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The role of university–industry partnership in innovative curriculum development: A case study of South African universities in the fourth industrial revolution

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ABSTRACT

This study was motivated by the need to strategically implement changes propelled by the advent of the fourth industrial revolution (4IR) to meet the increasing demand for theoretical skills required by industries for regional and global competitiveness through a university–industry partnership among South African universities. A total of 22 out of 26 South African Universities were purposefully selected for the study. A survey design was adopted in which a structured online interview was conducted with 70 out of 188 Deans/Executive Deans of faculties through the Microsoft Teams and Zoom platforms. The results show that most of the academic faculties had implemented the specific guidance provided by industry partners and relevant associations into the curriculum for teaching and learning at the faculty level. However, only 18% of the Deans/Executive Deans had the 4IR as a separate strategy formulated in their institutions, while about 30% of faculty Deans/Executive Deans had 4IR strategies integrated into the existing institutional strategy. Further findings revealed the unwillingness of the faculties of Engineering and the Built Environment and the faculty of science to embrace any form of institutional guidelines for responding to evolutionary change and for implementing the 4IR in their activities. They preferred to remain open to innovation and respond in the best way possible rather than being stiffened by organizational policy.

Contribution/Originality: In the South African context, no study has determined the views of academic leaders on the state of 4IR readiness, which is important in positioning universities to be competitive both regionally and globally. Therefore, this is a novel study that contributes to our understanding of South Africa's University strategies and tactics.

1. INTRODUCTION

The education sector is regarded as the medium for propagating technological invention, and at the same time, technological tools are fundamental to advancing educational institutions in this era more than ever (Dattijo & Adamu, 2022; Dunn & Kennedy, 2019; Siddiqui, Thomas, Nazar, & Zahid, 2020). Historically, institutions of higher learning had been shaped, reconfigured, and catalyzed into new learning environments by previous industrial revolutions (Downes, 2015). With the advent of the fourth industrial revolution, scholars, practitioners, and policymakers have noted the future of jobs as requiring creativity and amalgamation of socioeconomic actors to unitedly respond to the disruption (Dattijo & Adamu, 2022; Dziallas & Blind, 2019; Gachie & Govender, 2017; Gray, 2021; Peneder, 2017; World Economic Forum, 2016).

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Higher education institutions serve as the link that bridges the knowledge gap between the old and the new generations of learners to unite these socioeconomic actors in a manner that meets societal expectations. In line with the ever-evolving technological changes in recent times, these institutions act as a conduit for the transfer of new knowledge and skills to implement the requirements of the 4IR in a systematic and flexible manner to achieve national capacity building (Liboni, Cezarino, Jabbour, Oliveira, & Stefanelli, 2019; Yüceol, 2021).

Innovative curriculum design is central to actualizing digital ecosystems where a digital workforce with requisite critical thinking, problem-solving skills, other soft skills, and technological competence can manage the transformation. While the task of incorporating the necessary skills into modules remains the mandate of higher education, there is a need for collaborative research within the industry in defining the new jobs of this era (Yazici & Düzkaya, 2016; Yüceol, 2021). The outcomes of this collaboration will provide guidelines for determining the amount of training required for learners to achieve qualifications.

Most universities run on a faculty and/or college basis for the effective management of specialized courses/skills. Thus, fields of specialization, including Science, Technology, Education, Law, Management Sciences, Health Sciences, Humanities, Arts and Agricultural Sciences, among others, are being managed by Deans/Executive Deans. Curricula reviews and development are largely course-based within the purview of each faculty where the Deans/Executive Deans are key players.

The focus and emphasis of the recent Subsector Skills Plan (SSP) of the Education Training and Development Planning, Sector Education and Training Authority (ETDP-SETA) in various educational institutions in South Africa are to lead all the relevant institutions in the country to drive urgent transition and implementation of the demands of the 4IR across all sectors of the economy. This is in a bid to phase out obsolete skills and the related economic consequences (ETDP-SETA, 2021). The education sector has accomplished this mission in previous revolutions (Penprase, 2019). However, the pace of evolution of the higher education sector in this regard was arguably slow and patchy in comparison with the rate of response noticed in other sectors in this era (Downes, 2015).

