70;74;80;81;83;85
Critical thinking skills	4;7;8;10;11;12;14;15;18;21;22;23;24;25;28;31;34;35;36;37;38;40;41;43;44;45;47;49;50;53;54;55;56;60;62;63;65;70;71;73;75;76;77;80;81;83;85
Problem solving skills	2;4;5;8;11;12;14;15;18;19;21;24;25;26;31;33;35;36;37;39;40;41;44;49;50;51;55;56;59;62;65;66;70;71;73;74;75;76;82;83

3.1 Embedding Soft Skills in the Curriculum

Despite a prevailing consensus and comprehension within the area of academia and industry recognising the significance of soft skills, a lack of mutual understanding appears to persist between employers and higher education institutions. It has been found that young fresh graduates usually fail to acquire an adequate repertoire of soft skills during their collegiate education (Cook, 2022). Soft skills are considered employability abilities by employers due to their importance in fostering positive relationships with colleagues and customers. The efficient utilisation of soft skills is crucial for an employee's job performance and career success (Majid et al., 2019). The provision of soft skills in final year students is crucial for securing employment opportunities. Employers often encounter the need to get ideas for courses pertaining to essential soft skills. These lessons are intended for employment-oriented programmes that cater to individuals at the intermediate to advanced levels of proficiency. Ramnund-Mansingh and Reddy (2021) state that essential competencies in the workplace encompass a range of soft skills, including effective communication, problem-solving abilities, collaborative cooperation, sound decision-making, strong leadership qualities, critical thinking aptitude, efficient time management, and innovative creativity. However, this study grouped the key dimensions of soft skills into five classes namely, managing career, managing tasks, managing enterprise or businesses, managing others and managing self. According to Pitan and Muller (2020), enhancing soft skills is a very beneficial endeavour for graduates to undertake in order to enhance their prospects for future job success. Figure 1 below show the key dimensions of soft skills.

The new curriculum can be infused with soft skills in which soft skill module become compulsory from final year. In this case all the soft skills are expected to be delivered. The content is expected to have the same standard of content across the twenty-six (26) universities such that basic employers' needs would be met irrespective of the institution the candidate is coming from.

3.2 Inculcating Soft Skills in the Curriculum in South Africa Tertiary Institutions

From the analysis of extant literature, the issue of graduate unemployment has been heightened by inadequate level of competency among graduates which mostly which fall far below employers' expectations (Daubney, 2022). Furthermore, it has been consistently reported by employers that graduates demonstrate poor communication skills, analytical skills and critical thinking (Okolie et al., 2020). The absence of soft skills has adverse consequences on various aspects of organisational performance, including staff conduct, safety measures, levels of engagement, and overall productivity. Firms are engaged in competition by leveraging the proficiency of their employees hence soft skills is of great significance (Uddin, 2021). Pereira, Vilas-Boas and Rebelo (2020) state that in the contemporary dynamic economic landscape, individuals who have completed their education at institutions of higher learning are incapable of satisfying the expectations and job-related prerequisites set out by employers.

For accurately managing the programs in a manner that reflects the labour market demands, the process of revising the curriculum is presented (Nabulsi, McNally & Khoury, 2021). As part of the process of revising the curriculum, the anticipated key dimensions of soft skills have been examined and these include managing career, managing tasks, managing enterprise or businesses, managing others and managing self. The curriculum development model (Figure 2) is utilised for guiding the process of revising the curriculum. The soft skills matrix from the analysis forms the base on which curriculum practitioners can use to revise the courses. This can increase the required graduates with soft skill to meet occupational demands. The re-evaluation and redesign of the curriculum is the responsibility of the educators. Figure 2 illustrates a model that can be utilised to revise the curriculum. The model encompasses current environment review and need assessment of the employers to help identify the critical soft skills (Bridgstock, Grant-Iramu & McAlpine, 2019). When the skills are identified, the resources available including equipment and faculty can be assessed.

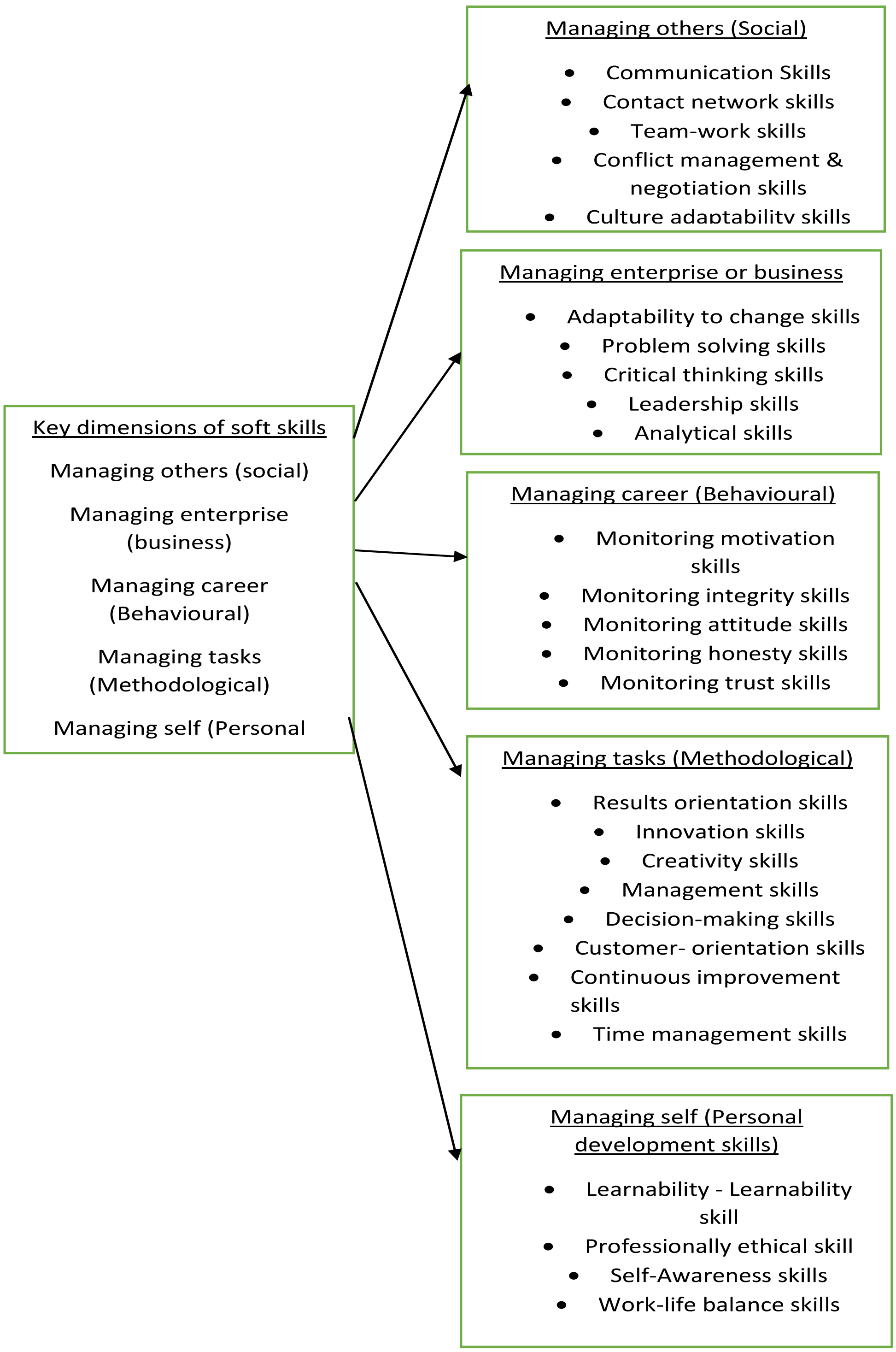

Figure 2. Key Dimensions of Soft Skills

Source: Researcher's analysis (2023)

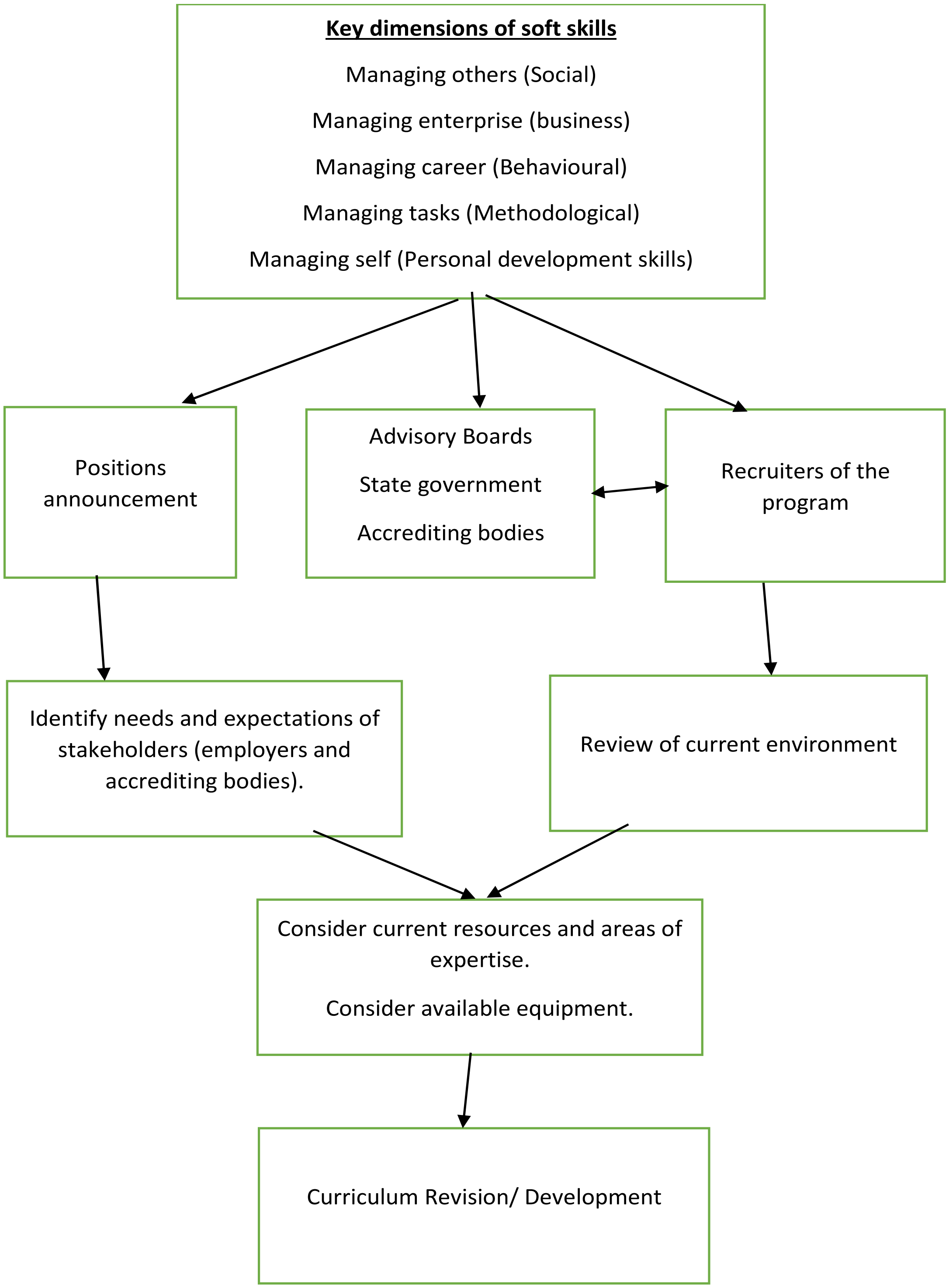

Figure 3. Curriculum Development Model
Source: Noll and Wilkins (2002). Adapted.

For inculcating the soft skills into the curriculum, the mutual-adaptation approach is recommended. Mutual-adaptation approach relates to the process of combined efforts of curriculum developers, employers and the external industry experts in adjusting the curriculum (Fagan, Cooper, Chatzifragkou & Bennett, 2020). In this case, the external industry expert team and employers advise curriculum developers the necessary modifications required to make curriculum pertinent to contemporary work environment. In the context of this study, modifications are made by infusing soft skills into the curriculum. Then, lecturers are compelled to make adaptations to the new curriculum under the supervision of curriculum experts. External industry experts are expected to continue provide curriculum knowledge. Lecturers' role must be active in curriculum development in order to make sound improvements in curriculum change. Although it is difficult to measure the soft skills, the application of six-level taxonomy of thinking may bring excellent results (Mpuangnan & Ntombela, 2024; Athanassiou, McNett & Harvey, 2003). Knowledge, comprehension, application, analysis, synthesis and evaluation are the six levels of influential taxonomy (Ozola, 2014). In other words, the student is expected to have a remembrance, understanding, application, analysis, evaluation and creation of knowledge. These learning outcomes are classified into high order, medium order and lower order. The higher order includes creativity, evaluation and analysis levels. The medium order incorporates levels of application and understanding. The lower order encompasses the remembering level. Each level demands a certain cognitive change. For instance, the learning outcomes at "level of understanding" demands high processes, whereas "level of understanding" needs lower cognitive processes which includes retrieving knowledge and recalling. The learning outcomes at the "level of application" demand the use of knowledge to perform tasks in the new environment. In addition, the learning outcomes at the "level of analysis" require high cognitive changes. This include breaking down of the main part into subparts. The learning outcomes at "the level of evaluation" encompasses setting objective criteria by giving judgements regarding the validity of the phenomenon. This incorporates the assessment of anticipated outcomes, weaknesses and strengths. Until lectures draw a plan to accomplish the sets of learning outcomes at certain levels and perform the assessments of the same learning outcomes, learning and teaching are bound to fail. Misalignment occurs when students are being taught at a "level of remembering", but are assessed at creativity, evaluation, analysis, application or understanding levels. For effective teaching of soft skills, an adjustment to the variations of learning outcomes is indispensable. The Figure 3 below shows the teacher curriculum implementation continuum.

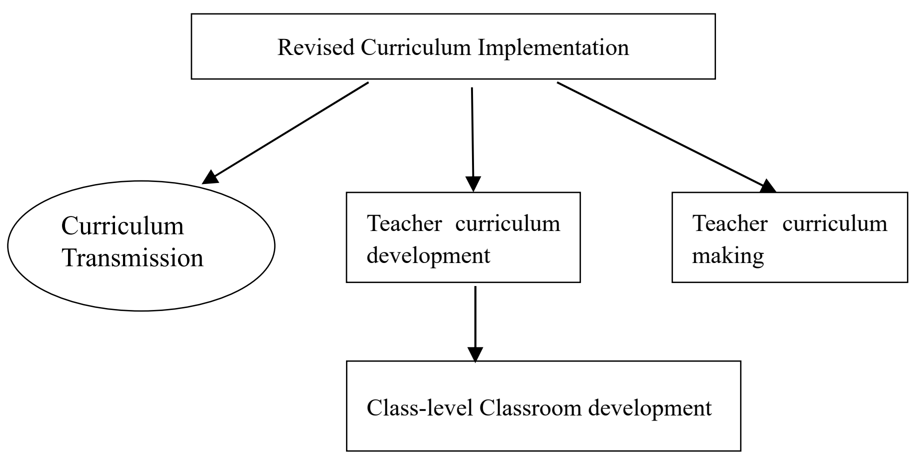

Figure 4. The Teacher Curriculum Implementation Continuum

Source: Warrner (2021). Adapted.

3.3 Inculcating Soft Skills into an Academic Curriculum

The module of soft skill needs to be done at the final stage and should be treated as one of the core modules in the curriculum of the final exiting year. The course should cover topics such as key dimensions of soft skills namely, managing career, managing tasks, managing enterprise or businesses, managing others and managing self. The first topic should be "managing tasks" which should focus on results-oriented skills, innovation skill, creativity, management skills, decision-making skills, customer or user orientation skills, continuous improvement skills, analysis skills and time management. The second topic must be "managing enterprise or business" which incorporates adaptability to change skills, problem-solving, critical thinking and leadership skills. The third topic of module should be "managing others" which includes communication skills, contact network skills, team-work skills, conflict management and negotiation skills. The fourth topic of module must be "managing-self" which must incorporate learnability skill, professionally ethical skill, self-awareness skills, life balance skills and self-direction.

The fifth topic should cover “managing career” which includes motivation skill, monitoring integrity skill, monitoring attitude skill, monitoring honesty skill and monitoring trust skill. After both in-class exercises, the students may come back together as an entire group to discuss and debrief about their experiences working on these activities. Role plays and in-basket need to be incorporated in-class exercises, thereafter whole group would meet to debrief and discuss about their experiences on the practical activities.

The soft skills must be acquired by every graduate entering the corporate world, failure to do he or she can be labelled incompetent (Noah & Aziz, 2020). The change of the curricula requires a close examination of the various factors which includes faculty skills, resources, students, current curricula and institutional environment. The redesign of the curriculum must be based on need and context (Adanlawo & Chaka, 2023; Yawson & Yamoah, 2020). The current curriculum requires regular upgrade especially considering the everchanging of required soft skills at the workplace. In the mutating situation of globalisation, soft skills have become crucial than the hard skills. In developing soft skills, a great effort should be given to practical exercises than theoretical teaching of content. The training methods for soft skills may include group discussions, debates, and role plays. Furthermore, there must be sessions on interpersonal skills, group dynamics, etiquettes and body language. Finally, curriculum must serve as a helping hand to graduates to move ahead in their selected career path with confidence (Bridgstock et al, 2019). The findings of this study can be utilised by tertiary institutions to identify potential skill deficiencies and design appropriate programmes for the development of soft skills. The final year students should be afforded an opportunity to develop strategies to practise the soft skills. The focus should be on providing soft skills based on industry needs. Higher education institutions should focus on developing and accurately assessing these important soft skills to align with the demands of the job market. For achieving success in the corporate environment, it is imperative for both faculty members to demonstrate a willingness and receptiveness to develop and refine their soft skills of final year students. The Table 3 shows the final articles that were used to extract data of this study.

Table 3. Data Sources

Data Sources	
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4. Conclusion

The study provided concerted view from various studies in different fields regarding the soft skills that need to be inculcated in the curriculum to improve employability of graduates. The study revealed the strong correlation between soft skills and employability, especially for recent university graduates seeking to enter the workforce. It is evident that organisations require a workforce that possesses enhanced proficiency. Consequently, it is imperative to provide graduates with opportunities to improve soft skills. These proficiencies are crucial for facilitating a smooth transition from formal education environment to the labour market environment. Since the soft skills have been revealed in the literature, the program and course requirements would be developed in the curriculum. After the revision to the courses and programs, the stakeholders must be given the opportunity to review and provide supplementary recommendations. Special topic courses and electives would be based on employment demands and faculty expertise. As part of the continuous program improvement and curriculum development process, placement data and trends of recruitment of graduates must be incessantly monitored. Despite the context of the case being quite specific to emerging economies, the principles of guidance have widespread relevance for embedding soft skills into the curricula. Overall, this study gave the comprehensive view of what employers look for from graduates, hence necessitates curriculum development, as well as graduate career path development.

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Authors contributions

Prof. Vezi-Magigaba and Dr. Utete were responsible for study design and revising. Prof. Vezi-Magigaba and Dr. Utete were responsible for data collection and analysis. Prof Vezi-Magigaba and Dr. Utete drafted the manuscript and revised it. All authors read and approved the final manuscript. The authors contributed equally to the study.

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Employment, Career Success and Learning Outcome Attainment of Computing Graduates in Klang Valley, Malaysia

Yogeswari Suppiah, **Rajermani Thinakaran***, **Marini Othman**
Faculty of Data Science and Information Technology, INTI International University, Negeri Sembilan,
Malaysia

Madina Yussubaliyeva
International Research Projects Office, D. Serikbayev East Kazakhstan State Technical University, Oskemen,
Kazakhstan

László Koloszár
Alexandre Lamfalussy Faculty of Economics,
University of Sopron,
Hungary

Abstract. This research explored the factors influencing computing graduates' transition from higher education into their career life and the effectiveness of educational programs in preparing graduates for job market challenges. The study used an exploratory sequential mixed-method approach, integrating literature review, and quantitative, and qualitative data collection. The study was executed in phases. Initially, a literature review and structured surveys were distributed to the computing graduates. Thereafter, an open-ended interview was conducted with the selected participants to get more relevant insights. The research contributes to the online survey data and the proposed model, which reflects all possible factors influencing graduate employability and career success. The results aim to inform educational institutions, policymakers, and industry stakeholders on the need for determination (grit') and resilience in educational strategies. The study emphasizes the importance of aligning with industry needs, cultivating soft skills, and developing a lifelong learning mentality to prepare graduates better. The study has limitations, including its regional focus, cross-sectional data, self-reported data, and potential bias. It also has implications for the United Nations' Sustainable Development Goals,

* Corresponding author: Rajermani Thinakaran; *rajermani.thina@newinti.edu.my*

particularly goal number 8, which emphasize decent work and economic growth. Future research should adopt a longitudinal approach and a more holistic lens to address access to equitable and inclusive employment outcomes worldwide. This research is crucial for policymakers, academic institutions, and industrial stakeholders to understand the factors affecting graduates' employment, career success, and program learning outcomes. It can guide the development of policies addressing post-COVID-19 challenges, and inform curriculum development, teaching strategies, and industry-relevant skills.

Keywords: Graduate employment; learning experiences; career success; program learning outcome; grit; resilience

1. Introduction

For many of the nations that have recently experienced sustained economic growth and a decrease in poverty, the development of human capital has been a key component. According to the World Bank (2022), the human capital of a nation is now even more strongly correlated with its riches due to the rapid advancement of technology. As industries across sectors such as manufacturing, agriculture, and services become more reliant on advanced human capital and technology-driven processes, there is a growing emphasis in the global economy on higher-level cognitive abilities. Skills such as advanced problem-solving, socio-emotional intelligence, and self-directed efficacy are increasingly seen as critical assets.

The Malaysian government has been implementing programs to bolster human capital to foster rapid and inclusive economic growth in a rapidly changing environment. These initiatives aim to equip the economy with essential knowledge, abilities, and skills. Enhanced levels of human capital will facilitate the failing areas in attracting the necessary investment to generate additional employment opportunities that require intermediate and advanced skills (World Bank, 2022). Malaysia's urbanization rate has been steadily increasing, with the Klang Valley being a key driver of this trend. This rapid urbanization has implications for the job market and the demand for skilled labor in the region.

Over the past 20 years, graduate employability has dominated the landscape of worldwide higher education policy. Governments view higher education as guaranteeing a trained labor force that is prepared for the workforce; students are calling for more financial returns on their "investments" in higher education related to employment; and graduate labor market results are becoming a crucial factor in many nations' regulatory and ranking systems (World Bank, 2022).

Worldwide, COVID-19 has had a significant effect on the job market for recent graduates. There are predictions of a worldwide recession, falling gross domestic product in several nations, and growing unemployment rates. Past experiences demonstrate that graduates who try to enter the workforce during such periods not only encounter major early obstacles but also run the risk of seriously damaging their long-term career paths and lifetime earnings (World Bank, 2022).

It is widely acknowledged that higher education and training institutions play a crucial role in Malaysia's social, economic, and political development by producing outstanding citizens, a highly skilled and talented labor force, and new knowledge. Malaysia's national education policy has served as a general framework for these advances. The Malaysia Education Blueprint 2015–2025 (Higher Education) complements the policy by outlining accountable ministries, institutions, agencies, plans, strategies, and key performance indicators within several robust supporting legal frameworks. Setting qualification criteria for all degrees in higher education and other fields is one of the main functions of the Malaysian Qualifications Framework, which was authorized by the Malaysian Qualifications Agency (2017).

Asada et al. (2017) stated that studies conducted by the Malaysia Productivity Corporation highlight the importance of addressing skill mismatches and improving educational outcomes to enhance employability. For graduates, the transition from school to the workforce is a crucial time in their life. To get a job offer and move forward in their career, people need the skills and traits required by today's competitive, evolving work market. Skill mismatches and deficiencies in educational achievement should be dealt with to improve employability.

The career success of a graduate can be affected by various factors, from personal traits to external aspects. A few of the determinants, such as educational background, skills and competencies, work experience, and striking the right tone during group discussions, could impact career status after graduation and meet industry requirements (Misni et al., 2020). Yun and Beh (2024) emphasized the urgent need for flexible policies and targeted educational efforts that prepare graduates with the necessary competencies and a resilient mindset to thrive in the rapidly changing job landscape shaped by the post-pandemic era.

Therefore, this study bridged the gaps by focusing on research discussing variables such as graduates' employment, career success, and program learning outcomes (PLOs). While there have been studies conducted in other nations, this is uncommon in Malaysia because of the unique situation it faces currently, such as the post-COVID effect and global climate change. This study considered the uniqueness of the Malaysian context and evaluated the relationships among all possible constructs and hypotheses and proposed an integral model that is resilient and adaptive.