1.1. Statement of the Problem

With the rise in emerging technologies and the associated skills required, employers are in doubt about whether the competence of people today will meet the requirements to operate in the 4IR work environment (Bondy & Hamdullahpur, 2017; Spottl & Windelband, 2020; World Economic Forum, 2017; Yang, 2019; Yende, 2021). In this context, it is not certain whether the response of the education sector in South Africa, especially the universities, to the fourth industrial revolution corresponds to industry requirements. There is, therefore, a need to investigate whether there is a link between the universities and industry in ensuring that the 4IR demands in the workplace are factored into the academic curriculum. The key research questions on actualizing the fitness of graduates in the fourth industrial revolution era include:

- How are 4IR strategies being formulated and implemented within South Africa's universities?
- How do the industry and relevant specialist associations contribute to the university curriculum for implementing the 4IR in the country?
- How do South African universities become aware of the relevant emerging technologies that are crucial for teaching and preparing students for the workplace?
- How do faculties communicate their needs to the relevant structures for the acquisition of required technology?

These questions are posed with a view to identifying the nature of the relationship that exists between the South African universities and industry as well as the outcome of the relationship. The remaining part of the article is divided into a review of related literature, materials and method, results and discussions, conclusion, and policy implications.

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2. LITERATURE REVIEW

Researchers and practitioners have come to realize the need to strengthen the ties between institutions of higher learning and industry in order to actualize sustained, life-long learning among the working class in the era of the fourth industrial revolution (Ivascu, Cirjaliu, & Draghici, 2016; Marr, 2019; Oke & Fernandes, 2020; Yang, 2019). One prominent feature of the 4IR, as envisaged by scholars and practitioners, is the fast-changing nature of job requirements. This also has direct implications for the nature of the education and training required to match the changes in the workplace (Butler-Adam, 2018; Spottl & Windelband, 2020). The partnership between the institutions of higher learning and industry is pivotal to linking theory to practice, matching the right skills to innovation, and translating policy into economic benefits or wealth. According to Guerrero, Urbano, and Herrera (2019) such a collaboration could create an innovation ecosystem. Thelen (2020) emphasized the role of the regional universities of applied sciences in attracting the brightest students as a strategy to meet the increasing demand for theoretical skills required in the transformation of the German economy. This model was sustained by adopting firm-based vocational training in managing knowledge-intensive production by high-quality manufacturing companies in Germany (OECD, 2016; Thelen, 2020).

Baccaro and Pontusson (2016) analyzed the contributory role of the education sector in Sweden as the supply side of human capital, which contributed immensely to the transformation of Sweden's economy. Thus, education and industry were identified as essential building blocks underpinning the growth of Sweden's economy, in which case, industry occupies the demand side while institutions of higher learning serve the supply side. Germany, Sweden, and the Netherlands leverage high-tech skills from institutions of higher learning for economic success (Thelen, 2020; United Nations Conference on Trade and Development, 2021). Guerrero et al. (2019) highlighted the role of universities in innovative exploration and exploitation. The experience of South Africa with a teeming population of youths requires realistic measures that could empower the youth with the right skills to guarantee capacity development, which would invariably translate to economic development.

2.1. Industry Partnership and the Role of Faculty Leadership

The executive influence of the Deans of faculties is taking a central place in the initiation and implementation of technologies in educational institutions. This role, according to OECD (2010) is a key success factor by means of their strategic intermediation between management and the faculty members. The faculty designs the pedagogical approaches; it garners the technical support and technology-related services required to offer quality education and ensures the effective coordination of departments through the various heads (Bondy & Hamdullahpur, 2017; Tomte, Fossland, Aamodt, & Degn, 2019). The faculty is able to facilitate the internal processes and provide the link between the Information and Communication Technologies (ICT) unit of the university and various specializations across departments for the requisition and further procurement of infrastructure as it may relate to different disciplines within the faculty. Academic and non-academic staff members with technical competence, and who are not in leadership roles, are sometimes brought in to collaborate at the faculty level to channel and advance digitization (Mavidis & Folinas, 2022; OECD, 2016; Tomte et al., 2019).

2.2. All-inclusive Academic Curriculum

The need for a pedagogical paradigm shift, curriculum reform, and policy change to enhance translation from traditional 19th century teaching and learning methods to 21st century digital-based teaching and learning cannot be overemphasized if the institutions of higher learning are to be relevant in the era of the 4IR. The strategy for implementing this change requires the development of an academic curriculum that meets the needs of society (Altun, 1996; Arek-Bawa & Reddy, 2022; Editorial, 2007).