The study selected areas that would offer rich knowledge that would assist industry stakeholders, educational institutions, and policymakers in creating enhanced employability solutions and career success strategies among graduates. This would potentially contribute towards sustainable economic development within Malaysia. Taking cognizance of the changing factors derived from recent global phenomenon, the research's objective was to explore the determinants impacting graduate employability and their career success.

2. Literature Review

Graduates' lives undergo a critical turning point when they go from higher education to the workforce, especially in vibrant cities such as Malaysia's Klang Valley. It is imperative for stakeholders who are committed to developing a skilled workforce and maintaining economic growth to comprehend the complex aspects that influence graduates' employment prospects, career advancement, and achievement of PLOs.

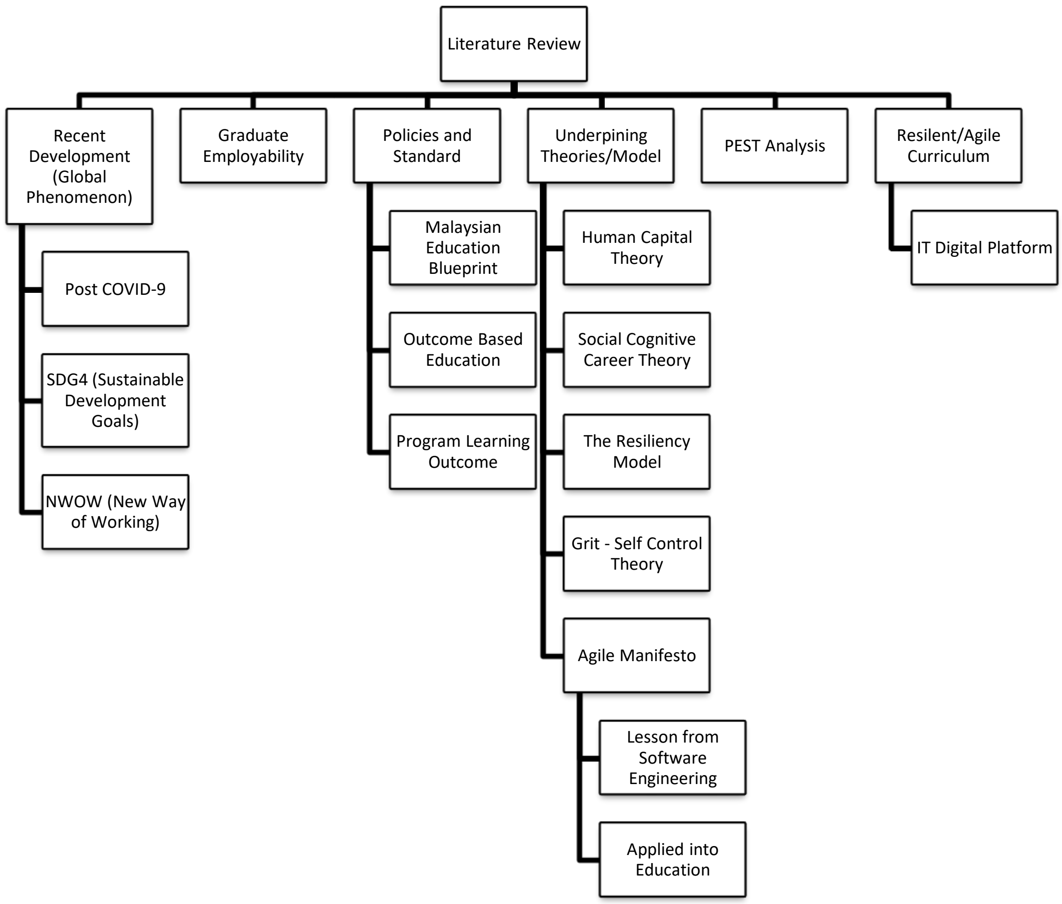

Figure 1: Literature Review Outline

Figure 1 presents a structured overview of the literature review, organized around six key domains that frame the discussion on graduate employability. The first domain, recent development (global phenomenon), highlights critical global trends shaping education and employment landscapes, including the ongoing impact of the COVID-19 pandemic, the objectives of the Sustainable Development Goal (SDG8), and the shift towards the New Way of Working. These developments serve as catalysts for rethinking graduate readiness and adaptability.

The second domain, graduate employability, focuses on understanding the complex factors that influence a graduate's transition into the workforce. The third domain, policies and standards, includes national initiatives such as the

Malaysian Education Blueprint, outcome-based education, and PLOS, which aim to align educational practices with evolving industry expectations.

The fourth domain, underpinning theories and models, provides the conceptual foundation for the research. It incorporates frameworks such as human capital theory, which links education to economic productivity; social cognitive career theory, which addresses the influence of self-efficacy and career decision-making; the resiliency model, which highlights psychological adaptability; and grit–self-control theory, which emphasizes perseverance and discipline. The agile manifesto, originally developed for software engineering, is also adapted to promote flexibility in curriculum development, encouraging iterative and student-centered learning. Its principles are further contextualized through lessons from software engineering, applied directly to educational settings.

The fifth domain, (Political, economic, social and technological) analysis, expands the focus by examining broader macro-environmental influences, including political, economic, social, and technological conditions that affect graduate outcomes. Finally, the sixth domain, resilient/agile curriculum, explores how digital platforms and agile strategies enhance institutional responsiveness, supporting learners in developing the competencies needed to thrive in a dynamic and unpredictable labor market.

2.1 Post COVID-19

According to Rahman et al. (2020), the COVID-19 pandemic that swept the globe in the first quarter of 2020 emphasized the issue of graduate employment. The movement control order made it harder for some businesses to pay their employees' salaries. As a result, employees were retrenched to reduce operating expenses and employers institute a hiring freeze. As a result, the pandemic affected the economy negatively. Both graduate unemployment and underemployment rates rose. The post-COVID-19 effect has resulted in a decrease in skilled job opportunities, which has contributed to the rising trend of underemployment among graduates.

The onset of the COVID-19 pandemic in early 2020 brought about widespread disruptions to societal and economic functions across the globe, and Malaysia was no exception. The enforcement of movement restrictions, closure of businesses, and suspension of numerous economic activities not only altered daily life but also contributed to a sharp rise in unemployment rates. Many companies were forced to shut down operations temporarily or permanently, which significantly reduced available job opportunities and created a more competitive and uncertain labor market environment (Bikar et al., 2023).

A recent study conducted by Kamaruddin et al. (2023) revealed that a significant number of graduates from University Sains Islam Malaysia are currently employed in areas that do not align with their original field of study. Moreover, it was found that many of these graduates experienced at least one job transition during the height of the COVID-19 pandemic. This indicates a level of instability and adaptability in the job market brought about by the unprecedented global crisis.

The study also identified several critical factors that have a notable influence on employment trends during the pandemic period. This includes demographic characteristics such as gender, as well as job-related elements such as the sector of employment, geographic location of the job, income level, and whether the graduates were involved in the graduate employability program. According to World Bank (2022), Malaysia's labor market has started to recover after the extended economic slowdown caused by the COVID-19 pandemic and the accompanying travel restrictions.

Although the unemployment rate remains above the pre-pandemic figure of 3.3 percent recorded in the fourth quarter of 2018, it showed a slight improvement, declining from 4.3 percent in Q4 2021 to 4.1 percent in Q1 2022. Alongside this, the labor force participation rate experienced a modest rise of 0.3 percentage points. While unemployment across all age groups has contributed to the overall rate, youth unemployment continues to be a concern, holding steady at a high rate of 11.1 percent since the previous quarter.

In 2021, the COVID-19 pandemic continued to pose challenges to countries worldwide, including Malaysia. The government implemented various strategies to protect lives, reduce the public health burden, and ensure livelihood. The National Economic Recovery Plan (PENJANA), otherwise known as *Pelan Jana Semula Ekonomi Negara*, was initiated by the Malaysian government incorporated stimulus package, with initiatives such as the Hiring Incentive Programme and PENJANA KPT-CAP Programme addressing job creation and unemployment.

Graduates Statistics 2021 provides statistics on graduates, including salaries and wages, from various data sources. Graduates are defined as individuals aged 15 and older with the highest certificates from universities, colleges, or polytechnics (Department of Statistics Malaysia, 2021).

2.2 Global Climate Change
A study by Rahman (2018) emphasized that climate change stands among the most pressing environmental challenges confronting humanity today. It has become a critical issue that occupies a central position on the global policy agenda. Although Malaysia is often perceived as being relatively shielded from extreme climate-related disasters, the country has nonetheless begun to experience an increase in the frequency of mild climate-induced disturbances in recent years. Various potential impacts of climate change in the Malaysian context have been identified, including rising sea levels, declining agricultural yields, the spread of diseases among forest ecosystems, loss of biodiversity, shoreline erosion, and more frequent and intense flooding.

2.3 Challenges of IT Professionals and Technology Churn
In recent times, the nature of the workplace has experienced continuous and significant transformation, especially concerning the types of tasks performed, the technologies and processes employed, and the skillsets necessary to sustain

organizational productivity and competitiveness. Several key drivers have contributed to this shift, notably large-scale technological advancements, demographic transitions, and unforeseen global events such as the COVID-19 pandemic. These evolving dynamics have further complicated the balance between the supply of skills from graduates and the actual demands of the labor market.

As a result, educational institutions and training providers are under mounting pressure to revisit and revise their curricula to reflect the needs of the modern workforce better. This includes integrating high-demand technical capabilities along with essential socioemotional skills. Moreover, there is an increasing emphasis on employing innovative teaching strategies—often referred to as signature pedagogies—that are adaptable to rapidly changing content requirements. One of the major catalysts of these changes is the Fourth Industrial Revolution (IR 4.0), which continues to introduce disruptive digital innovations across sectors.

In response, there is a growing call for pedagogical approaches that emphasize learner-centered methodologies, which shift the responsibility of acquiring new skills from instructors to students. These methodologies aim to develop learners' capacities for lifelong learning, critical thinking, and effective collaboration across disciplines. Such approaches are particularly important for preparing future professionals to solve novel and complex problems that may emerge as a result of technological disruptions brought about by IR 4.0 (Mukuni, 2023).

2.4 Theoretical Framework

The human capital theory by Becker (1964) suggests that individuals make deliberate investments in their education, training, and skill development, often at their own expense, with the aim of enhancing their productivity, employability, and long-term earnings prospects. This theory views knowledge, skills, and personal attributes as forms of capital that yield economic returns in the form of wages and career progression, which accumulate gradually over time. Its relevance is particularly notable among computing graduates in the Klang Valley, an area widely recognized as Malaysia's digital and economic hub.

In this highly competitive environment, many people pursue higher education in sought-after fields, such as data science, software engineering, and cybersecurity, hoping to secure stable and well-paying jobs. Nevertheless, even with technical qualifications, some graduates continue to face challenges in the job market. These include mismatches between their skills and industry needs, limited practical experience, and situations of underemployment where their roles do not fully reflect their qualifications.

2.5 PEST Analysis Framework

The political, economic, social, and technological (PEST) analysis framework in Figure 2 was used to investigate the factors affecting graduates' employment, career success, and PLO attainment in Klang Valley, Malaysia. This allowed the researchers to gain insight into the larger macro-environmental factors affecting the labor market, educational landscape, and socio-economic conditions. The

PEST analysis offers a methodical way to examine the outside elements influencing a certain situation. Political considerations include laws and policies from the Malaysian government that affect employment, education, and the growth of industries. Other than that, legal and environmental factors play a vital role in this study. This refers to laws and regulations such as employment laws and environmental regulations, environmental regulations, sustainability initiatives, and the impact of climate change.

Economic factors, such as gross domestic product growth, inflation, and unemployment rates, have a direct impact on the job market and the career prospects available to graduates in Klang Valley. Economic downturns may result in fewer job opportunities and more intense rivalry for available positions (Ramasamy, 2014). International trade agreements and economic globalization can impact the kinds of skills and competencies for which employers are looking, presenting graduates with both opportunities and problems (Mok, 2016). Social factors encompass cultural norms, demographics, and societal values. In the context of Klang Valley, social trends, such as the increasing importance of education and the growing diversity of the workforce, may impact career choices and opportunities for graduates (Kaur, 2016).

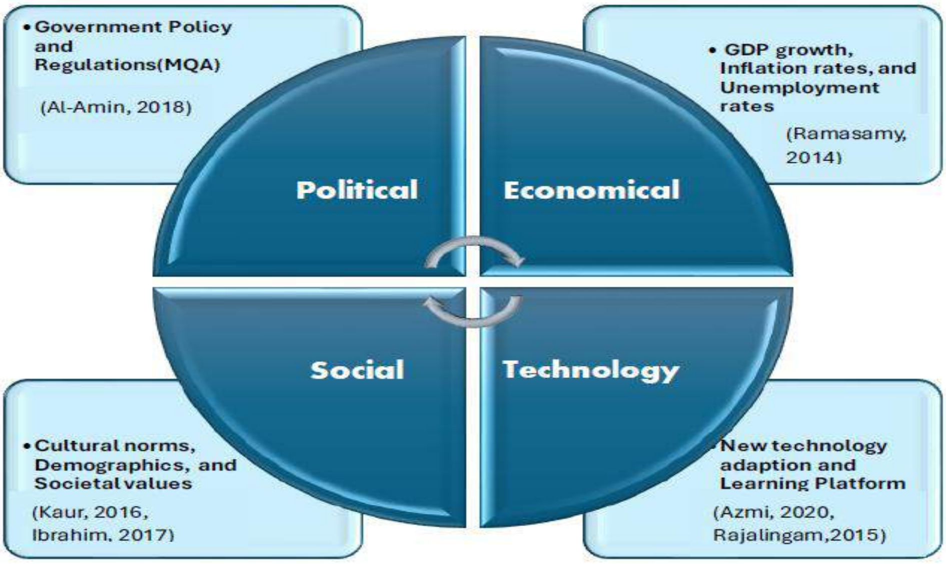

Figure 2: PEST Analysis

2.6 The Conceptual Model

Figure 3 presents a detailed theoretical framework for graduate career success, focusing on employability and resilience (RE). The key theories supporting this framework include the human capital theory, which underscores the value of skills and knowledge in career development; the social cognitive career theory, which emphasizes personal agency and decision-making; and the method of RE and resiliency, which highlights adaptability and grit (GT). The three main components of the framework are determinants of employability, challenges, and indicators of success. Determinants of employability include program learning outcome (PLO) attainment, academic performance, learning experiences (LE), and emotional intelligence.

Graduate faces challenges such as job demand mismatches, skills gaps, and the effects of the COVID-19 pandemic on the job market. Career success and employability are determined by how well graduates adapt to external economic, social, political, and technical factors while leveraging internal strengths.

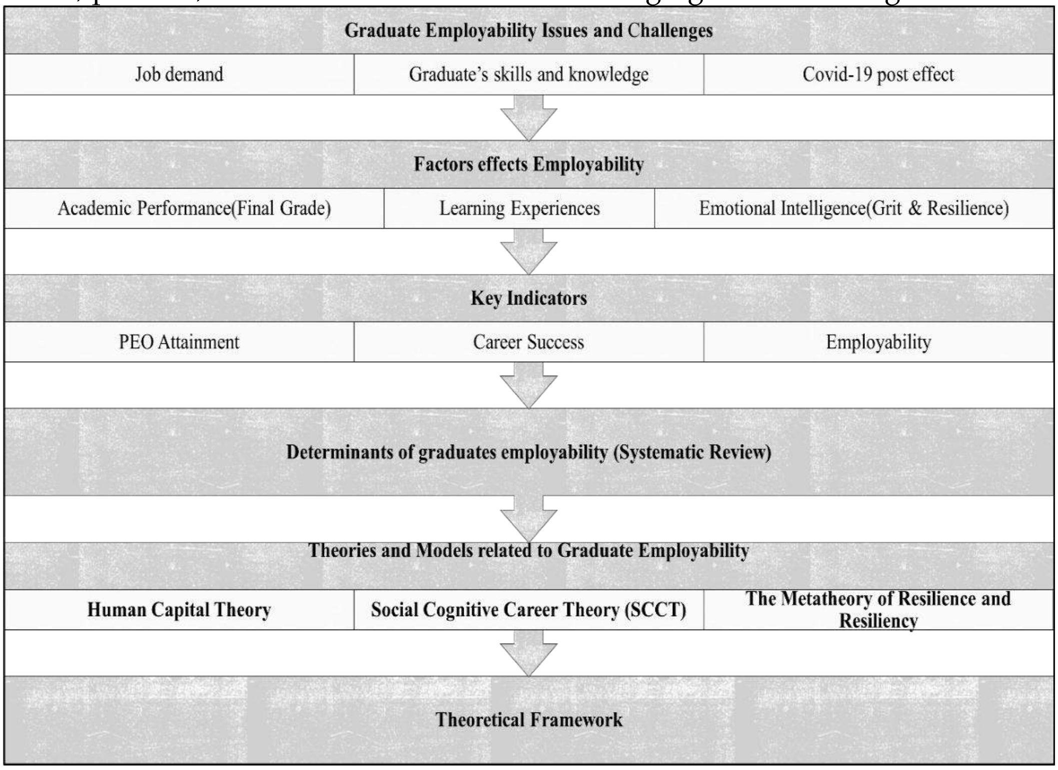

Figure 3: The research framework

3. Methods

3.1 Research Design

The data collection and analysis are directed by the design of the research, which functions as a study's outline. This study used an exploratory sequential mixed-method approach to integrate both qualitative and quantitative methodologies for the design of the tool. As depicted in Figure 4, the quantitative section used a structured online survey to acquire measurable data concerning levels of GT and RE that graduates have regarding PLOs and professional success. The qualitative component utilized open-ended structured interviews to explore the experiences of individuals with GT and RE. Using this mixed-methods approach allowed for a more in-depth understanding of the research areas, not merely by validating the study but also by attributing it to its other purposefulness. The qualitative aspect consisted of interviews applied to detailed examinations of the experiences engaged by participants, providing an in-depth understanding of GT and RE (Huyler & McGill, 2019); this combination enhances the strength and credibility of the research.

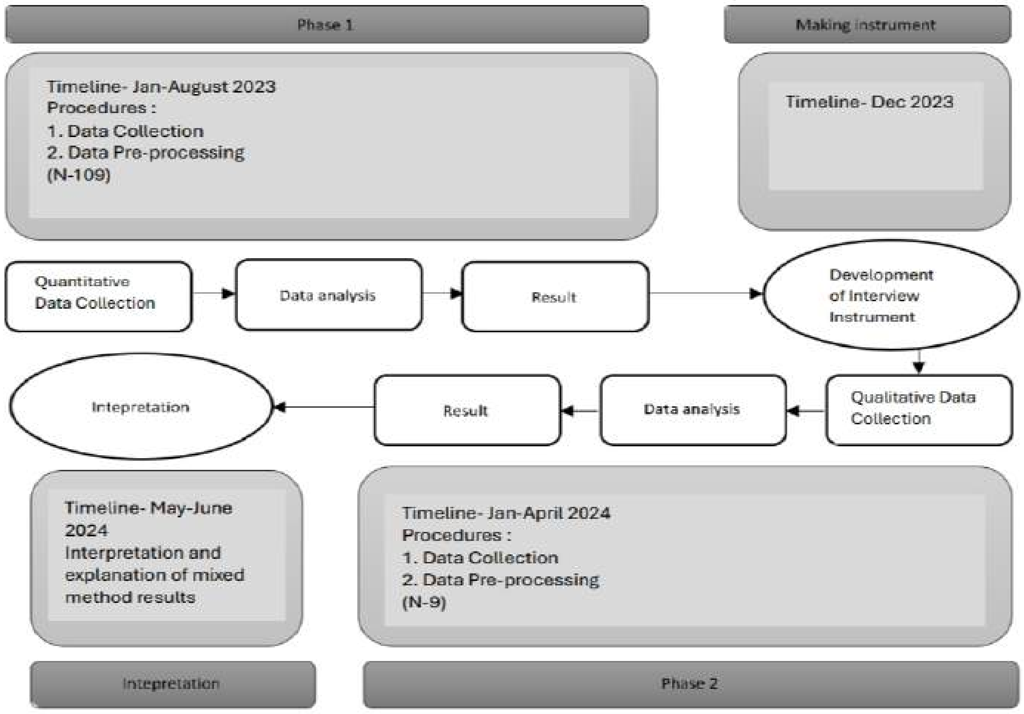

Figure 4: Exploratory sequential mixed-method research design

3.2 Hypotheses Development

The hypothesis was developed based on the assumption that GT and RE significantly influence career success, such as employment status, job satisfaction, and career progression, with PLO attainment serving as the mediator factor.

3.2.1 Grit and Resilience (Independent Variables)

According to Duckworth et al. (2007a), the grit scale measures tenacity and passion for long-term objectives. The Connor-Davidson resilience scale is used to measure RE, which is the capacity to overcome adversity constructively (Connor & Davidson, 2003). Their research demonstrated the validity and reliability of these measures in assessing RE and GT, respectively.

3.2.2 Program Learning Outcome Attainment (Mediating Variable)

The Program Learning Outcome (PLO) accomplishment is a measure of a graduate's success in achieving the learning objectives and skill levels specified by the computing program. The notion that PLOs contribute to graduates' overall achievement is supported by earlier research on educational outcomes conducted (Magolda & Astin, 1993).

3.2.3 Employment and Career Success (Dependent Variables)

Studies conducted by Ng et al. (2005) explored the factors influencing employment outcomes and career success, providing a foundation for understanding variables such as employment status, job satisfaction, salary levels, career advancement, promotions, leadership roles, etc.

3.2.4 Hypothesized Relationships

H1: Grit positively influences graduates' career success, including salary growth and promotions. Previous research by Eskreis-Winkler et al. (2014) suggested that GT positively impacts career success.

H2: There is a positive association between GT and the attainment of PLOs among graduates, indicating that higher levels of GT contribute better to mastery of the intended program outcomes. According to Duckworth et al. (2007a), GT positively predicts academic achievement, supporting the hypothesis that GT influences PLO attainment.

H3: Learning experiences positively influence career success among graduates. A study by Pianda et al. (2024) revealed that internship experience is very important in achieving multidimensional employability improvement in supporting the reduction of the unemployment rate.

H4: A graduate's LE positively affect their attainment of PLOs, indicating that immersive and effective LE contribute to better mastery of the intended program outcomes. A study by Thabassum et al. (2022) demonstrated that active and experiential learning strategies significantly enhance student's achievement of learning outcomes.

H5: There is a positive relationship between the level of RE and career success among graduates, including factors such as salary growth and promotions. Previous research by Eskreis-Winkler et al. (2014) suggested that GT and RE positively impact career success.

H6: There is a positive relationship between the level of RE and the attainment of PLOs among graduates. A recent study by Otaki et al. (2025) found that the role of RE is pivotal for academic achievement, enhances students' adaptability during educational transitions and contributes to the successful attainment of learning outcomes.

H7: Learning experiences positively influence GT level among graduates. A study by Yau and Shu (2023) investigated the relationship between GT and student engagement in higher education and confirmed that students with higher levels of GT were more engaged in learning.

H8: Learning experiences positively influence RE level among graduates. Chuang and Huang (2025) explored the impact of a life education program on students' psychological RE.

Figure 5 presents the model built on the hypothesis that GT and RE significantly influence career success, such as employment status, job satisfaction, and career progression, with PLO attainment as the mediating factor. It hypothesizes that individuals with higher levels of GT and RE are more likely to achieve their program's learning objectives, which in turn enhances their employability and career success.

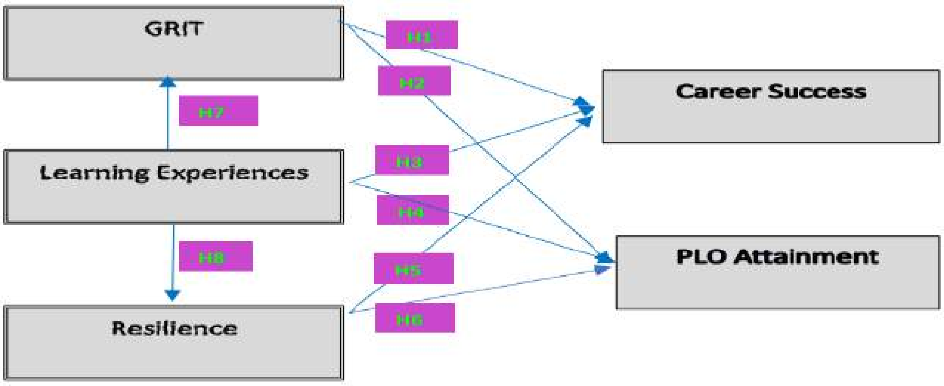

Figure 5: Research model

3.3 Participants and Data Collections

The data collection process took place over a span of ten months, beginning in January and ending at the end of October 2023. Prior to distributing the final version of the questionnaire, a pilot test was carried out to ensure that the instrument met acceptable standards of face validity, reliability, and overall quality. This preliminary phase was essential for confirming the consistency and clarity of the questionnaire before administering it to the target population. The participants involved in this study were alumni who graduated between 2015 and 2020. Of the 700 questionnaires distributed, a total of 115 responses were collected. However, six responses were excluded from analysis due to incomplete information.

A deterministic sampling process was used to ensure that the participants had experienced the situation being studied. The online survey included validated scales measuring GT and RE to gather quantitative data. Additionally, open-ended interviews were used to gather qualitative data on how participants experience GT and RE and their importance in their career success journey. The interviews were conducted from May to June 2024. A total of 20 participants were selected based on the criteria. This mixed-method approach allowed the complexity of individual experiences to be combined with broader quantitative trends, which supports a nuanced interrogation of the research aims.

A sample-to-variable ratio was used by the researcher for the quantitative investigation (Memon et al., 2020). A sample size is determined by dividing the total number of items by the sample-to-item ratio, which is typically advised for exploratory factor analysis. At least a 5-to-1 ratio is required. The sample -to variable ratio suggests a ratio of at least 5:1 between the variables and the observations. The total number of variables was five (GT, RE, career satisfaction, PLO, and LE). The 15:1 ratio preferred with the minimum number of samples was 75. The number of samples for this study was 109, exceeding the minimum number required.

For the qualitative study, several interviewees from the total survey responses were selected and invited to participate in the investigation of their career success stories. The selection of participants was based on the recommendation by Creswell and Poth (2016), with factors to consider when determining nonprobabilistic sample sizes for phenomenological study and grounded theory study. The selection criteria for the interviewees were based on graduates' salary earned, job satisfaction, and employment mode. The median monthly wages were selected according to Indeed and statistical analysis, and reports by the Department of Statistics Malaysia (2021).

3.4 Use of AI Tools

To improve the clarity and readability of this manuscript, the author(s) utilized ChatGPT, an artificial intelligence language model developed by OpenAI. This tool was employed solely for language refinement and enhancing the explanation of concepts. The use of ChatGPT did not influence research design, data collection, analysis, or interpretation. All intellectual content and research decisions remained the sole responsibility of the author(s).

4. Data Analysis

The quantitative data collected through the survey were processed and analyzed using statistical tools, particularly the Statistical Package for the Social Sciences (SPSS) version 27. This software was chosen for its strong functionality and ease of use, especially in conducting descriptive statistics and assessing reliability, as noted by Rahman and Muktadir (2021). It is also user-friendly and well suited for exploratory research and theory development.

The analysis employed a range of statistical methods, including correlation analysis and structural equation modelling (PLS-SEM), to explore and assess the relationships among key variables. These advanced analyses were carried out using SmartPLS version 4.0. As highlighted by Hair (2009), the PLS-SEM approach is advantageous for evaluating complex models that incorporate multiple constructs, indicators, and structural relationships. Moreover, it does not require the data to meet strict distributional assumptions, making it particularly suitable for exploratory research and the early stages of theoretical model development.

4.1 Model Development

The evaluation of the research model involved two key components: the measurement model (also known as the outer model) and the structural model (inner model). To begin with, the measurement model was assessed by examining the reliability and validity of the items used to measure each construct. This process is aligned with the approach commonly referred to as confirmatory factor analysis, which is used to ensure that the indicators accurately reflect their respective latent variables. Following this, the structural model was analyzed through techniques similar to those used in multiple regression, enabling the examination of relationships between the constructs within the model.

4.2 Assessment of Measurement Model

The initial step in evaluating the measurement model involved assessing its validity and internal consistency reliability. Confirmatory factor analysis was used in the measurement (inner) model to analyze how well the observed variables represented their underlying constructs (Chin, 1998). According to Hair et al. (2013), a theoretical framework requires a thorough re-examination of the measurement, grounded in well-established and relevant concepts related to information systems. To evaluate the reliability of the measurement model, both Cronbach's alpha and composite reliability were applied. The validity of the model was assessed by examining convergent and discriminant validity, which is discussed in more detail in the following sections.

4.3 Measurement of Reliability

Cronbach's α (CA) has historically been used to evaluate the data's internal consistency. It offers an estimate of reliability based on the inter-correlation between the indicators and correlations between the indices (Hair et al., 2021). Since CA has its limitations, another metric called composite reliability has been utilized to evaluate the reliability of internal consistency. According to Hair et al. (2013), a CA value of more than 0.6 is seen as acceptable, but a value greater than 0.8 is thought to be a stronger predictor of construct reliability (Nunnally, 1994).

The range of 0.6 to 0.9 is the permissible range for composite reliability, which was reported to be weak when the value was less than 0.6 (Hair, 2009). Strong internal reliability was demonstrated by the latent variables' CA, ranging from 0.855 to 0.901, composite reliability values, ranging from 0.892 to 0.985, and average variance extracted values, ranging from 0.528 to 0.860, as shown in Table 1. A model's acceptable level and ideal inner quality for exploratory research are indicated by values more than 0.70 (Hair et al., 2012).

Table 1: Construct validity and reliability overview

	Cronbach's Alpha	Composite Reliability (ρ_a)	Composite Reliability (ρ_c)	Average Variance Extracted
GT	0.914	0.970	0.926	0.686
LE	0.901	0.922	0.917	0.528
PLO	0.975	0.985	0.980	0.860
RS	0.855	0.892	0.892	0.581
ST	0.947	0.954	0.958	0.765

4.4 Measurement Model

An element of a path model that contains the indicators and their relationships with the constructs is also called the outer model in PLS-SEM (Hair et al., 2021). Figure 6 shows the structural equation model derived from the analysis.

4.5 Reflective Measurement Model

This type of measurement model is structured such that the observed indicators are viewed as outcomes or manifestations of an underlying latent construction. In this framework, the direction of causality flows from the construction to its respective indicators. In the context of PLS-SEM, this model configuration is also known as Mode A (Hair et al., 2021).

The evaluation of a reflective measurement model involves several key criteria:

i) Composite reliability (CR), which assesses the internal consistency of the construction,
ii) Outer loadings, used to determine the reliability of individual indicators, and
iii) Average variance extracted, which measures convergent validity and discriminant validity is assessed using multiple methods including the Fornell-Larcker criterion, analysis of cross-loadings, and the heterotrait-monotrait ratio.

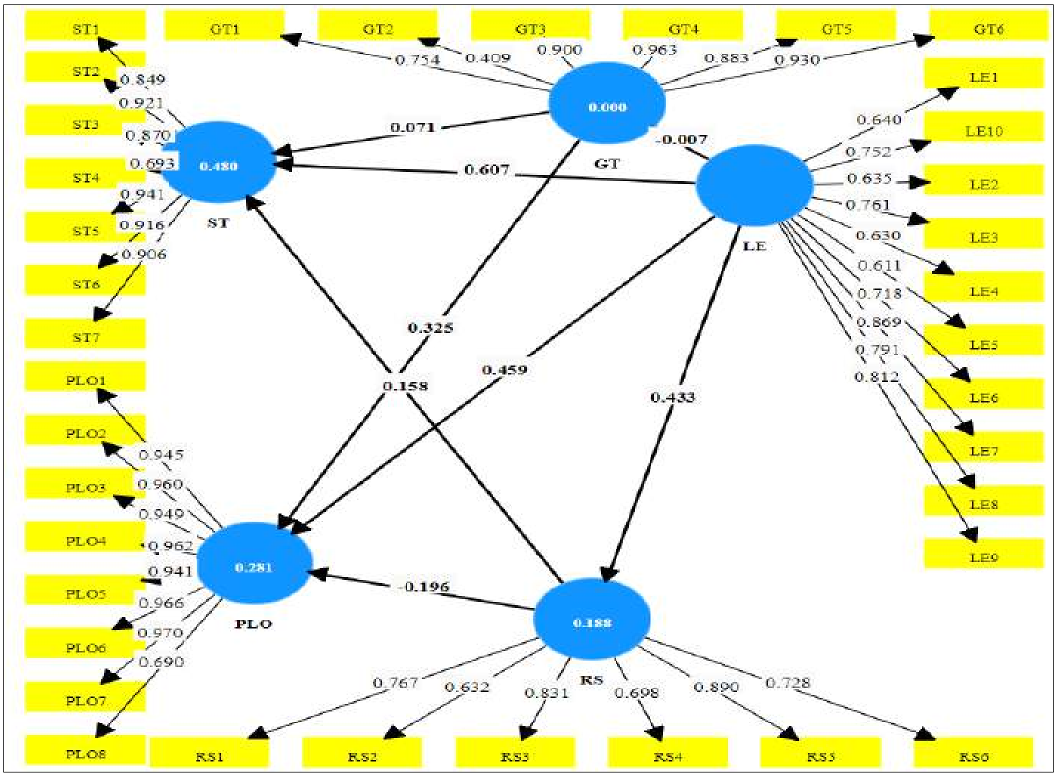

Figure 6: Structural equation model

4.6 Assessment of Structural Model

Estimating the linear relationships between independent (exogenous) and dependent (endogenous) latent variables is conducted after confirming the validity and reliability of the measurement (outer) model. To analyze the relationships among the constructs within the research framework, the structural model, also known as the path or inner model, was developed. The evaluation of this structural model aimed to verify whether the proposed hypotheses were supported by the empirical data collected in the study. The assessment of the structural model was based on the following key criteria:

1. Estimation of path coefficient (β) (hypothetical relations),
2. The coefficient of determination (R2),
3. Effect size (f2),
4. Predictive relevance (Q2), and
5. Goodness of fit (GOF).

For the evaluation of the path coefficients, the partial least squares (PLS) method was employed along with the bootstrapping technique using 500 resamples to estimate coefficient sizes and assess the statistical significance of the hypothesized paths. This approach generates T-statistics and P-values, which are critical for determining whether the relationships between latent variables are supported by the data. As shown in Table 2, eight hypothesized paths were tested within the model.

Table 2: Path coefficients

	Original sample (O)	Sample means (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P-values
GT -> PLO	0.325	0.301	0.180	1.810	0.070
GT -> ST	0.071	0.067	0.182	0.391	0.696
LE -> GT	-0.007	-0.023	0.221	0.031	0.975
LE -> PLO	0.459	0.455	0.197	2.334	0.020
LE -> RS	0.433	0.480	0.136	3.192	0.001
LE -> ST	0.607	0.618	0.106	5.750	0.000
RS -> PLO	-0.196	-0.192	0.165	1.185	0.236
RS -> ST	0.158	0.138	0.147	1.075	0.282

Of these eight paths, three showed statistically significant results at the conventional alpha level of 0.05. Specifically, the paths from the latent variable LE to PLO, RS, and ST had path coefficients of 0.459, 0.433, and 0.607 respectively, with corresponding T-values of 2.334, 3.192, and 5.750, and P-values of 0.020, 0.001, and less than 0.001. These findings indicate a significant positive effect of LE on these dependent constructs, highlighting its strong influence within the model.

Alternatively, five paths were found to be statistically insignificant. For example, the paths from GT to PLO and ST had coefficients of 0.325 and 0.071 with T-values of 1.810 and 0.391, and P-values of 0.070 and 0.696 respectively, which exceed the typical significance threshold. Similarly, the path from LE to GT was negligible and insignificant with a coefficient of -0.007 and a P-value of 0.975. Additionally, the relationships from RS to PLO and ST also lacked significance, with T-values of 1.185 and 1.075, and P-values above 0.2. These results suggest that these particular predictors do not have a statistically meaningful direct effect on their respective dependent variables in this study.

Overall, the results underscored the important role of LE in positively affecting several outcomes, while other latent variables, such as GT and RS, showed limited or no direct impact. This distinction helped understand the relative influence of each construct and may guide future refinement of the model or further research into possible mediating or moderating variables.

4.7 Moderation Results

This study proposed that LE act as a moderator in the relationships between several predictor variables: performance GT, RE, career satisfaction (ST), and PLOs. Moderation means that the strength or direction of the relationship between these variables may change depending on the level of LE.

To examine this, interaction effects were tested to determine whether LE significantly influence the impact of GT, RS, and ST on PLO.
Table 3 summarizes the moderation analysis results, showing the original sample estimates, standard deviations, T-statistics, P-values, and whether the hypothesized moderating effect was supported. The results indicate that LE significantly moderate the relationships involving RE, ST, and PLOs.

Table 3: Moderator results

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T statistics (|O/STDEV|)	P-values	Comment
GT -> PLO	0.325	0.301	0.180	1.810	0.070	Not Supported
GT -> ST	0.071	0.067	0.182	0.391	0.696	Not Supported
LE -> GT	-0.007	-0.023	0.221	0.031	0.975	Not Supported
LE -> PLO	0.459	0.455	0.197	2.334	0.020	Supported
LE -> RS	0.433	0.480	0.136	3.192	0.001	Supported
LE -> ST	0.607	0.618	0.106	5.750	0.000	Supported
RS -> PLO	-0.196	-0.192	0.165	1.185	0.236	Not Supported
RS -> ST	0.158	0.138	0.147	1.075	0.282	Not Supported

Specifically, the moderating effect of LE on the path from LE to PLO was statistically significant, with a path coefficient of 0.459, a T-value of 2.334, and a P-value of 0.020. This suggests that LE positively influence how well performance outcomes are achieved, strengthening the relationship between the predictors and PLO. Similarly, the moderation paths from LE to RE and ST were also significant, with coefficients of 0.433 and 0.607, T-values of 3.192 and 5.750, and highly significant P-values of 0.001 and less than 0.001, respectively. These findings indicate that LE enhance the positive effects of RE and ST on the overall model outcomes.

In contrast, other hypothesized moderation effects involving PLOs' GT were not supported. For example, the moderation of LE on the relationship between GT and PLO showed a coefficient of 0.325 but was not statistically significant, with a T-value of 1.810 and a P-value of 0.070. Likewise, the moderation effect on GT to ST was also insignificant, with very low path coefficients and high P-values. Furthermore, the moderation path from LE to GT was near zero and not supported, indicating no moderating influence in this case.

Overall, these moderation results reveal that LE play an important role in amplifying the influence of certain factors, such as RE and ST, on PLOs.
However, LE do does not appear to moderate the effects of GT in this model significantly. This insight highlights the importance of fostering enriching LE to

enhance RE and ST for better performance outcomes, while suggesting that GT may function independently of such moderation.

4.8 Hypothesis Summary

To provide a clear overview of the structural model outcomes, Table 4 presents a summary of the hypothesis testing results based on the correlation analysis conducted in this study. Each hypothesis was evaluated to determine whether the proposed relationships between the latent variables were supported by the empirical data.

Table 4: Hypothesis results

Hypothesis	Statement	Result
H1	Graduates' career success, including pay increases and promotions, is positively impacted by GT.	Not Supported
H2	PLOs are positively correlated with GT.	Not Supported
H3	Graduates' career success is positively impacted by their LE.	Supported
H4	PLOs are positively impacted by a graduate's LE, suggesting that rich and successful learning environments improve program objectives mastery.	Supported
H5	Graduates' RE has a favorable correlation with career success.	Supported
H6	Graduates' achievement of PLOs is positively correlated with their level of RE.	Not Supported
H7	Graduates' level of GT is positively impacted by their LE.	Not Supported
H8	LE positively influences RE level among graduates.	Not Supported

The findings reveal that while some hypotheses were strongly supported, others were not confirmed. Hypotheses 3, 4, and 5 showed significant positive relationships, indicating that graduates' LE play a crucial role in enhancing both their career success and PLOs. These results suggest that engaging and effective learning environments help graduates achieve better mastery of program objectives and advance professionally. Additionally, RE was positively correlated with career success, highlighting its importance in contributing to graduates' achievements. In contrast, hypotheses 1, 2, 6, and 7 were not supported by the data. Specifically, GT did not show a significant positive impact on either career success or PLOs in this study.

Furthermore, LE did not significantly influence the level of GT, and RE was not significantly associated with PLO achievement. These findings imply that some personal traits may have less impact on graduate outcomes than initially expected, at least within the context of this sample. The results provide valuable insights into which factors most strongly influence graduate outcomes, with LE and RE emerging as key contributors. The unsupported hypotheses suggest the need for further research to explore additional variables that might mediate or moderate these relationships.

Based on these findings, the lack of support for some hypotheses may be attributed to external factors such as socioeconomic status. Most participants were from urban areas and came from families with strong economic backgrounds. These favorable conditions could have overshadowed the influence of personal traits such as GT and RE on career trajectory and success. Therefore, future research should consider including socioeconomic variables as potential moderators or control variables to better understand their impact on shaping graduate outcomes.

4.9 Qualitative Analysis

The hypothesis about the impact of GT and RE on computing graduates' employability and career success was not amply supported by the quantitative data analysis. Thus, the research project was expanded by employing open-ended structured interviews to gather qualitative data. A total of 24 graduates were chosen based on their employment style and income range. These alumni participated in an open-ended structured interview to learn more about their RE and GT. The nine participants' comments were recorded and examined to gain more insight into the occurrence.

4.9.1 Thematic Analysis

Thematic analysis (TA) is a widely used qualitative research method that involves identifying, analyzing, and interpreting patterns or "themes" within qualitative data. This approach helps researchers to organize and make sense of large volumes of textual data systematically by breaking it down into smaller, meaningful units called codes. These codes highlight interesting or significant features related to the research questions. By grouping these codes, broader themes emerge that reflect underlying concepts or patterns common across the data set. The themes serve as a way to represent the researcher's interpretations and provide a structured narrative to explain the data. Clarke and Braun (2017) offer a detailed six-step framework for conducting TA, which guides researchers from familiarizing themselves with data to produce a comprehensive report of the findings. This structured process ensures clarity and rigor in qualitative analysis.

4.9.2 Qualitative Analysis Result

The qualitative component of the study was based on 29 direct quotations obtained from participants. These quotes offered deeper insight into their personal experiences and professional development. The responses revealed how individuals react to challenges, recover from setbacks, and evolve in their careers. Through TA, a variety of recurring patterns emerged. Each of these is explored in the following sub-sections to highlight the unique and often complex paths that participants have taken in navigating their professional journeys.

4.9.2.1 Challenges and Setbacks

Many participants reported facing major obstacles, particularly during the early stages of their careers. These challenges often included managing tasks beyond their prior experience and coping with limited resources. Addressing such issues requires independent research, identifying relevant stakeholders, and showing persistence. When critical errors occurred, such as failures in capstone projects or service delivery, they often had to start over. Breaking down problems into manageable parts, seeking guidance, and remaining resilient were all key strategies for overcoming difficulties.

4.9.2.2 Goal Setting and Achievement
The participants emphasized the importance of setting realistic goals and breaking them down into smaller, actionable steps. Progress tracking helped maintain motivation, while celebrating minor successes provided a sense of achievement. In many cases, social media and networking opened up unexpected opportunities. Continuous learning and personal development were viewed as ongoing necessities, regardless of job stability or career stage.

4.9.2.3 Discomfort and Uncertainty
The participants often had to step out of their comfort zones, whether in public speaking, solo travel, or accepting unfamiliar job roles. Strategies that helped them cope included preparation, a positive mindset, and the use of stress management techniques. Learning to adjust to new environments, whether social or professional, provided them with valuable life lessons and helped them build confidence to face future uncertainties.

4.9.2.4 Project Tracking
To manage demanding projects, participants adopted structured approaches that involved defining clear goals, breaking down tasks, setting timelines, and maintaining open communication with all stakeholders. This methodical process enabled them to handle overwhelming workloads more effectively and maintain focus throughout project implementation.

4.9.2.5 Criticism or Negative Feedback
The participants described criticism not as a setback but as an opportunity for improvement. Instead of reacting defensively, they used feedback to enhance their skills and performance. Many participants stressed the value of open communication and actively sought constructive criticism as part of their growth process.

4.9.2.6 Setbacks or Failures
When setbacks occurred, the participants often took time to pause and reflect. They analyzed what went wrong and considered what could be learned from the experience. This period of reflection, combined with logical thinking and emotional RE, helped them return to their tasks with renewed clarity and determination.

4.9.2.7 Stress or Pressure
To manage stress effectively, participants relied on techniques such as taking regular breaks, prioritizing workloads, and occasionally disconnecting from work-related tasks. Maintaining an organized approach to responsibilities and fostering a positive mindset were also seen as essential to coping with high-pressure situations.

4.9.2.8 Unexpected Changes or Challenges

The participants shared that sudden changes in their work or industry required flexibility and a willingness to learn new things. Staying curious and continually upskilling were important coping strategies. Engaging with industry professionals and mentors also provided helpful guidance and support during these periods of adjustment.

4.2.2.9 Resilience in Facing Obstacles

Resilience emerged as a recurring theme throughout the responses. Many participants developed it through patience, persistence, and a focus on solutions rather than problems. They reflected on their progress regularly, sought improvement through training, and overcame self-doubt by continuing to try despite challenges.

4.9.2.10 Impact of COVID-19

The pandemic had a mixed impact on the participants. While some were fortunate enough to find opportunities, others encountered job loss or delayed career progress. Nevertheless, many highlighted the emergence of remote work as a positive shift. They appreciated the flexibility and new prospects it offered in navigating their careers during uncertain times.

4.9.2.11 Survival or Successful Career Life

Participants who described their careers as successful credited this to a combination of continuous self-improvement, openness to new opportunities, and maintaining personal well-being. Rather than focusing solely on ambition, they highlighted the importance of work-life balance, self-awareness, and aligning career decisions with long-term satisfaction.

In conclusion, the qualitative findings underscore the importance of traits such as RE, adaptability, continuous learning, and effective stress management. These qualities enable individuals to handle the unpredictable nature of modern careers. The lived experiences shared by participants provide practical lessons for both current students and early-career professionals. The next section expands this discussion by examining how personal traits such as GT and RE further influence career growth and long-term professional success.

4.9.3 Grit and Resilience Among Graduates

To address the research objectives, the following research questions were sought.

RQ1: What are the factors that contribute to employment and career success among graduates?

Through literature analysis, the researcher found that GT, RE and LE are the most important factors that influence the career success of graduates. Through the survey, quantitative analysis, it is proven that LE positively influences career success among graduates.

RQ2: How do those factors influence career success indicators, such as job satisfaction, salary growth, and career advancement of graduates?

The main objective in using interviews was to collect a considerable amount of detailed information that could not be collected using a survey. Based on the TA, it is proven that GT and RE positively impact career success. Figure 7 shows the influence of G and RE among all the participants who are successful in their careers. The insight derived shows that GT is the most significant component reflected in the recorded responses. Resilience is another important component reflected.

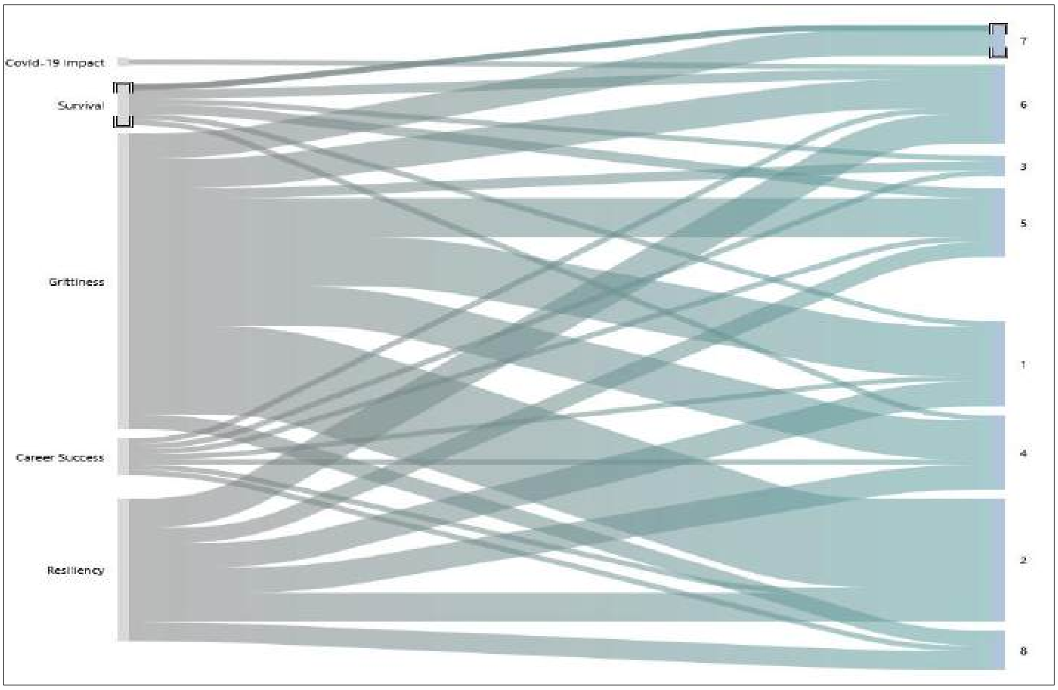

Figure 7: Sankey diagram from thematic analysis

5. Results

5.1 Summary and Interpretation of Hypothesis Results

H1: Graduates' career success, including pay increases and promotions, is positively impacted by GT. (Supported)
Interpretation: Grit (consistency of effort and perseverance) contributes to career success significantly influence measurable outcomes such as pay increases or promotions for these graduates.

H2: PLOs are positively correlated with GT. (Not Supported)
Interpretation: The lack of correlation here may suggest that while GT helps with sustained effort, it may not directly impact on the specific learning outcomes tied to program objectives. PLOs could be more influenced by other factors such as curriculum structure, quality of teaching, and engagement with relevant industry skills, such as Agile methodologies and IT tools.

H3: Graduates' career success is positively impacted by their LE. (Supported)
Interpretation: This result indicates that positive, enriching LE significantly contributes to graduates' career success. This suggests that interactive, industry-

aligned learning environments, internships, and hands-on Agile training provide graduates with skills and confidence that help them excel in their careers.

H4: PLOs are positively impacted by a graduate's LE, suggesting that rich and successful learning environments improve program objectives. (Supported)
Interpretation: The positive correlation implies that well-designed LE plays a crucial role in helping students meet program objectives. This could underscore the importance of practical, Agile-aligned curricula that prepare graduates with the necessary technical and problem-solving skills for the workforce.

H5: Graduates' RE has a favorable correlation with career success. (Supported)
Interpretation: Resilience, or the ability to adapt and bounce back from challenges, is shown to correlate positively with career success. This suggests that the capacity to handle setbacks is valuable in navigating career progression, likely reflecting the demands of the fast-paced IT industry in Klang Valley.

H6: Graduates' achievement of PLOs is positively correlated with their level of RE. (Not Supported)
Interpretation: Resilience may not directly affect the achievement of specific PLOs. This suggests that while RE is important for career success, academic outcomes may be more influenced by targeted skills and knowledge acquisition rather than the general ability to recover from setbacks.

H7: Graduates' level of GT is positively impacted by their LE. (Not Supported)
Interpretation: This finding suggests that positive LE may not necessarily increase a student's level of GT, as GT tends to be more of a personal characteristic. This implies that while supportive learning environments are beneficial, they may not directly impact a graduate's perseverance or consistency of effort.

H8: Graduates' level of RE is positively impacted by their LE. (Not Supported)
Interpretation: This outcome implies that RE, like GT, may not be directly influenced by LE. Resilience might be more closely tied to personal or life experiences outside of academic settings or possibly developed through other extracurricular activities or challenging life events.

The quantitative analysis results show inconsistency due to COVID-19 or post-pandemic factors and their impact on the computing graduate's employability and career success journey.

5.2 The Proposed Model
Figure 8 presents a comprehensive model that incorporates both internal and external factors contributing to a graduate's career success. The external factors include economic, social, political, and technical influences, which constitute the broader environment shaping the professional landscape in which graduates operate. These elements are positioned around the outer boundary of the model to signify their pervasive impact on graduate outcomes.
Within this environment, the internal success factors comprise Academic Performance, LE, and Emotional Intelligence, particularly the attributes of GT and

RE. These internal elements are enclosed within an Agile and Adaptive Layer, emphasizing the importance of flexibility and responsiveness to evolving challenges such as the COVID-19 pandemic and Climate-related disruptions.

At the center of the model lies the graduate's career success, which is directly influenced by internal factors. academic performance and LE contribute to the attainment of PLOs. Career success is shaped by academic achievement, emotional intelligence, and experiential learning. Emotional intelligence, in particular, plays a moderating role in this relationship. Graduates with higher levels of GT and RE are more likely to convert their LE into substantial career accomplishments.

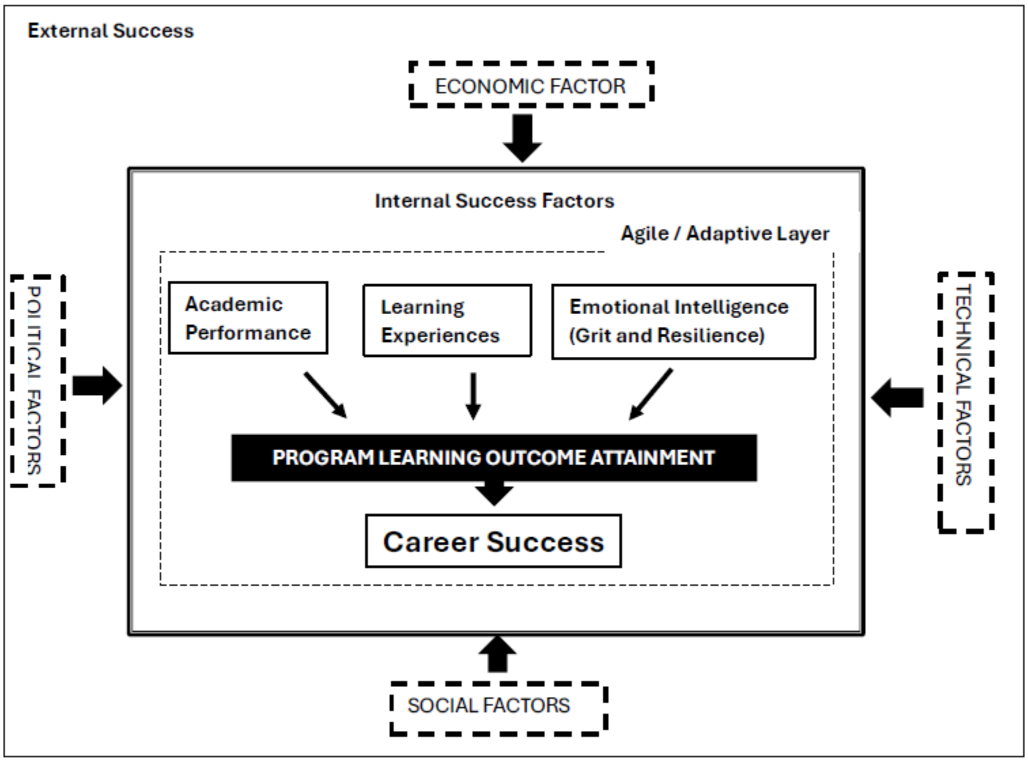

Figure 8: The agile career success model

The attainment of PLOs and the achievement of career success together form the foundation of graduate employability. Employability is supported by a combination of academic skills, personal attributes, and adaptability to external environmental factors. The model ultimately highlights the need for a balanced integration of internal capabilities and contextual awareness to ensure sustained success in an increasingly competitive and dynamic professional landscape.

5.3 Comparison with Existing Literature

The findings support GT as a strong positive predictor of career success in graduates, in terms of both salary progression and career progression. This result is consistent with the theoretical argument that GT—effort and passion for long-term goals (Duckworth et al., 2007)—is an important psychological resource for coping with setbacks in early career and for persisting in high-stake work contexts. Their result is consistent with previous findings by Eskreis-Winkler et al. (2014) who demonstrated that GT predicts success in the long-run in career and academic contexts, more than IQ and talent. In the Malaysian context, this finding is consistent with Yau and Shu (2023) which highlighted the line of positivity role of GT in student's engagement and goal pursuit under stress and disruption as evident in the COVID-19 outbreak.

The results provide support for H5: there was a statistically significant positive relationship between RE and career success for computing graduates. This is supported by existing evidence, such as Chuang and Huang, (2025) who observed increased confidence and flexibility among nursing students when exposed to RE-building programs, reflecting a comparably higher professional readiness. Similarly, (Otaki et al., 2025) reported that students who were exposed to interventions aimed at building their RE were also better equipped to deal with career uncertainty, a competence particularly appropriate in today's post-pandemic world.

5.4 Methodological Contribution

The research utilized an exploratory sequential mixed-methods approach, which evaluated the hypothesized relationships among constructs, including LE, GT and RE, and outcomes as graduates, with an initial, quantitative phase to measure these variables, Second, a qualitative phase was added to investigate the statistical results in a more detailed manner.

At a quantitative level, strong relationships were also unveiled, namely the effects of GT and RE on career success and the mediation of these personal resources between LE and employability in the job market. Nevertheless, not all the hypotheses were supported, and some pathways were weaker than expected. To delve into these results, a subset of graduating students was interviewed qualitatively to make sense of the "why" behind the numbers and deepen the contextual information.

The qualitative results helped to explain and nuance the model in three key aspects. They began by replicating the quantitative findings and stressing the importance of GT and RE in the development of one's career amid the aftermath of COVID-19. Second, interviewees helped unpack the results that presented an unclear or weaker picture in the statistical analysis; for instance, while quantitative data showed a slight relationship between LE and RE, the interviewees explained that perhaps this was because teaching quality was highly variable, structured support was lacking, and learning environments were passive. Third, the qualitative phase revealed new and unmeasured themes, e.g., the role of peer support, cultural norms, and the perceived value of computing degrees, which indicate opportunities for enhanced model development and future research.

This synthesis of findings is meant to be complementary such that the quantitative findings are broadly confirmatory and generalizable, while the qualitative narratives deepen understanding by adding lived experience, context, and mechanisms of action. These combined contributions enhance the soundness and generalizability of the agile career success model in the context of Malaysian computing education.

6. Discussion

6.1 Employment Outcomes

The study found that LE positively influences graduates' employability and career success. For instance, graduates' participation in extracurricular activities, social networking, community services, professional membership, internship, capstone projects, alumni events, employer projects, and guest lectures often determine the employability and career success of graduates beyond their academic achievements. Graduates who engaged in ongoing learning and skill enhancement reported higher job satisfaction and faster career progression.

6.2 Program Learning Outcome Attainment

The PLOs are positively impacted by a graduate's LE, suggesting that rich and successful learning environments improve program objectives. The study also suggested mechanisms for curricular alignment with industry needs and taught insights to enhance graduates' employability in tertiary education. Graduates from these programs integrate technical abilities with practical industry expertise, resulting in a cohort of more confident and employment-ready professionals. The LE of graduates make it easy for them to achieve the PLOs.

6.3 Resilience and Career Outcomes

The resilience level garnered a positive relationship with career success among graduates, measured by salary, career advancement opportunity, and recognition, as well as job quality (work environment, work-life balance, and job security). The theme analysis reveals the most significant resiliency attributes from graduates in supporting success in the career journey of all graduates. The study reveals the importance of patience, perseverance, and self-reflection in overcoming challenges. It highlights the importance of taking breaks, prioritizing tasks, and assessing the impact of obstacles.

6.4 Grit and Career Success

Grit and career success is concluded after the qualitative analysis, based on which GT also helps graduates climb the career ladder, improve salaries, and have higher job satisfaction. Most of the interviewees flexed their GT in their answers. This is why they achieved success in their career journey as fresh graduates; hence, the GT attribute plays a major part. The study revealed the importance of managing time, improvising, and seeking advice. It emphasizes the importance of breaking down problems into smaller tasks, perseverance, and teamwork. A journey is marked by facing challenges, managing stress, and maintaining focus. The importance of seeking feedback from managers and colleagues, maintaining a structured timeline, and developing advanced project management skills were highlighted.

6.5 Implications for Education Providers

According to the results, significant strategies are suggested for educational institutions to increase curriculum relevancy and employability skills.

6.5.1 Curriculum Enhancement

Industry-led skills and knowledge should be integrated in the curriculum. This means upgrading or updating course material to be able to deliver the curriculum in line with current market demands and technological advancements. The addition of modules such as digital literacy and emerging technologies should be encouraged to help graduates better prepare for an ever-changing job landscape.

6.5.2 Soft Skills Development

Roll out programs and workshops that focus on soft skills such as communication, teamwork, etc. incorporate exercises that can inculcate GT and resilient traits amongst the graduates. Employers greatly value these abilities, and they are crucial to getting ahead in careers.

6.5.2.1 Internship Programs

Industry partnerships may be developed for more internships, ensuring that these are field-related and provide solid work experience. An internship is the period when graduates reinforce knowledge and practical experience that aids their journey in their career life.

6.5.2.2 Sustained Feedback Mechanisms

Employers and alumni may develop mechanisms for regular feedback to improve curriculum and pedagogy. This feedback can be collected using surveys and focus groups. Further, the feedback from graduates or alumni also helps assess where they are in their academic and career journey, bridging the education-employment gap.

6.6 Implications for Policy Makers

The role of policymakers will be vital to bridge the education-employment gap. This implies policy interventions as follows:

6.6.1 Industry Education Collaboration

Education and industry sectors should enhance coordination between the more effective curriculum orientation to the job market. This might mean creating industry advisory boards for academic programs. This can only be achieved if education providers work in tandem with the industries to ensure that graduates get a timely opportunity for hands-on experience in their respective fields. This will give more confidence to the graduates and help them survive better in their career journey.

6.6.2 Funding and Support

Invest in programs that increase employability, e.g., vocational training and lifelong learning initiatives, by providing funding & resources. A generous scholarship or grant program for training programs and skill-based development could entice graduates into additional work.

6.6.2.1 Employment Initiatives
Promote programs that help young people get jobs, such as career counselling services placement, and mentorship. Incentivizing hiring graduates of college/vocational, and even primary education, may also help. Promotion of regular industry professional guest lectures and seminars for students to relate to real-world issues and processes.

6.6.2.2 Monitoring and Evaluation
Educational initiatives may be tracked and evaluated to determine how well they are meeting labor market demands. Program relevance may be attempted through periodic assessments and changes in response to labor market data. Longitudinal training programs may be instituted to stay relevant through lifelong learning, which enables graduates to continue mastering the latest skills to keep up with workforce change.

6.7 Advice for Employers
The following strategies could also be implemented by employees to provide graduates with a supportive entryway into the workforce.

6.7.1 Recruitment Practices
Employers may recruit graduates with academic qualifications and the appropriate soft skills. Employers may use assessment centers to assess competencies in totality. In practice, tests and team exercises are used when hiring a graduate.

6.7.2 Talent Development
Employers may invest in preceptorship training and continuing professional development to support graduates in the initial years' skills, personalized transition programs, and career progression; encourage mentorships and life-long learning, such as leadership development programs or technical skills workshops.

6.7.3 Internship and Apprenticeship Programs
Internship and apprenticeship courses may be organized to offer hands-on learning targeted at the skills. Employers may ensure proper oversight in line with the objectives of the firm. Rotational programs can also be effective (for example, these expose interns to multiple departments). Greater engagement between academia and industry may be encouraged to enable richer internships and experiential learning opportunities for students.

6.7.4 Feedback and Engagement
Employers may keep lines of communication with colleges and universities open, provide feedback on the performance of graduates, and suggest changes to curricula. Relationships can be created through regular meetings and collaborative projects with teams.

6.8 Novelty and Contributions
This study has offered several novel contributions to the existing literature on graduate employability and career success. Whilst past research has focused on technical skills or academic performance in the context of employability, in this

study GT and RE were highlighted as two psychological characteristics that are neglected in employability research and are introduced as catalysts of career success. The quality-of-life analysis finds that these personality characteristics do impact on job satisfaction, career prospects, and flexibility in the work force.

The proposal of the agile career success model is an important theoretical development. Contrary to static models of employability, the agile model captures internal qualities and external enablers (internal qualities: persistence; lifelong learning; motivation, external enablers: a curriculum relevant to the needs of industry; internships; policy support) to provide a dynamic and future-oriented picture of graduate success.

7. Conclusion, Limitations, and Future Directions

7.1 Conclusions

The research revealed the impact of immersive LE, industry-relevant curriculum, and RE on aligning transitions to employment for graduates. It is through this alignment with industry needs, the cultivation of soft skills, and the development of a lifelong learning mentality that higher education institutions can begin to prepare their graduates better. Collaboration among academia, industry, and policymakers bridge the education-employment gap for better career outcomes for graduates.

This alone should make the findings especially interesting to policymakers because implementing them can help increase a more skilled and adaptable workforce, which is ultimately beneficial for the overall economy and society. An agile career success model proposed (Figure 8) consists of external factors and internal factors that contribute to the employability and career success of graduates. The agile model developed should be capable enough to handle unforeseen changes if they occur in the future.

7.2 Limitations

While this study provides important insight, it also has some significant limitations. The research is constrained to Klang Valley in Malaysia; therefore, the applicability of findings may differ among regions with different economic contexts and cultures, as well as education levels. This is cross-sectional data as it examines the individual at the earliest point in our study. Future research should ideally adopt a longitudinal approach to investigate the long-term consequences of diverse factors that may contribute to or hinder career success and employability.

Tracking participants over multiple stages of their life, allows a better understanding of the evolving influence of personal traits and learning environments on career success and employability. Future studies should also incorporate sample data nationwide to capture more diverse and representative input. Since the findings are based on self-reported data from graduates, there is a potential bias present because participants may have overstated their skills and experiences.

The study on socio-economic technologies' impact on employment outcomes and career success has significant implications for the United Nations Sustainable Development Goals, particularly SDG8, which aims to promote inclusive and sustainable economic growth, employment, and decent work for all. Understanding the intersection between socio-economic technologies and other factors such as education, socioeconomic status, and geography are crucial for achieving this goal. Critical examination of these interactions can inform policies for equitable access to career development opportunities, aligning with SDG8. Future research should address the importance of a more holistic lens for addressing access to inclusive employment outcomes worldwide.

7.3 Future Works

Future research could explore and address the limitations of the current study by adopting different research methodologies or conducting longitudinal studies. Since this study was located, the observed phenomena may be influenced by specific regional factors, which limit the generalizability of the findings to other settings.

Expanding the scope to include multiple locations would provide a more comprehensive understanding of graduate employability and career success across diverse contexts. This broader approach would enable the development of more precise and practical interventions tailored to varying local conditions.

Due to time constraints, longitudinal design was not feasible in this study. However, implementing longitudinal research would offer valuable insights into how variables evolve over time and clarify cause-and-effect relationships that cross-sectional studies cannot capture. Such research is essential to grasp how motivation and external pressures related to sustainable practices influence employer expectations and potentially redefine what constitutes a successful employee.

To further enhance the applicability of future findings, it is recommended that research samples be diversified to include graduates from various regions across Malaysia, such as the East Coast states, Sabah and Sarawak. This inclusion would capture a wider array of socioeconomic backgrounds and cultural influences, providing richer data and a more nuanced understanding of the factors shaping graduate outcomes nationwide. To facilitate better integration in the future, mixed methods studies could use a more concurrent or iterative design, in which qualitative data directly drives item revision to the quantitative measure or explains unexpected statistical results.

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Appendix 1

SKEWNESS AND KURTOSIS

	Mean	Median	Observed min	Observed max	Standard deviation	Excess kurtosis	Skewness
Grit	0.000	-0.062	-2.955	2.263	1.000	1.887	-0.412
LearnExp	-0.000	0.059	-1.864	1.692	1.000	-0.813	-0.132
PLO	0.000	0.303	-1.951	1.553	1.000	-0.850	-0.126
Resilience	0.000	-0.276	-1.656	2.485	1.000	-0.001	0.651
Satis	0.000	0.040	-1.830	1.504	1.000	-0.986	-0.288

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Geographic Information Systems Methods in Practice: Higher Education Curricula and Practitioner Registration Standards in South Africa

Sizakele Matilda Serame [1] and Gbenga Abayomi Afuye [1,2,*]

[1] Department of Geography and Environmental Science, University of Fort Hare, Private X1314, Alice 5700, Eastern Cape Province, South Africa; sserame@ufh.ac.za
[2] Geospatial Application, Climate Change and Environment Sustainability Lab-GACCES, University of Fort Hare, Alice 5700, Eastern Cape Province, South Africa
* Correspondence: afuyeabayomi@gmail.com

Abstract: Integrating geographical information systems (GIS) in various sectors has significantly increased the global demand for skilled professionals, particularly in South Africa. Despite integrating GIS methods into higher education curricula, challenges like resource limitations, curriculum updates, and competency standardization may limit practical training scope. This study explores the alignment of South African qualifications and practitioner registration standards, including the South African Qualifications Authority (SAQA), National Qualification Framework (NQF) requirement, South African Council for Natural Scientific Professions (SACNASP), and South African Geomatics Council (SAGC), with job market demands. A structured literature review of scientometric research from 2004 to 2023 was used to assess the current GIS educational programs in South Africa, identify training gaps and skills, and propose strategies to enhance their relevance. The results indicated that, despite adhering to policies and standards, the GIS curriculum's capacity to meet market demands is uncertain due to insufficient job market research and disparities between higher education curricula and practitioner registration standards (HEC_PRS). The University of Cape Town (UCT) and the University of South Africa (UNISA) are the top two South African institutions contributing significantly to GIS practice through published articles, with a few coming from affiliated research centres. The results revealed significant changes in higher education from 2004 to 2018, with teacher education becoming the most prominent theme. The 2019–2021 period emphasized interconnectedness between curriculum development, experiential learning, and 21st-century skills, while the 2022–2023 segment used curriculum as the most prevalent theme in this field. The prominence of key terms like "higher education", "curricula", "students", and "teaching" highlights the role of educational institutions in preparing students for professional practice in GIS. These findings provide strategies for evaluating current GIS practices, identifying areas for improvement, and implementing modifications to enhance their effectiveness in practice.

Keywords: curriculum development; GIS methods; higher education; teaching and learning; sustainable development

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1. Introduction

Misconceptions often arise regarding the complexity of tasks like map-making, which often require prior knowledge of spatial analysis and training. Modern technologies like Geographic Information Systems (GIS), often assumed to be easy to use for map analysis and decisionmaking, further fuel this misconception [1,2]. However, GIS, like any tool, necessitate a fundamental comprehension of their language, encompassing spatial awareness, cognition, spatial analysis, and geographical data. Integrating higher education teachings with GIS professional requirements ensures that student training is tailored to individual student needs, aligning with work requirements and competencies [3,4].

Hence, this study explores the alignment of GIS curricula with South Africa's registration requirements, emphasizing the significance of this alignment for its seriousness. Numerous studies underscore the significance of integrating basic geographical concepts and principles for effective GIS user service, potentially impacting the GIS profession in South Africa [5–8]. A well-developed spatial awareness, essential in GIS education and practice, involves understanding one's environment, organising surroundings, and recognising spatial patterns, making it a skill rather than a necessity. Positioning is comprehending one's position among one's surroundings, including people and objects. A study accentuates the significance of spatial awareness in achieving effective orientation, wayfinding, and navigation, highlighting its enhancement through exposure to diverse environments and territories [9]. Spatial analysis requires reading spatial patterns and making decisions based on proximity, scale, and direction.

Global Positioning Systems (GPSs) and smartphone devices rapidly complete spatial analysis, making them accessible to non-specialists [9,10]. The effectiveness and efficiency of GIS as a tool are largely dependent on the user's proficiency in the tool's language [11,12]. Spatial awareness is a vital skill in GIS, and its significance should not be underestimated in the field. Many studies have proven the successful application of GIS in field research projects, their advancements in understanding complex spatial patterns, and their real-world impact in addressing environmental and societal challenges [2,8,12,13]. Therefore, the current GIS education in South African universities is inadequate, indicating a gap between academic programs and industry demands, particularly in high school curricula. The higher education curricula and practitioner registration standards (HEC_PRS) in South Africa provide frameworks and guidelines governing education, training, and professional qualification in specialized fields like Geographic Information Systems, Geomatics, and related disciplines. These elements are crucial for graduates to possess the necessary knowledge, skills, and credentials to meet industry standards and contribute effectively to their respective sectors, ensuring that they are well-equipped to meet these standards. Therefore, the gaps in higher education curricula and professional body registration standards pose significant implications for the GIS workforce. This study aims to enhance GIS education, professionalise the workforce, and bridge the gap in curriculum development and GIS technology to tackle societal challenges. In addition, the study employs scientometrics to analyse the evolution of research articles on GIS methods in South Africa's higher education curricula and practitioner registration standards (HEC_PRS). Scientometrics is widely used for assessing research advancements, scientific publications, and collaboration networks across various niche areas [14–17]. This study examines South Africa's curricula integration of Geographic Information Systems methods in practice in HEC_PRS. Additionally, the study evaluates GIS education and professionalisation by promoting curriculum alignment and fostering a skilled workforce capable of using spatial intelligence for sustainable development. Understanding the dynamic trend of GIS methods in South Africa's HEC_PRS is crucial given their prominence in the workforce and the global economy.

Spatial Analysis

Quantitative studies primarily utilize numbers to count and measure people or objects, as they are the foundation for data analysis. Spatial analysis involves manipulating spatial data to identify, evaluate, and predict relationships. Several authors agree that the common characteristic of spatial data is a study of phenomena that occur in space [18–21].

> "The quantitative study of phenomena that manifest themselves in space." (Anselin 1989, 2)

> ". . .studies how the physical environment and human activities change with distance from reference locations or objects of interest" (Wang 2014, 27).

> "The process by which we turn raw data into useful information, in pursuit of scientific discovery, or more effective decision making" (Longley et al., 2011).

"A set of techniques designed to find a pattern, detect anomalies, or test hypothesis based on spatial data" (Goodchild 2008, 200).

Spatial analysis is a term that includes "spatial data manipulation through Geographical Information Systems (GIS), spatial data analysis in a descriptive and explorative way" [22]. A study described spatial analysis as a collection of methods and techniques that integrate concepts to analyse, investigate, and explain geographic context patterns, actions, or behaviours [23]. Spatial analysis has various functions, ranging from investigating population patterns and vegetation species to determining the distance and scale of an area [22,23]. The concept of spatial analysis is divided into various categories for its various uses, as follows:

Social systems: for studying human interaction in social, political, and economic contexts;

Environment: studying natural phenomena, natural resource management, and sustainable development;

Economy: for analysing, mapping, and modelling interrelations among humans and various economic dimensions of economic life.

Geographic Information Systems are one way of conducting spatial analysis. Accordingly, GIS is a powerful tool for comprehensive location study, enabling the identification and analysis of land features, climates, boundaries, populations, and resources [24]. GIScience, a combination of GIS software and hardware, enables users to manipulate layers to answer questions, explain phenomena, or track events over time. GIS software can be categorized into general-purpose geo-computation platforms like ArcGIS, QGIS, and SuperMap and specialized tools like Landserf, TauDEM, and SoLIM [25]. Research indicates that, despite the advancements in spatial analysis software, proper training is still necessary for users to effectively utilize these tools [21,25,26]. A study indicates that successful software usage necessitates users to complete specialized courses or even pursue degrees [25]. The increasing use of GIS in various fields may pose challenges for non-GIS-trained individuals, potentially leading to a mismatch or insufficiency in GIS-quality work. This study aims to assess the alignment of South African qualifications and practitioner registration standards, including the South African Qualifications Authority (SAQA), National Qualification Framework (NQF) requirement, South African Council for Natural Scientific Professions (SACNASP), and South African Geomatics Council (SAGC), with job market demands. Additionally, the study explores the implementation of GIS education in South African universities, focusing on classroom teaching and practical applications for sustainable development, addressing three key questions.

(i) How do we integrate GIS curricula in South African high school curriculum policy and practitioner registration standards based on learning objectives for GIS skills and qualifications?
(ii) How does HEC_PRS overcome the challenges of regional disparities and create opportunities for harmonization to enhance accessibility and applicability in the workforce?
(iii) What are the evolutionary trends of the dominant themes influencing GIS methods in South Africa's HEC_PRS hotspots using scientometric analysis for future research directions?

Hence, the findings of this study are crucial for overcoming barriers and utilizing GIS opportunities to improve field research, drive innovative solutions, promote equitable development, and provide sustainable professional workforce opportunities.

2. GIS Education

GIS education is a comprehensive academic and professional training that focuses on the theory, principles, and practical applications of GIS technology [27,28]. GIS education is crucial for creating a skilled workforce capable of using spatial data for decisionmaking, planning, and problemsolving across sectors, identifying gaps, addressing regional disparities, and offering strategies for integration and standardization. The Curriculum and Assessment Policy Statement (CAPS) by the Department of Basic Education guides

South Africa's high school curriculum. For instance, GIS application in grade subjects aims for a standardized, equitable education system, preparing students for higher education, vocational training, and workforce readiness [29]. The CAPS policy outlines the learning objectives, content, and assessment criteria for Grade 10 to Grade 12 students. GIS education covers fundamental concepts, software proficiency, spatial analysis, cartography, map design, data management, applications across disciplines, remote sensing integration, and project-based learning [30,31]. However, GIS is taught as part of the geography subject in the final three years of high school. The curriculum focuses on improving students' understanding of GIS data, preparing them for higher education, and providing basic training in GIS skills and methods from Grades 10 to 12, as shown in Table 1.

Table 1. GIS curriculum focused on skills and techniques.

Grade 10	Grade 11	Grade 12
Concept of GIS.	Spatially referenced data.	GIS concepts: remote sensing and resolution.
Reasons for the development of GIS.	The spatial and spectral resolution.	Spatial and attribute data, and vector and raster data
Concept of Remote Sensing.	Different types of data: line, point, area, and attribute.	Data standardisation, data sharing, and data security
How remote sensing works.	Raster and vector data.	Data manipulation: data integration, buffering, querying, and statistical analysis.
GIS concepts: spatial objects, lines, points, nodes, and scales.	Application of GIS to all relevant topics in the grade.	
	Capturing different types of data from existing maps, photographs, fieldwork, or other records on tracing paper.	Application of GIS by government and the private sector.
		Develop a "paper GIS" from existing maps, photographs, and other records on layers of tracing paper.

The South African Qualifications Authority has outlined the learning objectives for GIS qualification at the National Qualification Framework (NQF) levels 4, 5, and 6. NQF level 4 is an entry-level education for someone entering the field of GIS; NQF level 5 is intended for persons who aim to achieve career advancement by gaining GIS skills, leading to the qualification. At NQF level 6, the individual will have a basic understanding of GIS data structures for data capture, their relationship to GI Science, and their potential benefits across various disciplines, as shown in Table 2.

Table 2. National Qualification Framework (NQF) levels based on GIS skills and qualifications.

Level 4	Level 5	Level 6
Launch the application and access geo-information.	A prescribed spatial reference framework will set up a data capture environment.	Demonstrate a generic understanding of what GIS is.
Perform basic queries and data manipulation.	Use the appropriate feature type when capturing data.	Demonstrate an appreciation of the specialist knowledge needed to build a proper GI Science.
Produce primary product output.	Explain the basic theory and principles of spatial data models in data capture.	Demonstrate an understanding of how GIS can be used in different industries.
	Explain basic database structures for data capture.	Demonstrate an understanding of the functionality available from a GIS.
	Exploit big geo-data	

Overall, GIS education is available at various levels, including secondary schools, colleges, universities, and through professional development programs. The goal is to equip individuals with the necessary knowledge and skills to utilize GIS technology in various industries and sectors effectively.

GIS in the Workplace (Job Requirements and Work Scopes)

Geographic Information Systems positions require technical skills, domain knowledge in geography, environmental science, and urban planning, and soft skills in communication, problemsolving, and project management. Advanced positions may necessitate programming, spatial statistics, database management, and programming proficiency. GIS professionals are advised to stay abreast with emerging technologies such as machine learning and cloud-based GIS platforms. GIS professionals play a crucial role in decision-making processes by providing valuable insights from spatial data analysis and visualization across various industries. GIS-related job requirements and scope vary significantly based on the industry and specific job functions. The relevance of GIS taught in higher education in South Africa to workplace requirements can vary depending on numerous factors [32,33]. These factors may include the curriculum alignment with industry requirements, practical skills development, industry collaboration, technology focus, soft skills, job market trends, and continued professional development [34,35]. To assess if South Africa's GIS education meets workplace needs, it is recommended to consult recent graduates, employers, and industry experts for feedback on strengths and areas for improvement. Some of the GIS-recognised practitioner registration standards and registration set by professional bodies are shown below.

1. The South African Geomatics Council (SAGC) 2024 regulates GIS practice in South Africa, stipulating the requirements and conditions for registration as a GIS candidate, technician, technologist, or professional. The Geomatics Profession Act (Act 19 of 2013) makes allowances for people from professions outside of GIS to register, provided the process follows the following stages:

- Completion of an academic qualification that complies with the particular branch and category (https://www.sagc.org.za/ (accessed on 15 May 2024)).
- Registration as a candidate.
- Completion of prescribed work-integrated learning.
- Successful completion of the SAGC Law exams and assessments.
- Registration in the respective category.

The registration process requires that an academic qualification offers particular Knowledge Areas (KAs), which are as follows:

- Fundamental KAs—Geographical Science: Geographical Science, Mathematics and Statistics, and Physical Science. The students should have geographical knowledge and spatial orientation knowledge.
- * Core KAs: Analytical models, conceptual foundation, cartography and visualization, design aspects, data modelling, and data manipulation. Students should have the ability to use GIS software to collect, process, and model data.
- Non-core KAs—Research methodology: The students should have the ability to conduct research projects.

Registration with the South African Geomatics Council (SAGC) is often a requirement in the GIS workplace; it is an added advantage in some work advertisements. This indicates that the GIS content in higher education has to adhere to the KAs stipulated by the Council, but this is not always the case. This creates a gap between higher education content and job requirements, which begs the following question: Are the GIS curricula relevant to what is required to what is needed in the workplace?

2. The South African Council for Natural Scientific Professions (SACNASP) Act of 2003 mandates the registration and practice of natural scientists in various fields, which are now gazetted in the amended schedule I of the Act (NOTICE 469 of 2021).

Some currently gazetted fields of practice related to GIS are listed as follows—the SACNASP's current Code of Conduct for registered scientists.

- Geospatial science, water resources science, environmental science, ecological science, atmospheric science, and conservation science (https://www.sacnasp.org.za/ (accessed on 16 May 2024)). The goal is to uphold high professional and ethical standards for the natural scientific workforce, promote science engagement in South Africa, and facilitate professional development and transformation.
- * Geological and Earth Science (Includes L4 Competent Natural Science Geo-Professionals). The Natural Scientific Professions Act of 2003 mandates all natural scientists to register under Sections (18) and 20(2)(a).
- Registration offers quality assurance of one's capability to current or prospective employers/clients. The Council stipulates that GIS content in the workplace must adhere to the code of conduct if a person is a practising natural scientist in South Africa. South African natural scientists must register under the Natural Scientific Professions Act to ensure legal compliance and quality assurance for employers and clients. The Act requires all practising natural scientists to adhere to Sections (18) and 20(2)(a). This may not always be the case, leading to a gap between education content and job requirements. This raises questions about whether GIS curricula are relevant to any sub-fields under appropriate fields of practice in Natural Science or are not a requirement in the workplace.

3. Data Identification and Methodology

3.1. Documentary Review of GIS Methods in Practice

The study utilized specific search phrases to identify articles on "geographic information systems methods in practice" and "higher education curricula and practitioner registration standards in South Africa". The Scopus, Google Scholar, and Web of Science databases were utilized as search engines to review and search for English-only papers. The documentary analysis utilized a qualitative research method to review changes and transformations in existing research on geographic information systems methods in practice, higher education curricula, and practitioner registration standards in South Africa through peer-reviewed journal publications [33,34]. The content analysis was analyzed using GIS methods to align South African qualifications and practitioner registration standards [35,36], including SAQA, NQF requirements, SACNASP, and SAGC, with job market demands, ensuring effective data analysis in practice.

3.1.1. Scientometric Mapping

Scientometrics is a widely used method that reviews academic research to develop a new approach and provide a scientific understanding of a niche research area [37,38]. This method encourages researchers to advance their specialisations, influencing academic affiliations and the thematic evolution of keywords through findings from review-based studies [39]. The literature has connected scientometric studies with a conceptual–theoretical review based on existing research or studies [27,29]. Scientometric analysis is a methodological approach used to assess the scope and appropriateness of research efforts in a specific area of expertise [16,37–39]. The analysis utilized the search phase "Geographic Information Systems Methods in Practice" OR "Higher Education Curricula" OR "Practitioner Registration Standards in South Africa" to retrieve published research documents and summarise our scientific findings on the research outputs. Zipf's law was used to select frequent author keywords that reflected the broader research subjects, directions, and trends of all publications in the field [40].

3.1.2. Scientometric Data Identification and Processing

This study utilized the Scopus database for systematic data mining on 15 May 2024, as shown in Table 3. The scientometric analysis was conducted using the bibliometrix R-package (RStudio v.3.4.1 software) and biblioshiny, both open-source software designed for web interface use. The documents focused on GIS methods in higher education curricula and practitioner registration standards (HEC_PRS) in South Africa were retrieved from 46 articles published between 2004 and 2023. The databases were selected based on their reliability, coverage, efficiency, and high-impact scientific research [39,40]. This study used search criteria for Scopus based on these keywords: ("Geographic Information Systems Methods in Practice") OR ("higher education curricula") OR ("Practitioner Registration Standards in South Africa") AND PUBYEAR > 2004 AND PUBYEAR < 2023 AND (LIMIT-TO (AFFILCOUNTRY, "South Africa")). The search generated the titles, abstracts, and keywords (author keywords and keywords plus) of articles published between January 2004 and December 2023. Studies utilize precise titles and topics in databases to ensure significant recovery and minimal loss compared to multiple searches [37–40]. In addition, the retrieved publications included articles, proceeding papers, review articles, book chapters, editorial materials, book reviews, and books. The analysis used 46 articles from the Scopus database, specifically focusing on GIS methods in HEC_PRS in South Africa, as detailed in Table 3. The study involved 104 international authors with a global co-authorship index of 21.74% and 18 single-authored documents, contributing to advancements in scientific research publications on G_MFRA during the study period. The study evaluated published articles from 39 sources, with an average citation of 9.457 per document, 2.33 co-authors, and an average age of 5.09 per document. The annual percentage increase rate for citations per analysis article in South Africa was 12.88%, indicating a minor focus on GIS methods in practice to develop high school curricula and sustainability policies, as depicted in Table 3.

Table 3. Descriptive information on GIS methods in practice.

Description	Results
Scopus	Database
Timespan	2004–2023
Sources (journals, books, etc.)	39
Documents	46
Annual growth rate %	12.88
Document average age	5.09
Average citations per doc	9.457
References	0
DOCUMENT CONTENTS	
Keywords plus (ID)	13
Author's keywords (DE)	176
AUTHORS	
Authors	104
Authors of single-authored docs	18
AUTHORS COLLABORATION	
Single-authored docs	20
Co-authors per doc	2.33
International co-authorships %	21.74
DOCUMENT TYPES	
Article	31
Book	1
Book chapter	8
Conference paper	3
Review	3

4. Results and Discussion

4.1. Assessment of GIS Methods in Practice

GIS methods are constantly evolving to meet specific spatial analysis and decision-making needs across various sectors and industries [41,42]. GIS practice encompasses data collection, management, spatial analysis, geoprocessing, cartography, visualization, modeling, decision support, web and mobile GIS, and spatial data infrastructure. Consequently, GIS courses and their applications enhance decisionmaking, critical thinking, and inquiry-based and learner-centred learning, improving education quality. GIS professionals utilize these techniques to provide valuable insights, address intricate spatial issues, and facilitate informed decisionmaking in both public and private sectors.

In response to the following question: Is the GIS taught in higher education in South Africa relevant to what is required in the workplace?We explored geography curriculum policies, GIS qualification requirements, and SAGC registration requirements. These are aligned at face value, limiting a skills shortage for GIS-focused jobs.

Can curricula and the South African Qualifications Authority (SAQA) and SAGC registration requirements align with what the job market requires? The relationship between geography curricula policies, GIS qualification requirements, and SAGC registration requirements can influence the skills shortage for GIS-focused jobs in South Africa. Each factor plays a significant role in controlling these requirements, as shown below.

1. Curricula Policies for Geography:

The relevance of geography curricula policies influences the content and structure of GIS education in South African universities [8,43]. An outdated or unsuitable curriculum can result in graduates lacking the crucial skills that employers require. Policies encouraging flexibility and innovation in curriculum design enable universities to adapt GIS programs to the industry's ever-changing demands. This can help to bridge the skills gap by ensuring that graduates have the necessary skills.

2. GIS Qualification Standards:

Precise qualification requirements for GIS-related programs ensure a standardised level of knowledge and skills among graduates, which can assist employers in evaluating job applicants' qualifications [41,42]. The degree or certificate specificity of GIS qualification requirements can significantly influence the level of skills that graduates acquire. Specialised programs can produce highly skilled professionals, while general programs may offer broader but potentially shallower knowledge.

3. SAGC Registration Qualifications:

The SAGC registration sets professional standards for geomatics practice, including GIS. Due to the requirements for registration and the influence of qualifications and experience, GIS education often emphasizes specific skills [8,43]. SAGC's registration ensures that practitioners meet specific standards, indirectly addressing skill shortages by upholding professional competence, as shown in Table 4.

Table 4. Impact on the skill shortages in GIS-based SAGC registration.

Positive Impact	Negative Impacts
Clear geography curricula policies, GIS qualification requirements, and SAGC registration can help to address skill shortages by producing graduates with the required skills and credentials.	Overly rigid or outdated policies can hinder innovation and adaptability in GIS education, potentially leading to mismatches between graduate skills and industry needs.

4.1.1. Has the South African Curriculum Kept Pace with the Technological Advancements and Methods in GIS Practice?

South African geography curricula have adapted to incorporate Geographic Information Systems methods and technologies, keeping up with global geospatial trends [44,45]. South African education has integrated GIS methods and practices into its curricula through the following.

1. Integration into Geography Education: GIS have become a crucial element of geography education in South Africa. Schools- and university-level geography curricula frequently incorporate modules or courses centred on GIS concepts, applications, and techniques.

2. National Curriculum Statements: The South African Department of Basic Education has integrated Geographic Information Systems (GIS) into the National Curriculum Statement (NCS) for geography, especially in the Further Education and Training (FET) phase. This inclusion ensures that students are exposed to geospatial technologies and their practical applications.
3. Inclusion in University-level Programs: South African universities offer degree programs in GIS and related fields like Geographic Information Science and Geomatics. These programs extensively cover GIS methods and prepare students for careers in various industries where GIS is utilized.
4. Advancements in Research and Development: South African academic institutions and research organisations are actively involved in GIS research and development, contributing to its continuous evolution and integration into educational curricula.
5. Collaborative Initiatives: Educational institutions, government bodies, and private sector organisations collaborate to integrate GIS technologies into South African curricula. This collaboration ensures that educational content remains relevant and updated with technological advancements.
6. Market Demand and Employment Landscape: The increasing demand for GIS professionals in South Africa has influenced the integration of GIS into curricula. These curricula are designed to equip students with practical skills that are highly sought after in the job market.
7. Continued Professional Development (CPD): Initiatives are being implemented to offer continuous training and professional development in GIS for teachers and educators. This ensures that educators are adequately equipped to effectively teach GIS and stay abreast of the latest advancements in the field.

South African curricula have made significant efforts to keep up with the latest GIS methods and technological advancements. GIS and related fields curricula are constantly updated and refined to keep up with the latest trends and developments.

4.1.2. Practitioner Registration Standards: Assessment and Challenges

The current state of higher education curricula includes GIS courses offered by universities and technical institutions, which prioritise theory over practical application [45,46], reflecting the increasing emphasis on theoretical learning in the field. For instance, professional registration faces obstacles like costs, geographic access, awareness, and disparities among graduates, highlighting the gap between academic training and professional needs. The educational backgrounds and regional inequities of registered practitioners can significantly influence their professional competency and readiness [47,48]. Regional disparities in GIS education are primarily due to course quality, availability, and economic and social barriers, disproportionately affecting remote or underserved students and rural institutions. Rural and underserved institutions face challenges like resource limitations, faculty expertise differences, financial constraints, and limited practical training, limiting their access to GIS technology and software. Additionally, the curriculum-industry misalignment gap highlights a lack of practical GIS skills in education and outdated technologies in academic programs, necessitating professional registration and certification of SAGC, SAQA, SACNASP and NQF requirements to ensure GIS practitioners adhere to these standards. This study emphasises the importance of geo-information access for employers to enhance skills and competencies, improve accessibility, and increase awareness.

The continuous assessment and improvement of GIS methods are crucial for maintaining the competence of GIS professionals and ensuring that GIS education remains relevant to industry needs. This assessment should evaluate GIS methods, academic performance, and professional certification data through strategies, professional development, industry collaboration, policy, and regulation. Consequently, regular reviews of GIS curricula are crucial for ensuring alignment and relevance, considering feedback from employers and practitioners. This study provides strategies for assessing current GIS practices, identifying areas for improvement, and implementing modifications to enhance their effectiveness in practice. South Africa can tackle GIS skill shortages by utilizing industry feedback, improving curricula, promoting professional development, fostering collaboration, and implementing robust policies. The goal is to equip graduates with essential technical, problem-solving, and soft skills, fostering knowledge exchange and curriculum enhancement through collaborations between academia, industry, and professional organizations. Addressing educational disparities can bridge the GIS skills gap, enhance spatial data analysis capabilities, and promote sustainable regional development.

4.2. Scientometric Analysis

4.2.1. Analysis of Top Author's Affiliations and Thematic Evolution of Keywords

Figure 1 shows the top 20 contributors to the publication outputs of affiliated institutions regarding GIS methods in higher education curricula and practitioner registration standards (HEC_PRS) in South Africa. The University of Cape Town (UCT) was ranked first and was closely followed by the University of South Africa (UNISA), with (n = 6 articles, 13.04%) and (n = 5, 10.87%) published articles. Other South African institutions and affiliated research centres, including the North-West University, Universitat Autonoma de Barcelona, University of Johannesburg, University of Botswana, and Coventry University, ranked among the top 20 contributors. Collaborative pathways among South African scholars were intra-national and very scant, as indicated by the few articles. This connotes that studies on GIS methods in practice in HEC_PRS are rare. However, only a few South-African-affiliated institutions have received attention regarding GIS education in practice. This may also be attributed to the challenges of incorporating GIS modules or subjects centred on GIS methods, concepts, and applications in high school curricula. On the other hand, the publication of articles in the field by affiliated institutions needs to be more prominent to keep up with the global trends in geospatial information science education. This implies that research erudition is mainly witnessed at UCT and UNISA, contributing to the total number of publications in South Africa, while a few came from internationally affiliated institutions. Specifically, the UCT Geomatics Department accentuates a shortage of professionals in surveying, geographic information science, and remote sensing [44]. Globally, affiliated institutions and research centres may have significantly influenced the structure of collaboration and funding for geospatial information science education at the national level. Studies indicate that South Africa has been enhancing its international collaborations through mobility funding initiatives, focusing on reviewing GIS applications in secondary schools and enhancing skills in teaching with or through GIS [36,45,48]. This may significantly influence the development of GIS education in South Africa at various levels, including secondary schools, colleges, universities, and professional development programs. As such, this may signal a notable increase in GIS education, including methods in practice, concepts, and applications, particularly in high school curriculum development.

The relationship between the top author affiliations and the thematic evolution of keywords in South Africa's GIS methods in practice is depicted in Figure 1. The thematic advancement, research clusters, and origin were determined by analysing the occurrence of key phrases in the field. The bar's height indicates the frequency of publications used to understand and visualize the thematic evolution of keywords over time [49,50]. The thematic evolution of the author keywords revealed stable themes clustered into the following three research timeframes: 2004–2018, 2019–2021, and 2022–2023 (Figure 1). The results show that the most stable author themes with a significant appearance were higher education transformed into teacher education in 2004–2018. The second segment of 2019–2021 reveals higher education and curriculum development interconnected to several methodologies used in the research domain. These methodologies may include experiential learning, e-learning, and 21st-century skills, which evolved into higher education curricula and became prominent in 2019–2021. The last segment of 2022–2023 shows that curriculum remains the most commonly used keyword theme in this field in recent decades. The literature suggests that teacher education, design thinking, lifelong learning, entrepreneurship, and sustainability education could be integrated into curriculum development, design, and review. Therefore, GIS education in South African higher education curricula and high school curriculum policy is still lacking. This indicates its minimal use, particularly in education research, in South Africa [8,43,44]. This draws attention to the gaps in research and practice methods, as well as concepts and applications of GIS in higher education and high school curricula. The Sustainable Development Goals emphasize promoting spatial intelligence and pedagogical skills in teacher-training universities for sustainable development. This aligns with the Education for Sustainable Development Goals, SDG 4, to promote lifelong opportunities and inclusive quality education, incorporating various sustainability themes [45,46]. South Africa's research efforts to integrate GIS methods into practice, including practical skills development, industry collaboration, and technology focus, have not been fully incorporated. Others include job market trends, concepts, applications, soft skills, and professional development. Many studies have not fully considered these aspects, resulting in the insufficient integration of GIS methods in HEC_PRS in South Africa [23,50,51]. Therefore, the thematic evolution of the author keywords highlights the scientific progress and research gaps in applying geospatial technologies to South Africa's higher education curricula and practitioner registration standards (Figure 1).

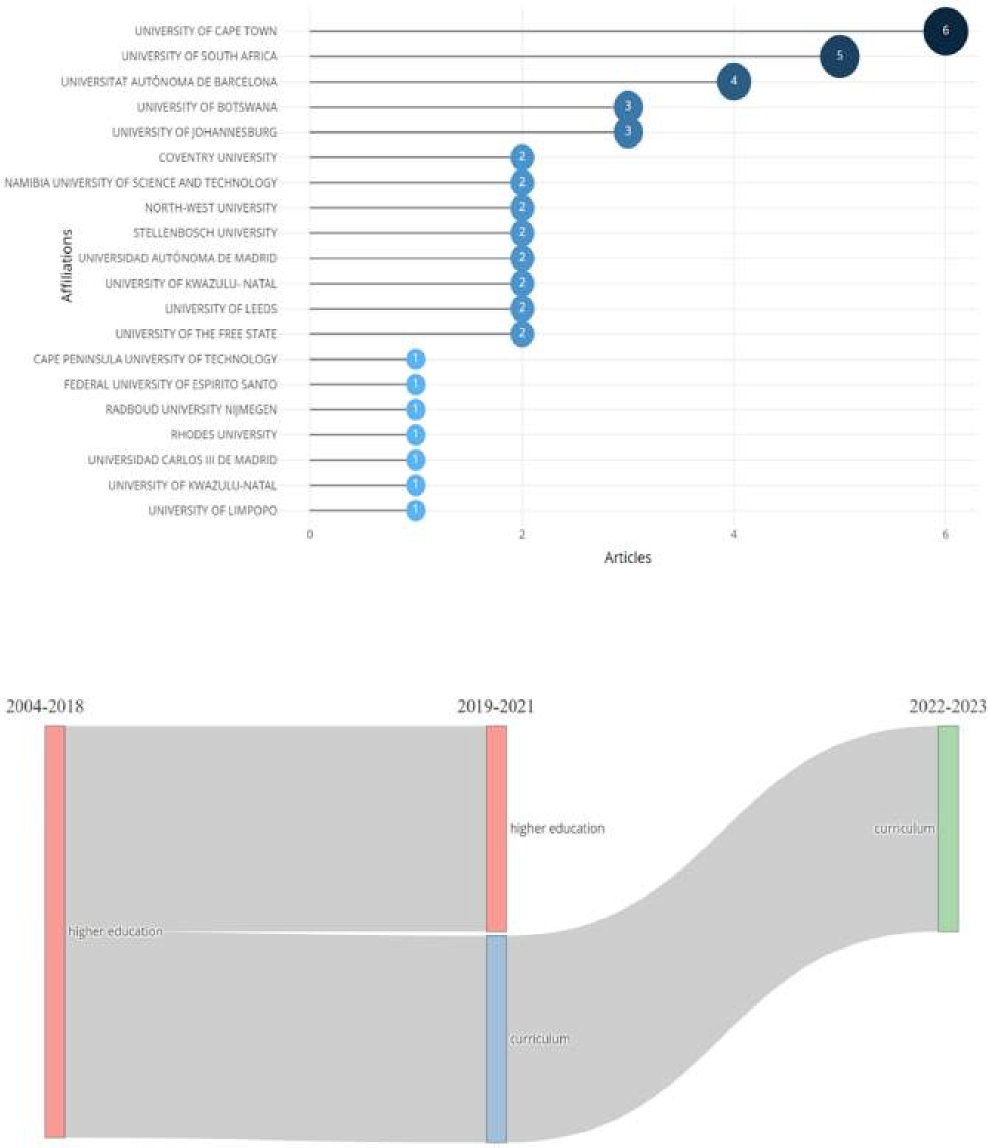

Figure 1. Relationship between the affiliations of top authors and the thematic evolution of keywords in South Africa's GIS methods in practice.

4.2.2. Analysis of Word Cloud Visualization

Figure 2 shows the word cloud of frequently occurring keywords in GIS methods in higher education curricula and practitioner registration standards (HEC_PRS) in South Africa. The word cloud visualization shows each keyword's strength and frequency within the literature, as indicated by size. The closer the keywords are to each other, the more likely their interrelation in the literature during the survey period. The word cloud visualizes the key terms in studies on GIS methods in HEC_PRS in South Africa, highlighting specific focus areas for future directions. For example, higher education, curricula, student, engineering education, learning, sustainable development, curriculum, and education. Other dominant terms are high education, e-learning, design, education computing, education curriculum, personal training, professional development, and perception, etc. The study reveals that higher education and curriculum are the main keywords in this niche area, based on the observed trends in GIS methods. Their development can be associated with the influence of curriculum development, design, and review on higher education curricula and policy [23,52,53]. The study of GIS methods in higher education and curriculum is undergoing continuous scientific innovation, which should be further advanced by addressing the identified gaps provided by these keywords. Keywords focusing on GIS methods, practical skills development, industry collaboration, technology focus, job market trends, concepts, applications, soft skills, and professional development did not significantly appear. South Africa's higher education curriculum incorporates word cloud visualization, utilizing GIS methods for sustainable development and modern technologies, emphasizing their interdisciplinary nature. Overall, the prominence of key terms like "higher education", "curricula", "students", and "teaching" underscores the centrality of educational institutions and their role in preparing students for professional practice within the field of GIS.. The identified gaps are crucial for advancing knowledge of GIS methods in HEC_PRS, particularly in South African high school curricula.

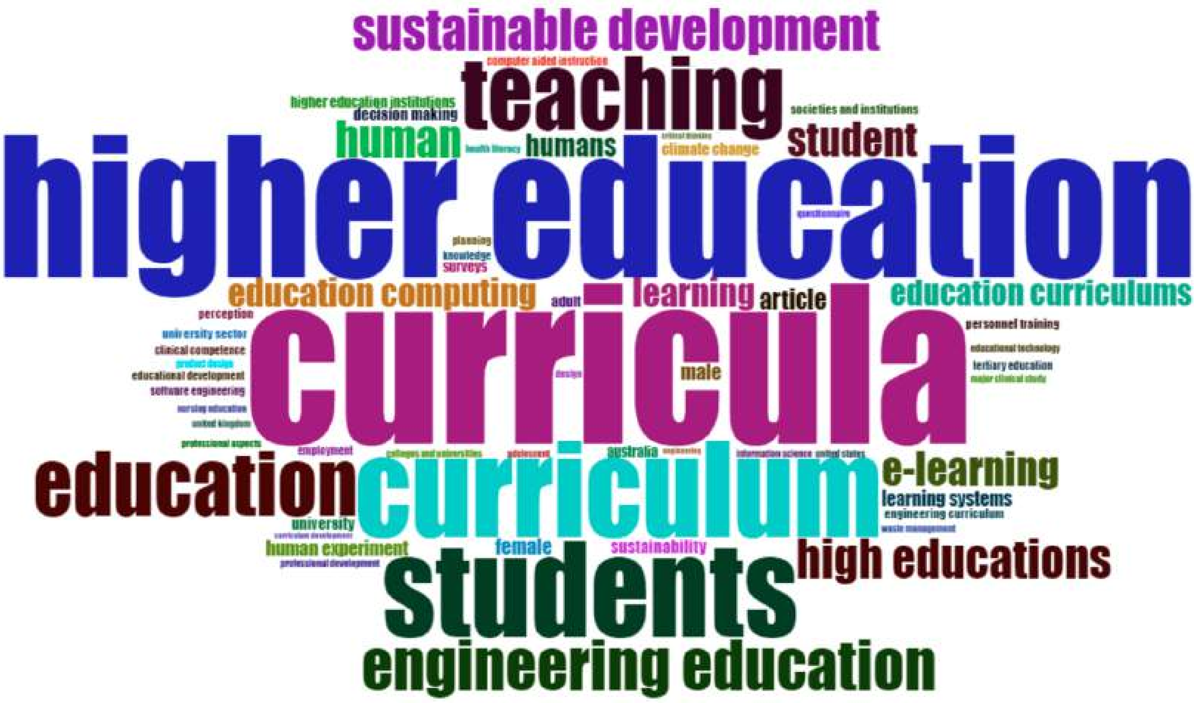

Figure 2. Word cloud visualization of GIS methods in HEC_PRS in South Africa.

4.3. GIS Technology and Advancements

Geographic Information Systems have revolutionised how we analyse and interpret spatial data, including data acquisition, processing, analysis, and visualization techniques [54,55]. Geographic Information Systems (GIS) have advanced significantly since their introduction in the 1960s, making possible their broad applicability in various fields [56,57]. GIS have played a vital role in various sectors of the economy and society, including transportation, public health, environmental management, urban planning, and disaster response [58,59]. Despite studies on their use in teacher training and retraining on GIS technology in high-income countries, GIS education is a relatively new field of study in southern African countries, particularly South Africa [45,48,60]. A study showed that only South Africa, Botswana, and Malawi teach GIS in their teacher-training universities and high schools, while Lesotho only teaches it in high schools [61]. In Zambia, Namibia, and Zimbabwe, GIS is not taught in teacher-training universities or high schools, but only applies to universities or departments that do not offer teacher training [62]. Moreover, GIS areis not offered at universities in Angola, Mozambique, Eswatini, and Lesotho [45,48]. In South African universities, including academic programs and industry demands, GIS education still needs to be improved, particularly in high school teaching and learning [7,48]. This study explores a comprehensive overview of GIS curricula in South Africa and their advancement in high school curriculum development and policy. The implementation gap delves into implications for policy, practice, research, and the prospects of GIS curricula. In addition to examining the societal effects and difficulties related to GIS implementation, it dives into the technical components, including data collection, processing, analysis, and visualization approaches. Developing GIS professionals through higher education curricula and practitioner registration standards (HEC_PRS) is crucial. There is a gap in the current state of GIS education in South African universities, including academic programs and industry demands [6,45,63,64].

The implementation gap in the HEC_PRS set by professional bodies has implications for the GIS workforce [11,35,65,66]. This study aims to enhance GIS education and professionalisation by addressing these alignments, fostering a skilled workforce capable of utilizing spatial intelligence for sustainable development. Examining the gap in curriculum development and associated GIS technology and methods is crucial in addressing societal challenges. This, therefore, would bridge the gap between higher education curricula and practitioner registration standards into promoting innovation in sustainability curriculum development. Over the years, one significant initiative in higher education institution curricula included subjects like Information and Communication Technology (ICT) [65,66]. Consequently, tackling socio-environmental challenges has extended beyond the conventional scope of ICT, which typically covers technology and services related to information processing, telecommunications, and electronic systems [66]. Satellite technology advancements have developed GIS tools to tackle socio-environmental issues like floods, drought, wildfire risks, air pollution, heat stress, greenhouse effects, and environmental degradation on local, regional, and global scales [67–70]. For instance, emerging technologies like machine learning, artificial intelligence, and predictive analytics have enabled tackling complex climate-related challenges [71–73].

South Africa's higher education curricula and practitioner registration standards have continuously been updated to keep up with technological advancements, a process similar to many other countries [74,75]. The country recognises the significance of incorporating GIS technology and methods into HEC_PRS. This initiative aims to equip students with the necessary skills for the contemporary workforce and the global economy. The implementation gap identified by professional bodies in HEC_PRS still lacks a full integration of GIS methods, particularly within South African curricula, to effectively align with technological advancements [35,51]. Therefore, these challenges identified in the body of the extant literature about implementation may be related to resource constraints and a lack of consultation with technical expertise in the field of study. The rapid pace of technological change has created challenges in incorporating GIS curricula into South African high school curriculum policy and ensuring that the curricula stay fully current [65,76]. Moreover, the limited access to technology in some schools and disparities in resources between urban and rural areas have also contributed to these challenges. This study proposes a holistic solution that incorporates this subject as a whole to equip students with digital literacy skills with ICT and the ability to effectively utilize GIS technology to co-design sustainability solutions to promote sustainable development goals in South Africa. There is a need to prioritise the holistic solution of these interconnected technological advancements by integrating technologies across various subjects to improve teaching and learning experiences. Hence, this study suggests further investigation into the integration of Geographic Information Systems methods in South Africa's curricula. The continuous review and adaptation of curricula are essential to address these challenges and ensure that South African students receive a relevant and quality education that prepares them for the future.

This study underscores the importance of adopting a holistic approach integrating ICT and GIS intelligence to leverage cutting-edge technology. This approach is essential for developing a skilled workforce capable of harnessing spatial intelligence for sustainable development. This all-inclusive approach calls for continuous teacher training and retraining on GIS technology, webinar series, in-person seminars, workshops, and collaborative efforts to co-design sustainability solutions. It emphasizes innovations in curriculum development and plenaries on education and workforce development. This approach can enhance discussions from the summer webinar series hosted by organisations like the National Service Scheme (NSS) and the National Senior Certificate (NSC) Examination, especially for higher education students. This will help them to achieve their goals by facilitating the informed implementation of GIS technology and providing valuable insights into its advancement. As a result, this serves as a valuable resource for stakeholders engaged in GIS education, including policymakers, educators, industry professionals, and students.

4.3.1. Innovative Solutions to Addressing the Skill Shortages in GIS Methods in Practice

The field of Geographic Information Systems (GIS) is rapidly evolving due to technological advancements and the growing demand for spatial data analysis across various sectors [76–78]. South Africa faces a significant GIS skills shortage, necessitating a multifaceted approach involving technological innovation, curriculum reforms, professional development, and collaborative efforts to bridge this gap. Addressing the skill shortages in GIS methods in practice requires coordinated efforts by professional bodies, educational institutions, and government agencies. Partnerships between institutions and policy frameworks between SAGC, SAQA, and SACNASP are crucial for setting high standards for education and professional practice in the GIS workforce. Fostering collaboration between academia, industry, and professional bodies is crucial for addressing skill shortages and ensuring curriculum alignment with industry requirements. South African higher education can cultivate a proficient GIS workforce through innovative methods like e-learning, virtual reality, interdisciplinary programs, industry partnerships, and open-source resources. Strategic partnerships and continued investment in education and training are crucial for bridging the skills gap and maximizing the use of GIS technologies across various sectors. The goal is to ensure that qualification requirements are flexible enough to accommodate the diverse career paths within GIS. Strategic policy requires continuous review and updating to keep up with technological advancements and evolving job market demands. Geography curricula policies, GIS qualification requirements, and SAGC registration are crucial in shaping the skills landscape for GIS-focused jobs in South Africa, addressing skill shortages and ensuring that graduates are well-prepared for successful careers in GIS. The alignment of GIS curricula with South Africa's job market requirements is crucial, requiring collaboration between academia and industry. The regular evaluation and adaptation of curricula are crucial to ensure that graduates are well-prepared for successful careers in GIS, alongside SAQA requirements and SAGC registration standards. This study examined the alignment of South Africa's curricula requirements for GIS, SAQA, and SAGC registration and their influence on the skills and knowledge of graduates entering the job market.

4.3.2. Limitations and Future Prospects in GIS Methods in Practice

Addressing educational disparities can bridge the GIS skills gap, enhance spatial data analysis capabilities, and promote sustainable regional development. This can bridge academic training gaps, promote uniform standards, and support the equitable advancement of GIS education and practice across South Africa, enhancing the overall skill set and promoting uniformity in industry requirements. Research centres and institutions face financial constraints due to the high costs of GIS software licenses, data acquisition, and field equipment, especially in low- and middle-income nations or remote areas. Moreover, many high school teachers and researchers often lack GIS training, hindering their ability to utilize its capabilities to equip students with highly sought-after practical skills in the job market. This hinders their capacity to acquire accurate and up-to-date spatial data. There is a need for collaboration between educational institutions, industry stakeholders, and government agencies to ensure GIS education accessibility and standardization in South Africa. GIS education necessitates specialized knowledge in spatial analysis, data processing, and visualization for efficient use, providing detailed insights into geographical features and effective stakeholder communication. Consequently, this review scope should extend into the policy domain to guide the development of GIS methods in South Africa's higher education curricula and practitioner registration standards, ensuring industry alignment and equitable professional access. The scientometric assessment suggests the need for further research on integrating various databases to identify potential developments, improvements, and future research directions.

5. Summary and Recommendations

The insufficient GIS education at South African universities, particularly in high school, is causing a gap between academic programs and industry demands, impacting the GIS workforce This study reveals that the disparity between higher education curricula and professional body registration standards significantly affects the GIS workforce. The assessment and approach described will aid the comprehension of GIS methods in South Africa's higher education curricula and practitioner registration standards (HEC_PRS). The study indicates that, despite adhering to policies and standards, the GIS curriculum's capacity to effectively meet market demands is uncertain due to insufficient job market research. Therefore, this study suggests the need for future research using questionnaire surveys to assess job market demands and ensure that curricula, policies, and standards effectively meet market demands. Furthermore, the study assessed South Africa's GIS practices, identifying research hotspots, top authors affiliation, the thematic evolution of keywords, and word cloud visualization in the intellectual domain. The University of Cape Town and the University of South Africa were the top two South African institutions contributing significantly to GIS research, indicating the need for empirical studies and potential solutions. The findings reveal that higher education and curriculum were the most significant keywords in preparing students for professional practice in GIS, emphasizing the role of educational institutions in this field. This study highlights regional disparities in GIS education, challenges in aligning with practitioner standards, and barriers to broader GIS applicability in South Africa, highlighting the need for further research and development.

The key results are associated with the significant roles of GIS curriculum development, design, and review in enhancing higher education curricula and policy, indicating their potential for curriculum advancement. Governments and institutions should integrate GIS and pedagogical skills in teacher-training universities to bridge the gap between higher education curricula, market demands, and employment opportunities. This study recommends that future research re-evaluate the content of South Africa's GIS-specific qualifications and compare it to global market standards. Moreover, collaboration with GIS industries can aid scholars in comprehending their expectations for potential employees and pinpointing areas for enhancement in future recruitment. The findings reveal research hotspots and the current GIS education curricula in South African universities and high schools, providing insights into market demands and employment opportunities for GIS-focused jobs. This study contributes to advancing GIS methods in practice, achieving the SDGs for educational outcomes, and promoting quality education and lifelong learning opportunities.

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ARTICLES FOR UTM SENATE MEMBERS

"Curriculum for Careers: Embedding Employability and Industry Relevance in Higher Education"

TITLE	SOURCE
10) Integrating Rapid Application Development Courses into Higher Education Curricula (2025)	Applied Sciences (Switzerland) (Article From : MDPI)

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Article

Integrating Rapid Application Development Courses into Higher Education Curricula

Urtė Radvilaitė * and Diana Kalibatienė

Department of Information Systems, Faculty of Fundamental Sciences, Vilnius Gediminas Technical University, 10223 Vilnius, Lithuania; diana.kalibatiene@vilniustech.lt
* Correspondence: urte.radvilaite@vilniustech.lt

Abstract: As the development of technology and business improvement is rapidly advancing these days, higher education (HE) should continually provide and develop up-to-date knowledge and skills for students. This is crucial for training competitive specialists, addressing digital transformation and enhancing digital readiness of HE institutions, as well as increasing students' employment opportunities. Therefore, this paper explores the development and implementation of the new courses for teaching Rapid Application Development (RAD) on the Oracle Application Express platform at five European universities. Consequently, a new and flexible methodology for the integration of developed courses into existing study programs with different integration strategies is proposed and implemented. The effectiveness of the courses' integration, implementation and students' satisfaction were evaluated using Kirkpatrick's model. The results reveal that students' knowledge of RAD increased after completing the courses, which can improve students' employment opportunities and promote digital transformation in HE institutions and studies. In addition, a majority of the students expressed positive feedback for both modules, finding the courses relevant, well delivered and motivating for future study. This study and its results are expected to inspire researchers, teachers and practitioners for further work towards the digital transformation of HE and offer valuable insights for future HE digitalization and research.

Keywords: knowledge evaluation; Kirkpatrick's model; higher education; digital transformation; database; rapid application development

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1. Introduction

Higher education (HE) is responsible for preparing young specialists. Therefore, higher education institutions (HEIs), especially universities, should provide study programs that are up-to-date and resemble the latest development of technologies regarding the EU Digital Education Action Plan (2021–2027) [1] that prioritizes the improvement of digital skills and competencies to facilitate digital transformation. This entails creating opportunities and providing support for the digitalization of teaching methods and learning processes, as well as developing infrastructure for inclusive and resilient remote learning. As HE is a complex process including different stakeholders such as students, teachers and administrative personnel of HEIs, any changes impact all of these parts.

There is no unified definition of digital transformation (DT) from the HEI point but the review on research from 1980 in this field is presented in [2]. Although the creation of the Internet in 1983 is considered one of the foundations of DT, an increase in DT research in HEIs has been observed only since 2016. Significant changes to DT in HEIs have been driven by the need to transition to online learning during the pandemic. Educational technology has taken a dominant position, becoming one of the essential factors for the sustainable development of HE [3,4]. While technological advances affect HE, DT in HEIs should include teaching, research, pedagogical approaches, administrative processes and people [2,5,6].

Technological improvement arouses the rapid changes that HEIs need adjusting to, and those changes need to be cultural as well as technical [7]. Universities respond to different digital technologies and take actions to improve learning experience. Artificial intelligence (AI) [8–10], cloud computing [11], big data [12] and the Internet of Things (IoT) [8,11,13] are impacting digitalization in HEIs. While technology development is transforming HE, digitalizing the learning contents and using educational solutions like Learning Management Systems (LMS) are interconnected rather than separate paths [14,15].

Several studies [2,7,16,17] agree that the pandemic and COVID-19 accelerated technology integration in HE. As the pandemic affected the area of education, universities need to be prepared to adapt digital technology in any unexpected situation [18]. Therefore, the necessary skills that are required in the 21st century should be revised as technological growth urges HEIs to offer courses that focus on technical, knowledge-based and digital skills [19]. While technological advancements offer benefits like flexibility and personalized learning, they also affect emotional wellbeing by requiring students to manage technology, offering less face-to-face interaction and more self-regulation [20].

Furthermore, DT in HE significantly influences student dropout rates through various mechanisms, both beneficial and detrimental [21]. The integration of digital tools and methodologies reshapes learning environments, impacting student engagement and success. Digital platforms provide students with greater access to learning materials and resources, which can enhance understanding and retention [22]. Online learning options allow students to learn at their own pace, potentially reducing dropout rates for those who may struggle with traditional classroom settings [23]. Nevertheless, practical fields, compared to theoretical fields, may face challenges that lead to higher dropout rates [24]. Moreover, students from marginalized backgrounds may struggle with access to technology, which can lead to them dropping out [22].

The factors influencing dropout rates have been studied [25–28] and can be grouped into two main categories. The first category is the student themself, with personal and academic data [26]. The second is external and consists of information about the university, environment and support for the students [27]. While learning analytics (LA) or other models can contribute to predicting students' performance, it is important to consider privacy issues as well [25,29,30].

As HEIs tend to collect feedback from students about the courses they took, such textual data can help to predict the dropout rates in HEIs [27]. Despite the different learning types, whether it is online education or in person, dropping out is an essential problem that needs to be minimized. Dropping out should be explored as a complex process including students' experience and satisfaction related to the HEI [31]. Student satisfaction is one of the components that has an impact on students' motivation to learn and show good performance, as well as showing the quality of teaching. It is confirmed that the lecturer itself as well as high-quality and up-to-date course content are two key factors that enhance students' motivation and can reduce dropout in HEIs [31].

In conclusion, DT in HE has multifaceted effects, influencing student dropout rates and the overall learning experience. While DT in HE offers opportunities for enhanced engagement and accessibility, it also presents challenges that require careful observation and analysis. Furthermore, understanding the dynamics of DT in HE is crucial for institutions aiming to optimize their digital strategies.

In the scope of the aforementioned and in order to modernize the existing HE studies on databases and rapid application development, five European universities (Vilnius Gediminas Technical University (VILNIUS TECH) in Lithuania as the coordinator, Tallinn University of Technology (TalTech) in Estonia, Riga Technical University (RTU) in Latvia, Technological University Dublin (TU Dublin) in Ireland and University of Rijeka (UNIRI) in Croatia) in cooperation with the Oracle Academy joined to implement the project KA220-HED-E99B8F14 "Embracing rapid application development (RAD) skills opportunity as a catalyst for employability and innovation" (RAD-Skills) in 2022, introducing a new approach to software development. In order to achieve the project's goals, the project participants, on the basis of the Oracle Academy, provided material to develop two modules for delivering fundamental (Module 1) and intermediate (Module 2) knowledge and skills on database and rapid application development (RAD). A number of local and international workshops and roundtables were organized for the business and HE representatives and students to disseminate the project results and inform interested parties on rapid application development, specifically targeting Oracle APEX low-code development platforms (LCDP).

This research presents the achieved VILNIUS TECH project results on implementing Module 1 and Module 2. Consequently, the main aim of this research is to investigate the effect of digital transformation at VILNIUS TECH in the scope of implementing RAD-Skills. Achieving this aim involves solving such research questions as follows: (1) How do the developed modules fit and integrate into existing university study programs? (2) Were the modules effective in providing students with knowledge and skills in database and RAD? (3) Were students satisfied with the delivered courses?

The main contributions and novelty of this paper are as follows:

1. A methodology that is sufficiently flexible to accommodate the integration of the prepared modules into a variety of study programs, with courses of different credit sizes, is proposed.
2. An approach to assessing students' knowledge and skills in database and RAD using Kirkpatrick's Model Level 2: Learning Survey is developed.
3. An approach to assessing student satisfaction with the courses delivered using Kirkpatrick's Model Level 1: Reaction Survey is developed.
4. The proposed methodology is implemented by integrating the developed modules into two study programs, delivered to the students, at VILNIUS TECH.
5. The efficacy of the developed courses in imparting knowledge and skills in database and RAD to students is investigated.
6. The level of satisfaction among students with regards to the courses they have received is examined.

The rest of the paper is structured as follows. Related work is discussed in Section 2. Section 3 presents the course design and structure as well as the methodology used to evaluate the course. The results of the evaluation are given in Section 4. The discussion is held in Section 5 and finally, the conclusions are presented.

2. Related Work

Training or course evaluation and its effectiveness are widely researched. There are 414,417 papers that can be found in the Web of Science database (WoS) when the search query "(training OR course) AND (effectiveness OR evaluation)" is used (Figure 1). For this scoping and quantitative review, WoS has been chosen, since it is suggested as the principal search system in [32] and allows the acquisition of a sufficient volume of bibliometric data and is suitable for quantitative analysis [33]. Moreover, WoS is among 1 of 14 well-suited academic search systems for systematic literature review (SLR) and contains more than 73,000,000 publications in multidisciplinary subjects. As scoping and quantitative review here is used as an auxiliary tool for choosing the most suitable model for course evaluation, WoS is selected because it is recognized as the one having the highest quality standards and used by various authors [34,35].

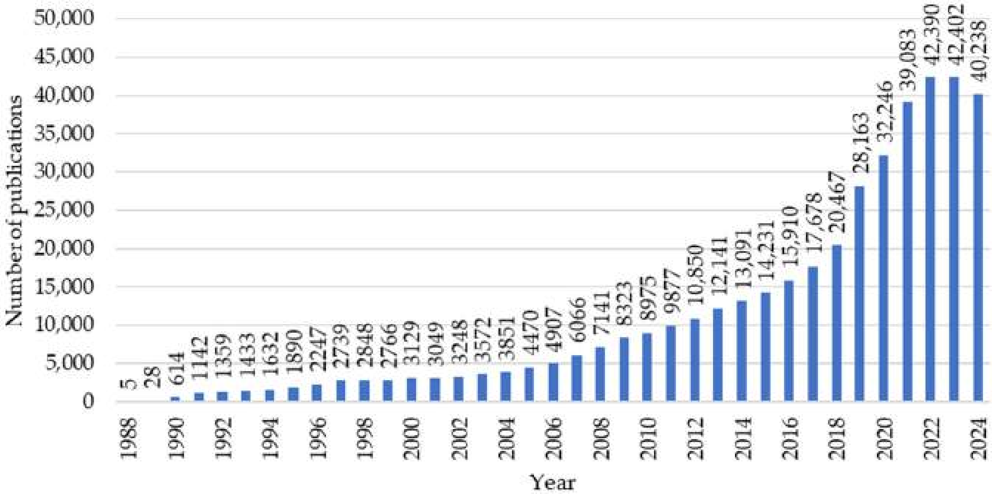

Figure 1. The number of publications in 1988–2024 related to training or course evaluation.

Over the past 20 years, training evaluation has become a more popular research field due to the rising possibilities of e-learning and online trainings that digital transformation has enabled. Moreover, it is needed to explore the effectiveness of training or courses and how to prevent or minimize dropout. While in 2004 the number of papers considering training effectiveness of evaluation was less than 1% of all papers published in WoS, this number increased by 2.23% in 10 years and by 8.78% in 20 years. Such an increase shows that evaluation of the courses or trainings are significant.

According to [36], evaluation is a very important part and cannot be excluded when determining whether the training or course objectives have been accomplished. The author has not only discussed the need for training evaluation but has also provided a review of different training evaluation models. Although there are many various models for evaluating the trainings, ref. [37] also discussed similar models as [36], explaining their advantages and disadvantages.

The most common models for evaluating trainings, courses or educational programs are summarized in Table 1. Also, in the scientific literature, some other methods exist, like Phillip's ROI model, Kaufman's Five model evaluation, Rossi's Five Domain Evaluation model and Holton's model [36–38]. But, they are not analyzed here because of their specificity and narrow applications. Consequently, Table 1 consists of the following columns: (1) model, defining the name of the model; (2) levels, showing what is evaluated in the model; (3) usage, specifying the field in which the model is applied; (4) data collection tool, indicating how the data for evaluation are collected; and (5) purpose, defining the evaluation objective of the model.

Among the chosen models, Bloom's taxonomy also is presented, but it does not measure the effectiveness of training, it just helps to determine the level that students or trainees have achieved after the course or training.

As presented in Table 1 Column (4), most models, like Kirkpatrick's model, CIPP or CIRO models, collect data by using questionnaires, while some of them (Brinkerhoff's Success Case Method (SCM) or IPO model) use interviews in addition to surveys. For example, in Brinkerhoff's SCM, the survey helps to identify two groups: one, of successful cases; second, of unsuccessful cases. Later, these individuals are interviewed to acquire a deeper understanding of what worked for them and what did not. Several other models, e.g., IPO model, focus also on the cost of trainings and can be more appropriate for business organizations or companies.

Table 1. Comparison of most often used evaluation models.

Model	Levels	Usage	Data Collection Tool	Purpose
(1)	(2)	(3)	(4)	(5)
Bloom's taxonomy	1. Knowledge 2. Comprehension 3. Application 4. Analysis 5. Synthesis 6. Evaluation [39–41]	Preparing assessment questions, planning learning outcomes and assessment [40,41]	Set of 30 questions, 5 for each level [39] Empirical test [40]	Determine which learning (competency) level has been achieved [40,42]
Brinkerhoff's Success Case Method (SCM)	1. Goal Setting 2. Program Design 3. Program Implementation 4. Immediate Outcomes 5. Intermediate or Usage Outcomes 6. Impacts and Worth [38]	Online teaching for postgraduates [43]	Survey and interviews [43]	Identify the additional factors impacting the success of failure
Kirkpatrick's model	1. Reaction 2. Learning 3. Behavior 4. Results [36,37,44]	Training for healthcare staff [45] Medical education [46] Scientific writing workshop for medical students [47] Cybersecurity training [48] Flight attendant training program [49]	Questionnaire for reaction; pre-test and post-test for learning; observational checklist for behavior [45,48]	Effectiveness of training, learning measurement [38]
CIPP model	1. Context evaluation 2. Input evaluation 3. Process evaluation 4. Product evaluation [36,37,44]	for formal education systems [36,37] medical education programs [50]	Questionnaires [50]	Improve the curriculum or the educational program [50]
CIRO model	1. Context 2. Input 3. Reaction 4. Output [36]	research methodology workshop for postgraduate students from medical colleges [51]	Feedback questionnaires; follow-up test; pre- and post-test [51]	Monitor trainee's progress before, during and after training [38]
IPO model	1. Input 2. Process 3. Output 4. Outcome [36]	Elderly students' perceptions regarding their Zoom learning experiences [52]	Online survey and focus group interviews [52]	Maximize the efficiency of training but lower (reduce) the cost of training [38]

Authors of [36,37] concluded their review that Kirkpatrick's model is a universally recognized and accepted framework for training evaluation. The Kirkpatrick Four-Level Training Evaluation Model is designed to objectively measure the effectiveness of training.

The model was created by Donald Kirkpatrick in 1959 and became an inspiration and basis for developing other evaluation models like Phillip's ROI model, Kaufman's model, Rossi's Five Domain Evaluation Model or Holton's model [36–38,46].

The acceptance and popularity of Kirkpatrick's model also can be seen from the number of publications in WoS.

The growth in number of publications about Kirkpatrick's model through the years is quite steady as seen in Figure 2. This number almost doubled in 2020, from 44 publications in 2019 to 83 publications in 2020, and stayed at this high number until now. Such a rise can be explained by the COVID-19 pandemic and emergence of e-learning and online teaching.

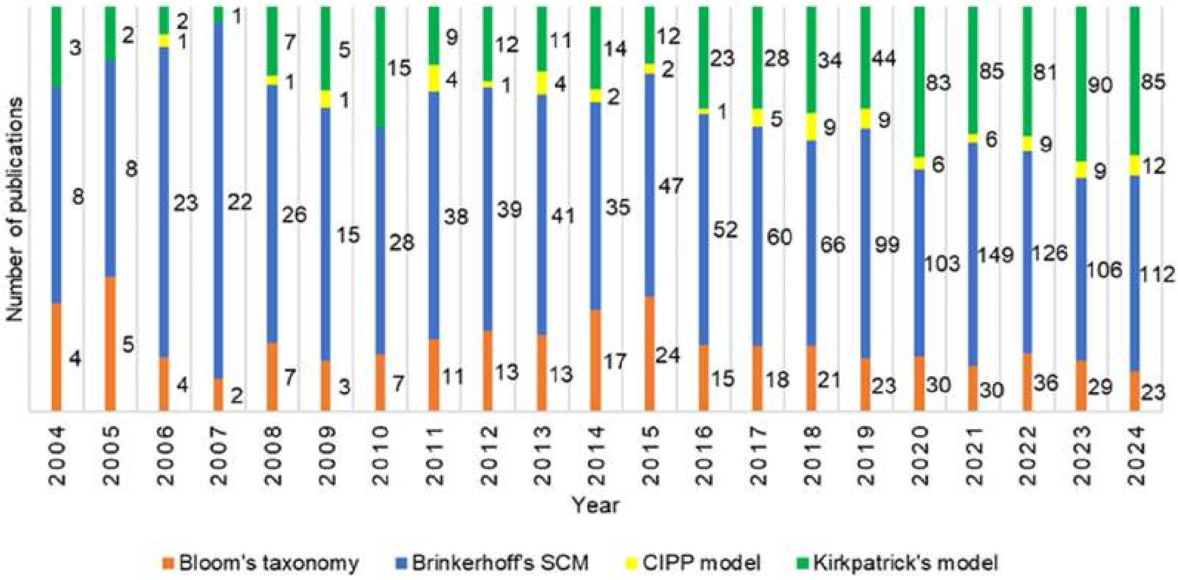

Figure 2. The number of publications in 2004–2024 related to different training evaluation models.

Viewing the usage of training evaluation models from the research area perspective (see Figure 3), Bloom's taxonomy and Kirkpatrick's model are two of the most popular approaches in the "Education Educational Research" area. In the "Computer Science" area, the leading method is Brinkerhoff's Success Case Method. It allows the determination of what is effective in training by detecting the most successful cases and the opposite—the worst cases. Brinkerhoff's SCM is more suitable for organizations where interviews with trainees can be easily organized due to a smaller number of participants as in [53]. Here, the authors selected 14 success stories and interviewed these participants. In order to avoid subjective opinions, the authors included external people in nominating the participants and another three experts in performing 40–60 min long interviews [53]. Thus, the inclusion of this method in HEI courses can be complicated because of the complex adaptation procedure of the method itself and the large number of participants in a course. The use of Brinkerhoff's SCM will require more resources such as time or people in order to conduct high-quality evaluations of the course.

Another researcher has shown that Kirkpatrick's model is preferred over others because it is easy to use and applicable almost everywhere [38]. Consequently, Kirkpatrick's model can be used in HE. Its advantages as well as limitations are discussed in [54]. The author empathizes that HEIs usually use only the first two levels of Kirkpatrick's model. Higher levels of this model need to be measured in workplaces and for longer time periods. Thus, measuring these levels should be adjusted in the context of HE [54].

In conclusion, the reviewed works presented various models for evaluating trainings or courses and highlighted the necessity of applying appropriate models to measure the effectiveness and efficiency of the trainings or courses. Due to clarity and ease, Kirkpatrick's model is mostly used. HEIs can effortlessly adapt Kirkpatrick's model, especially Level 1 Reaction and Level 2 Learning that will be discussed in the next section together with the methodology of implementing the newly developed modules.

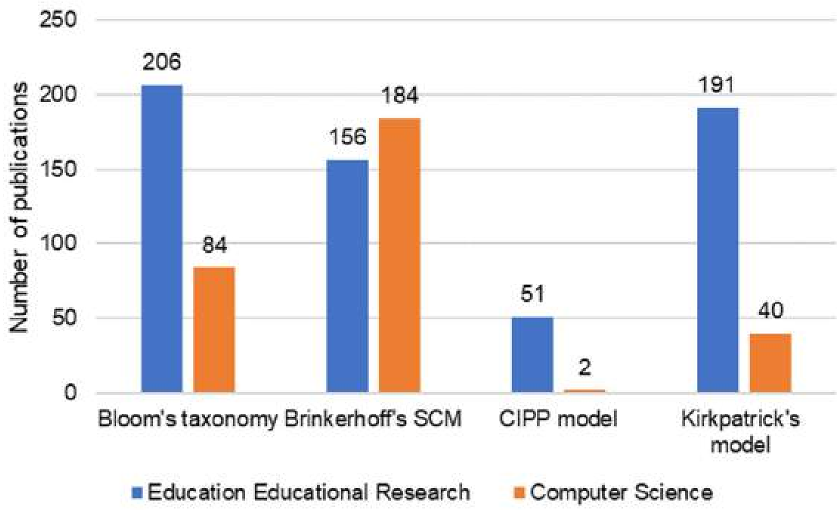

Figure 3. The number of publications with different training evaluation models in the "Education Educational Research" area and "Computer Science" area.

3. Materials and Methods

This section presents the developed methodology to accommodate the integration of the prepared modules into a variety of study programs, with courses of different credit sizes. The methodology was developed together with all five project partner universities to fit study curricula universally. So, the methodology of integration of the developed modules into universities' study programs is presented in Figure 4. It consists of three strategies as follows:

1. The two developed modules are added to the study program as separate courses each of 3 ECTS (Figure 4, colored in blue). To implement this methodology, a university should support the 3 ECTS system.
2. The two developed modules are added together to form one single course of 6 ECTS (Figure 4, colored in green). To implement this methodology, a university should support the 6 ECTS system.
3. The two developed modules are added in conjunction with other supplementary topics to make courses of >3 ECTS (Figure 4, colored in orange). To implement this methodology, a university should support any ECTS system. This is the most flexible strategy of incorporating the module into the existing study program. For this strategy, new modules or courses should not be developed, i.e., the topics of existing courses should be modified by including the topics of the developed modules.

The proposed methodology consists of three quite different strategies, as Figure 4 presents. These strategies vary not only by the scope of the modules and the size of the credits. The first two strategies require the creation of completely new courses while the third strategy incorporates the topics of developed modules into the existing study courses at the university. Furthermore, the third strategy requires less effort to introduce new skills to the students.

The RAD-Skills project consortium developed two modules (each of 3ECTS) as follows: (1) the fundamental course (Module 1), which provides fundamental knowledge of databases and is intended for students both of computer science and who have no knowledge in information technologies; (2) the intermediate course (Module 2), which provides an advanced level of knowledge for students. Table 2 presents the topics for both modules.

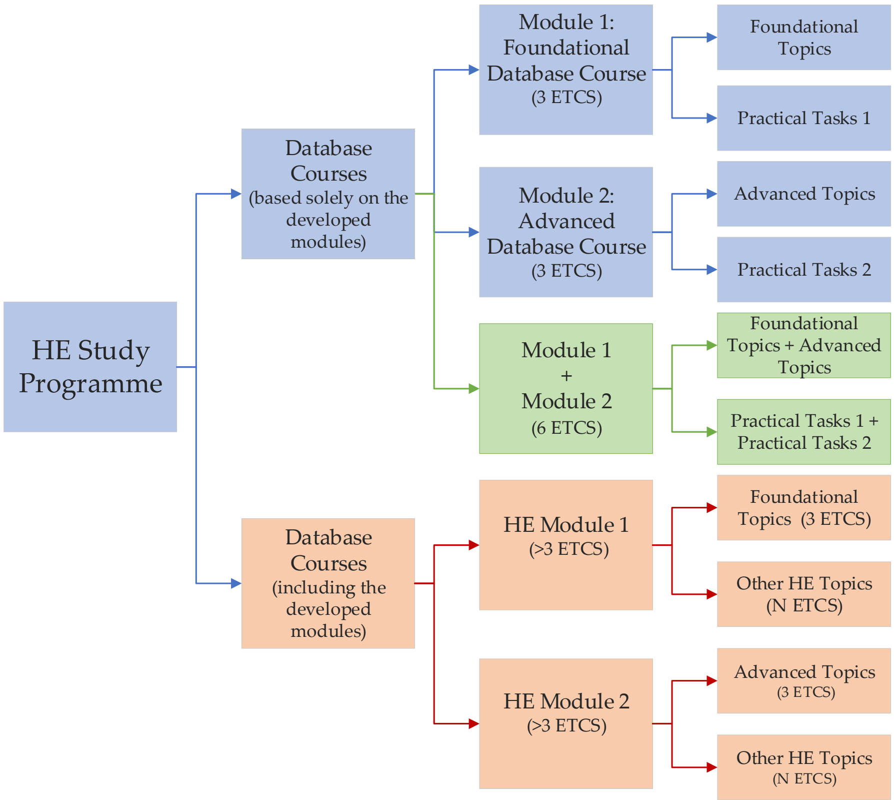

Figure 4. The schema of the methodology of integration of the developed modules into universities' study programs.

Table 2. Topics for the developed modules.

Module 1	Module 2
1. Introduction to Module 1	1. Introduction to Module 2
2. Introduction to Databases	2. APEX Course Project
3. Relational Databases	3. Advanced Data Normalization (3+ additional)
4. Database Normalization (1–3)	4. Advanced SQL
5. Physical Data Model	5. App building in APEX: pages and reports
6. Access to Oracle APEX Environment	6. App building in APEX: forms
7. Introduction to Structured Query Language (SQL)	7. App building in APEX: navigation and styles
8. Application (App) Development in APEX (at wizard level)	8. Other Advanced Functions in APEX

All topics were classified into categories for further analysis as follows:

1. Introduction to Databases (Module 1)
2. Relational Databases (Module 1)
3. Data Modelling (Module 1)
4. Introduction to SQL (Module 1)
5. Advanced SQL (Module 2)
6. Application and page design in APEX (Module 2)
7. Forms and data integrity in APEX (Module 2)
8. Reports in APEX (Module 2)

The approach for assessing students' knowledge and skills in database and RAD using Kirkpatrick's model Level 2: Learning Survey and assessing student satisfaction with the courses using Kirkpatrick's model Level 1: Reaction Survey is developed and presented in Figure 5. The same schema was used in both developed modules.

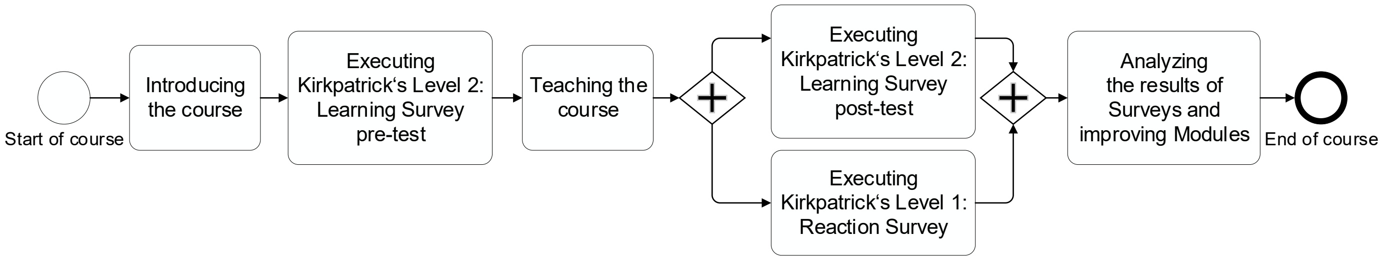

Figure 5. The approach for assessing students' knowledge and skills in database and RAD using Kirkpatrick's model Level 2: Learning Survey and assessing student satisfaction with the courses using Kirkpatrick's model Level 1: Reaction Survey.

The proposed approach for assessing students' knowledge and skills in database and RAD using Kirkpatrick's model Level 2: Learning Survey and assessing student satisfaction with the courses using Kirkpatrick's model Level 1: Reaction Survey, presented in Figure 5, can be applied once per course if the first, second or third strategies are chosen (Figure 4). The proposed approach can also be applied twice, i.e., separately for Module 1 and Module 2, if the second strategy is chosen (Figure 4, green color). In the case of using the third strategy for the implementation of the developed modules into the study program, additional questions, covering other HE topics on databases, should be developed and included into Kirkpatrick's model Level 2: Learning Survey to assess the knowledge and skills of the whole course.

For assessing students' satisfaction with the course, Kirkpatrick's model Level 1: Reaction Survey was developed and used at the end of the course. The questions were adopted from the Kirkpatrick's model Level 1: Reaction Survey template, because it fully met the research objectives. It consists of 7 questions on a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) as follows:

- Q1. I was satisfied with the course overall.
- Q2. This course enhanced my knowledge of the subject matter.
- Q3. The course was relevant to what I might be expected to develop rapid applications/a need to develop applications rapidly.
- Q4. This course provided content that is relevant to my daily job.
- Q5. This course provided delivery methods and materials appropriately.
- Q6. I would recommend this course to others.
- Q7. This course acted as a motivator towards further learning.

The students' knowledge and skills in database and RAD were evaluated by Kirkpatrick's model Level 2: Learning Survey, which consists of two parts, i.e., a pre-test and a post-test. Students were asked to take the same test before starting the course module and after finishing it. The results of both tests were compared to determine learning effectiveness.

A pre-test and post-test question set was created based on the 36 existing Oracle APEX questions from different topics included in the developed modules. For the assessment of Module 1, the project partners selected 19 questions by voting, for Module 2, 20 questions were selected. The types of questions were either multiple choice or true/false.

The tests for both modules were combined for the questions of the same weights since they have predefined answers. These questions satisfy the knowledge level according to Bloom's taxonomy [39]. Higher levels of Bloom's taxonomy were evaluated by practical tasks performed during the course. The main scope of this study is related to the assessment of student achievements and knowledge level using only tests. Based on the collected number of points for the tests, the knowledge level of the students was evaluated using three levels as follows:

- threshold level (i.e., satisfactory) when the student knows the most important theories and principles of the course and is able to convey basic information and problems;
- typical level when the student knows the most important theories and principles and is able to apply knowledge by solving standard problems, and possesses learning skills necessary for further and self-study;
- outstanding level (i.e., advanced) when the student identifies the latest sources of the course, knows the theory and principles and can create and develop new ideas.

An example of the question is presented in Figure 6.

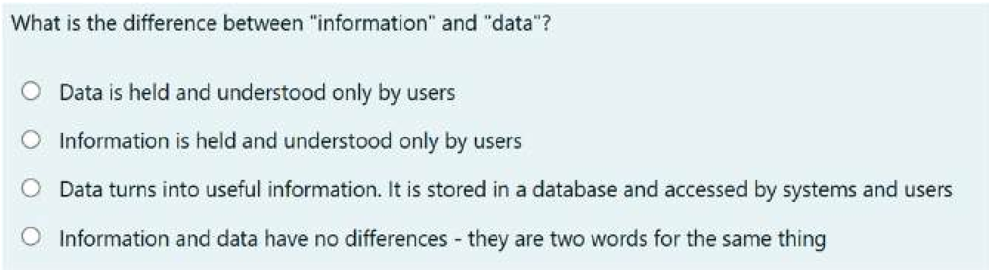

Figure 6. An example of the question for pre-test or post-test.

The collected answers were tabulated and compared by applying paired *t*-tests as presented in [55,56], confidence intervals [57,58] and effect sizes [58,59].

4. Results

This section presents the results of implementing the proposed methodology and approaches at VILNIUS TECH. Other universities have presented their cases of implementing the proposed methodology in their publications, like TalTech [60,61]. Several partner universities (i.e., TalTech, RTU and UNIRI) have chosen to implement the first strategy, i.e., to add the newly developed module into their study program. Others (i.e., RTU, TU DUBLIN) have chosen to integrate the topics from developed modules into already existing courses in the study program.

At VILNIUS TECH, the third strategy was used for the integration of the developed modules into two existing study programs of “Information Systems” (ISsp) and “Software Engineering” (SEsp). These study programs already had the Databases (with coursework) (6 ETCS) and Database Management (with coursework) (6 ETCS) courses in their curriculum, so the necessary topics of Module 1 and Module 2 were included in the existing ones. These courses are taught in the fourth and fifth semesters, i.e., the second year of studies.

More details about the implementation of Module 1 are presented in [62].

The assessment of students’ knowledge and skills in database and RAD using Kirkpatrick’s model Level 2: Learning Survey and student satisfaction with the courses using Kirkpatrick’s model Level 1: Reaction Survey were evaluated by applying the approach presented in Figure 5.

Kirkpatrick’s model Level 1: Reaction Survey was performed at the end of the course. In total, 8 ISsp students and 25 SEsp students (i.e., 33 students in total) answered the satisfaction survey for Module 1. In total, 8 ISsp students and 19 SEsp students (i.e., 27 students in total) answered the satisfaction survey for Module 2. Note that answering the satisfaction survey was optional. Also, ISsp student groups are smaller. Finally, the number of survey responses was sufficient to draw some conclusions about the students’ feedback on Module 1 and Module 2.

The responses, in percentages, to each module are shown in Table 3. As can be seen from the table, more than half of the responses (59.83% for Module 1 and 58.79% for Module 2) were Somewhat Agree (33.62% for Module 1 and 35.16% for Module 2) or Strong Agree (26.20% for Module 1 and 23.63% for Module 2). The results indicate that the students see the courses as effective and relevant.

Table 3. Kirkpatrick's model Level 1: Reaction Survey responses for Module 1 and Module 2.

Answers	Module 1	Module 2
Strongly Disagree (1)	9.17	4.40
Somewhat Disagree (2)	8.30	11.54
Neither Agree nor Disagree (3)	22.71	25.27
Somewhat Agree (4)	33.62	35.16
Strong Agree (5)	26.20	23.63
Number of responses	33	27

Visualizations of the survey responses are shown in Figure 7 for Module 1 and Figure 8 for Module 2. Those figures show that 70% (Figure 7, Module 1, row 1) and 55% (Figure 8, Module 2, row 1) of students were satisfied with the course overall, 76% (Figure 7, Module 1, row 2) and 67% (Figure 8, Module 2, row 2) agreed that this course increased their knowledge of the subject matter, 63% (Figure 7, Module 1, row 3) and 38% (Figure 8, Module 2, row 3) agreed that the course was relevant to what they might expect from RAD, 61% (Figure 7, Module 1 and Module 2, row 4) agreed that the course provided appropriate delivery methods and materials, 61% (Figure 7, Module 1, row 6) and 42% (Figure 8, Module 2, row 6) would recommend this course to others and for 53% (Figure 7, Module 1, row 7) and 38% (Figure 8, Module 2, row 7) of students, the modules acted as a motivator for further learning.

As the courses were well received by the students, they also agreed that their knowledge had increased after the courses.

The learning results and how the students' knowledge had improved were determined by the means of the pre-test and post-test. In total, for Module 1, 40 (i.e., 12 ISsp and 28 SEsp) students participated in the pre-test, 42 (i.e., 8 ISsp and 34 SEsp) students participated in the post-test. In total, for Module 2, 37 (i.e., 8 ISsp and 29 SEsp) students participated in the pre-test, 47 (i.e., 4 ISsp and 43 SEsp) students participated in the post-test. The numbers of pre-test and post-test responses are sufficient to draw some conclusions about the students' knowledge level on Module 1 and Module 2.

The obtained grades for Module 1 and Module 2 are shown in Figures 9 and 10, where the pre-test results are colored in yellow, and the post-test results in green. The overall points were grouped as follows:

- [0; 4.8)—students who failed the test;
- [4.8; 7.4)—students who have satisfactory knowledge level;
- [7.4; 8.4)—students who have typical knowledge level;
- [8.4; 10]—students who achieved the advanced knowledge level.

As can be seen from Figure 9, the majority (80%) of students obtained grades less than 7 in the pre-test for Module 1, indicating that their knowledge of databases is basic. Only 20% of students achieved a typical or advanced knowledge level, meaning that they could be interested in databases and studied independently. Such results could also be explained by the topics of Module 1 being more or less covered in other courses of these study programs. After teaching the course (Module 1), the post-test results had increased, i.e., 45.24% of students obtained grades less than 7 while 54.76% of students achieved a typical or advanced knowledge level. The results show that the course presented the fundamental knowledge of databases and established the ground understanding necessary for the next course with more advanced topics.

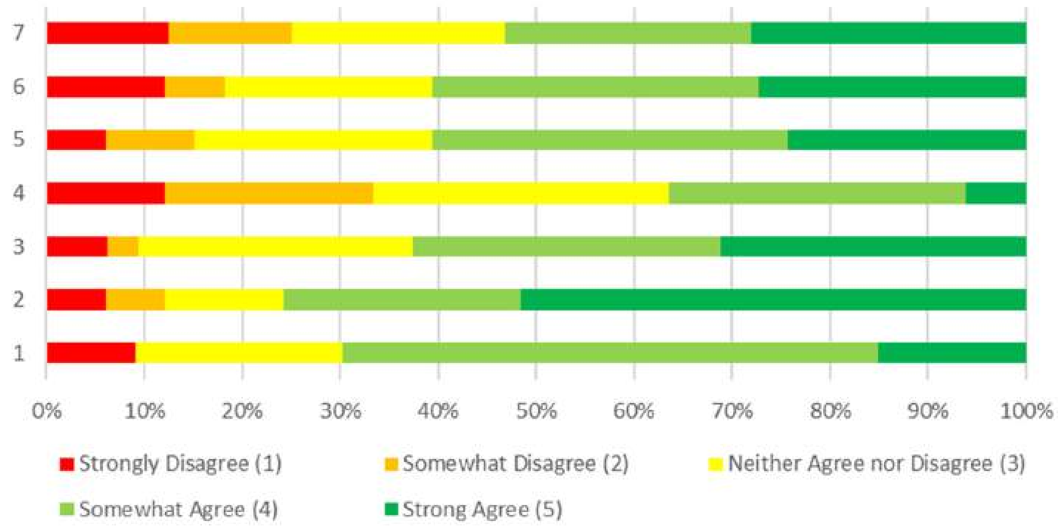

Figure 7. Satisfaction survey results for Module 1.

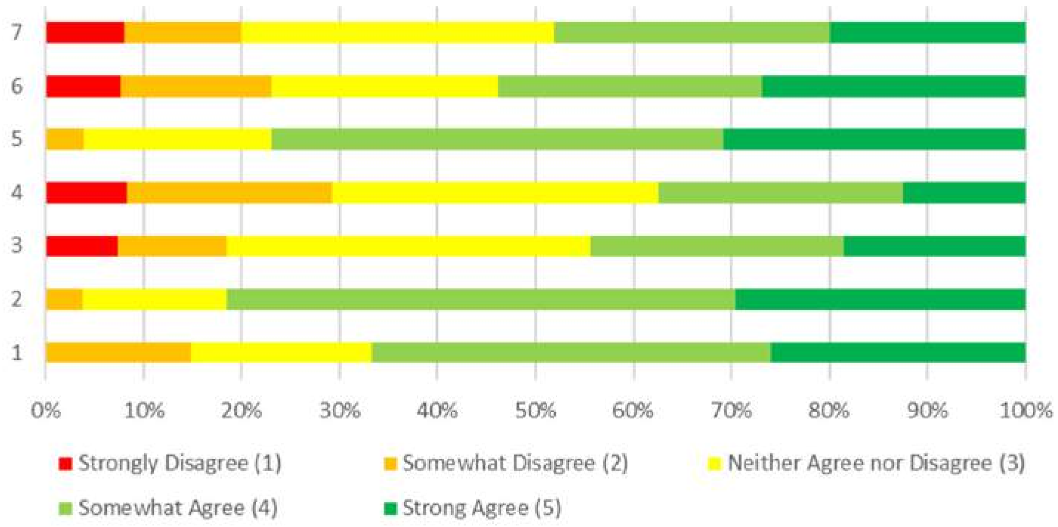

Figure 8. Satisfaction survey results for Module 2.

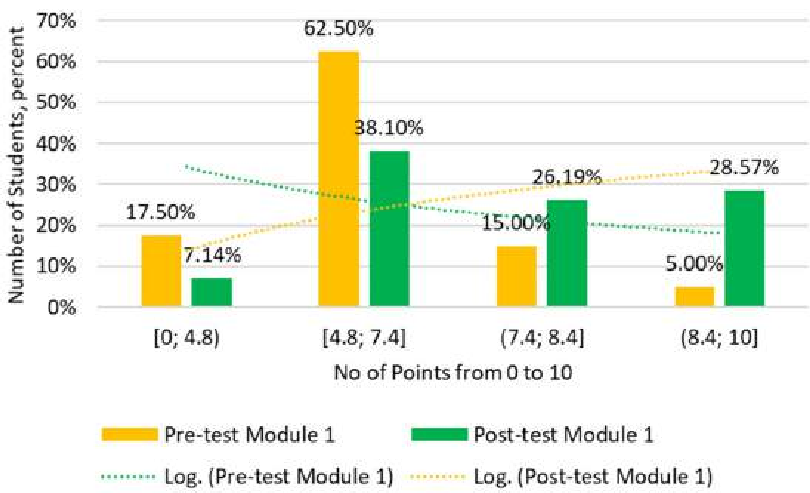

Figure 9. Kirkpatrick's model Level 2: Learning Survey grades for Module 1.

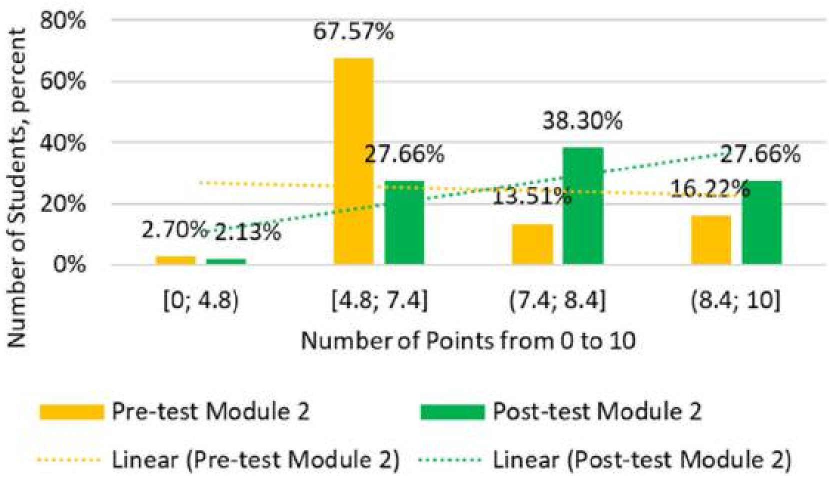

Figure 10. Kirkpatrick's model Level 2: Learning Survey grades for Module 2.

As shown in Figure 10, the majority (70.27%) of students obtained grades less than 7 in the pre-test for Module 2, showing only satisfactory levels of knowledge. Only 29.73% of students achieved a typical or advanced knowledge level. After teaching the course (Module 2), the post-test results had increased, i.e., 29.79% of students obtained grades less than 7 while 70.21% of students achieved a typical or advanced knowledge level. So, the notable increase in knowledge level is observed as Module 2 presents more specific knowledge and skills not covered in any other course at the university.

The pre-test and post-test grades according to categories (see Section 3) of both modules are shown in Figure 11. The red color represents the wrong answers to the questions while the correct answers are shown in green color. As the figure shows, knowledge on the introduction to database (DB) topic was improved slightly by 6%. This small improvement suggests that the students are more or less familiar with the concept of database. A significant increase in knowledge was observed on the topic of Relational Databases (DB)—33%. This topic presents the fundamental knowledge and formal definitions of the relational databases. Although students might be acquainted with databases before this course by self-study, they are usually more interested in practical knowledge. Therefore, the results indicate that the course provides a theoretical background for relational databases. Other increases were as follows: Data Modelling—10%, Introduction to SQL—10%, Application (App) and page design in APEX—11%, Forms and data integrity in APEX—14%, and Reports in APEX—15%.

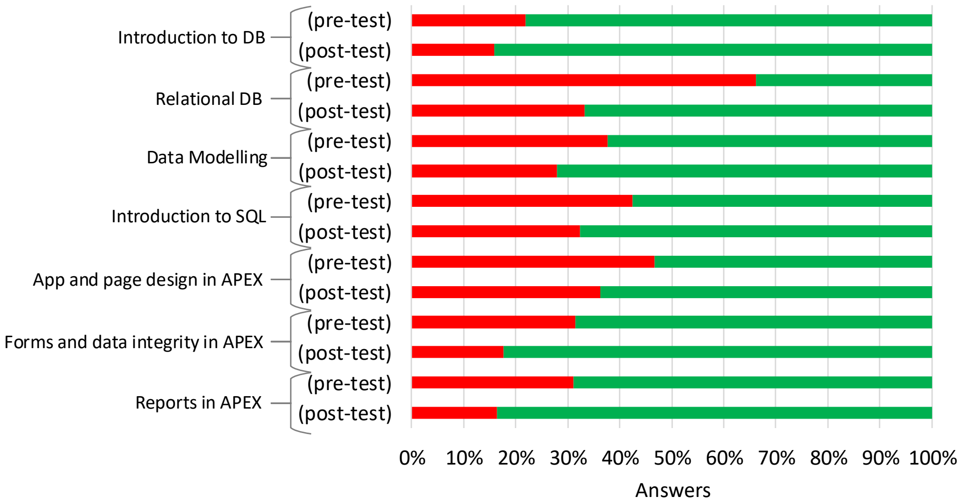

Figure 11. The results of tests for Module 1 and Module 2 according to categories.

The results of the paired sample *t*-test for Module 1 and Module 2 are presented in Table 4. The results show a statistically significant difference in the students' knowledge before and after attending Module 1 (t(79) = −3.7964, $p \leq 0.01$) and Module 2 (t(77) = −2.8808, $p \leq 0.01$). Thus, students achieved better performance on the post-test for both modules.

Table 4. A paired sample *t*-test and confidence level to measure students' knowledge level for Module 1 and Module 2.

Attributes	Module 1 Values	Module 2 Values
Variance for pre-test	1.68	1.54
Variance for post-test	2.27	1.50
Mean for pre-test	6.05	6.78
Mean for post-test	7.23	7.56
DF	79	77
t Stat	−3.7964	−2.8808
P(T ≤ t) two-tail	0.00029	0.00514
t Critical two-tail	1.99045	1.99125
Confidence level	0.95	0.95
Confidence interval	0.378–1.29	0.193–1.075
Effect size	0.838	0.634

Based on Table 4, for Module 1 the effect size equals 0.838 that corresponds to a large effect or zone of desired effect according to [58]. For Module 2 the effect size is 0.634 that corresponds to an intermediate effect or zone of desired effect.

5. Discussion

The results presented in this study help to answer the research questions.

In order to answer the first research question *(1) How do the developed modules fit and integrate into existing university study programs?*, a methodology with three different integration strategies has been suggested and presented in Figure 4. The developed modules introduce new skills and can be easily integrated into existing courses at different universities with various modularity of courses. The proposed methodology is quite flexible and provides choices for the implementation of modules based on how much effort the university wants to spend on improving the study programs. While the developed modules were included as part of bigger courses in this study, universities can choose to create entirely new courses based on the developed Module 1 and Module 2. Consequently, the proposed methodology helps to improve existing study programs and add digitalization to the universities.

The answer to the second research question, i.e., *(2) Were the modules effective in providing students with knowledge and skills in database and RAD?*, is based on the conducted Kirkpatrick's model Level 2: Learning Survey consisting of the pre-test and post-test. The results of the paired sample t-test for Module 1 (t(79) = −3.7964, $p \leq 0.01$) and Module 2 (t(77) = −2.8808, $p \leq 0.01$) showed a statistically significant difference in the students' knowledge before and after attending these modules. Also, the increase in knowledge is grounded by the large effect size for Module 1 (0.838) and the intermediate effect size for Module 2 (0.634) that both corresponds to zone of desired effect. Therefore, the conclusion that *the modules are effective in providing students with knowledge and skills in database and RAD* can be drawn, although this effectiveness depends on the topic taught. From Figure 11, it can be seen that the knowledge improvement is smaller in some topics and bigger in others. Also, it should be noted that this effectiveness and learning outcome depends strongly on factors such as: (1) the student's motivation to learn, (2) methods used for teaching and (3) the teacher's character traits. These factors are intertwined together and closely depend on each other. It is confirmed in [63] that teaching quality significantly influences the students' satisfaction because students appreciate a lecturer's presentation style more than content itself. Teaching quality, as shown in [26], together with a good student–teacher relationship, affects students' satisfaction. Satisfaction with the teacher impacts satisfaction with the course and motivation to achieve high learning outcomes [31]. In any case, better knowledge improvement should be pursued in the future by supplementing the developed courses with the newest teaching methods, such as Flipped Classroom [64–66], Gamification and Simulation [67–69], etc., which encourage and motivate students to learn and increase digitalization of the developed courses.

Furthermore, it was noticed that the questions in the pre-test and post-test should be revised and improved. The current questions were taken from Oracle Academy materials and approved by the partners of the project mentioned in the introduction, since they were suitable for the project purposes. Nevertheless, the analysis of the pre-test and post-test results show that in the future, the question bank should be augmented with new questions to have a bigger coverage of topics. As the number of questions increases, it will be necessary to consider whether the tests are too long for the number of credits in the module.

The results for Kirkpatrick's model Level 1 (Figures 7 and 8) have shown that the majority of the students were satisfied with the course, and this provides the answer to the third research question *(3) Were students satisfied with the delivered courses?* Although there is room for an increase in satisfaction level, these results depend on several factors. Besides the student's motivation to learn, the teacher is also one of the main factors influencing satisfaction as noticed by several authors [26,31,63]. Therefore, it is important to ensure the continuous improvement of teachers' pedagogical competencies and the inclusion of new digital methods in teaching like generative AI (GenAI) tools, i.e., ChatGPT, offering great pedagogical potential [70–73].

Here, the fourth question can be raised. Did how a teacher is as a person influence the level of students' satisfaction? The fifth question can also be raised. How do digital technologies, especially GenAI tools, influence learning outcomes? However, these research questions were out of the scope of this study. The satisfaction survey was created for the course and its contents. Consequently, the results in this study do not reflect the students' opinions on the teaching methods or the teacher as a person. Despite that, the results of Kirkpatrick's model Level 1: Reaction Survey are useful, as they both reveal the students' satisfaction and emotional level, and find places for future improvements and digitalization of the course.

On the other hand, the number of students that participated in this study was small but sufficient to perform statistical analysis and draw initial conclusions. As students differ in skills, motivation and abilities, the analyzed results should take into account these factors as well. Perhaps another evaluation model can be considered to complement the analysis of the result from a different perspective. Moreover, the methodology presented in this study has been applied to IT students in two study programs. The results could differ if different study programs, i.e., not IT, were chosen.

A similar study has been performed by the project partners [60,61], and their results also indicate that the course was well-received by the majority of students. In [60], TalTech found that around 62% of correspondents were satisfied with the RAD course material, while in this study, around 60% of students were satisfied. This slight difference can be explained by the use of different teaching techniques, i.e., partners at TalTech chose self-regulated learning in online modes, minimizing contact with a lecturer, which could be the factor resulting in slightly better results. Similar results were obtained by partners for learning outcomes, i.e., TalTech results [61] show a knowledge improvement of 36% while results at VILNIUS TECH indicate an improvement of 35%. Similar results in different universities imply that implementing the database and RAD skills course enhanced students' knowledge and digital skills.

Limitations of the Study

Some limitations of the study were discussed during the discussion. Consequently, summarizing the previous discussion, the following limitations of the study can be observed:

1. The developed strategy was implemented only for the courses taught for the entire semester (i.e., 16 weeks). This study has not examined the case when the courses are taught in cycles (i.e., ~4 weeks). However, the proposed methodology does not set strict time limits for teaching and could be applied without time limitations.
2. The bias of students regarding the feedback about the course. Another limitation of this study is that Kirkpatrick's model Level 1: Reaction Survey has been constructed to obtain feedback from the student about the course and its contents. The questions in a survey do not distinguish the content of the course from the teaching quality and the teacher as a person. Nevertheless, the performed Kirkpatrick's model Level 1: Reaction Survey satisfies the scope and aim of the current study. So, the refinement of the feedback part of the survey is left for future works.
3. There are limitations regarding the pre-test and post-test questions. During the study, it was observed that for a more detailed evaluation of the students' knowledge, some questions should be revised or additional questions should be added. Nevertheless, the current set of questions satisfies the scope and aim of the study. So, the extension and refinement of the questions remains for future works.
4. There were a limited number of participants and duration of the study. The methodology and developed modules were integrated into existing study programs only two years ago. Therefore, only a limited number of students and only in two study programs at VILNIUS TECH could be investigated. However, the study is ongoing and the effect of the newly integrated modules on students' knowledge levels is under investigation with new students' groups.

6. Conclusions

Responding to technological development, HEIs should address digital transformation in order to stay competitive in the market. Furthermore, by introducing new skills or implementing new courses into study programs, HEIs stay attractive to students, and can minimize dropout rates and digitalize HE.

As the analysis of the related works shows, the high number of publications on training or course evaluation highlights the significance and importance of evaluating the courses themselves. There exist many various models for evaluating trainings, satisfaction of the participants, knowledge level gained by participants, etc., that allow HEIs to obtain feedback from the participants and to improve the quality of the courses. Among the analyzed courses evaluation models, Kirkpatrick's model is the one most accepted and easily applied in HE, especially its lowest two levels—Reaction and Learning. Consequently, it was chosen for the presented study to evaluate students' satisfaction level and gained knowledge level.

A sufficiently flexible methodology has been developed for the integration of the newly prepared modules on RAD. The main advantage of the proposed methodology is its suitability for quick and flexible integration of newly developed courses into existing study programs by applying one of the following three strategies: (1) introducing the new module as a separate course; (2) combining two modules into a single bigger course and (3) incorporating new topics from the developed module into existing courses at the university. The last strategy was used at VILNIUS TECH as the most suitable and was discussed in this study.

The results of Kirkpatrick's model Level 1 showed that a majority of the students (~59%) expressed positive feedback for both Module 1 and Module 2. Therefore, the results indicate that the developed modules were well received by the students. Also, the responses from the students show that they acknowledged an increase in their knowledge of the subject matter and found the courses to be relevant and well delivered as well as motivating them to study further.

The results of Kirkpatrick's model Level 2 allowed for the observation and measurement of the improvements in knowledge for different topics. The average increase in knowledge was 12% in five topics of the course, while two topics, Introduction to Database and Relational Database, stood out with the lowest 6% and the highest 33% increases, respectively.

The data gathered in this study can help to improve the course in the future as the results highlighted areas needing further enhancement. The satisfaction with the developed modules indicate that the topics are relevant and effectively covered with appropriate teaching methods and material. However, the small increase in knowledge in some topics suggests that they need to be improved in terms of teaching quality, new digital learning methods and techniques. Although most of the topics are relevant and provide new skills, the insights of this study can help to better address students' needs as well as maximize learning outcomes.

In conclusion, the presented results demonstrate that implementing new courses can increase students' skills and enhance the digital transformation in HEIs and studies. Thus, the undergoing digital transformation urges researchers to perform studies similar to the research presented in this paper in order to measure and evaluate the impact of that transformation on society, business and education.

Future Research

Based on the research results, discussions and limitations of this study, future research can be summarized as follows:

1. Deeper and more extensive investigation of the developed methodology at other partner universities.
2. Investigation of the proposed methodology with different study time cycles.
3. Supplementing the developed courses with the newest teaching methods, which encourage and motivate students for learning and increase digitalization of the developed courses.
4. Improvement and extension of the feedback survey with the possibility to exclude the students' and teachers' biases from the results.
5. Improvement and extension of the pre-test and post-test questions.
6. Longitudinal survey of the integrated modules with different students over several years, i.e., collecting more test responses and conducting similar research with a larger set of respondents.
7. Evaluating the teacher as a person and the teacher's influence on the learning outcomes, as well as investigating the impact of digital technologies on the learning outcomes and students' satisfaction.
8. Conducting similar studies with other study programs and courses.
9. Summarizing the obtained results together across all five partner universities to highlight and generalize the best practices of RAD course implementation, teaching and course digitalization.

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Conflicts of Interest: The authors declare no conflicts of interest.

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