The industrial revolution with respect to education has propelled change, and a drastic shift was witnessed during the first industrial revolution, which, in the US, resulted in a shift in conventional education to the German

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university model for postgraduate research. The second "New Economy" brought with it a curricula shift associated with expanded incentive structures and a community of researchers within the US. Subsequently, the concept of an interdisciplinary curriculum and collaboration were introduced to Science, Technology, Engineering and Mathematics (STEM) education, with due emphasis on global citizenship during the third industrial revolution. The unprecedented change propelled by the 4IR is characterized by the convergence of exponential technologies and the resultant shifts in the education system. Thus, promoting flexibility is necessary in adapting academic knowledge to meet job-related knowledge in the world of employment globally (Penprase, 2018; Yende, 2021).

Extant literature has established a positive relationship between the mandatory deployment of technological tools for the teaching and learning experience of students. This is undoubtedly achievable through the epistemological transformation facilitated by curriculum reform, which provides the pedagogical foundation for the inclusion of technologies in teaching and learning (Burns, 2014; Dattijo & Adamu, 2022; Elayyan, 2021; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011; Whittier & Lara, 2007). Accordingly, it translates to transformed attitudes, beliefs, and performance among students, improves the student–teacher relationship, and facilitates skill acquisition by teachers (Light, 2009). Considering the future economic implications of equipping students with the right skills, emphasis was placed on the need to align a skills-based curriculum with technology (Arek-Bawa & Reddy, 2022; OECD, 2016; World Economic Forum, 2020). Institutions of higher learning needed to reimagine and redesign the academic content to match the skill changes necessitated by the 4IR.

2.3. Theoretical Framework

This study hinges on the philosophical belief of diffusion of innovation and triple helix theories. On the one hand, Rogers (1995) argued that different groups of beneficiaries of new innovation respond differently and embrace and utilize innovation at a different pace. This is evident in the uneven pace at which the education sector responds to adopting emerging technologies for disseminating educational instruction across universities. On the other hand, the theory proposed by Etzkowitz and Leydesdorff (1995) defines the integrated responsibility which the 4IR imposes on institutions of higher learning, industry, and the government to combine efforts to ensure a sustainable regional innovation environmental model.

Theorists have argued that universities will define regional economic innovation and social development by creating and transferring knowledge flows into technological innovation, reinforcing human capital and tacit knowledge, among others (Etzkowitz & Leydesdorff, 1995). In this relationship, the triple helix model emphasizes necessary and continual reorganization across industries to accommodate new knowledge and innovation from universities. Guerrero et al. (2019) and Gachie (2019) also highlight effective collaboration and research commercialization of innovative ideas and inventions in industry. The government is responsible for stimulating universities to contribute directly to wealth creation over and above education and research functions (Etzkowitz & Leydesdorff, 1995; Guerrero et al., 2019; Nkosi, Aboginije, Mashwama, & Thwala, 2020). National investment in this relationship would bridge the gap between the rich and poor, temper geopolitical conflicts, and strengthen the rate of transformational development across the world (Chatzinikolaou & Vlados, 2019; Maynard, 2015).

3. RESEARCH METHODOLOGY

3.1. Research Design

The study adopted a survey design using a well-structured and validated interview guide to elicit first-hand information from respondents. This was found to be the most appropriate method to fulfil the purpose of the study.

3.2. Research Participants

The study participants comprised the Deans/Executive Deans of faculties from the 26 universities in the Republic, out of which 22 were purposefully selected to ensure that all three categories of universities across the

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nine provinces are fairly represented. These comprise traditional, comprehensive, and technology universities. The choice of the Deans/Executive Deans for the interview was based on their role as academic and intellectual leaders who offer guidance for effective and efficient academic transformation to build institutional identities within and outside their universities.

3.3. Instrumentation and Validation

The study employed a structured interview guide to gather data. The validation process of the research instrument involved both the office of the Research Chair for the 4IR, based at the University of Johannesburg, and the Research Unit of the ETDP-SETA. While the office of the Research Chair was responsible for the coordination and supervision of the design, the Research Unit of the ETDP-SETA was responsible for quality control to ensure that the questions were appropriate to achieve the objectives of the study. The questions were subsequently vetted by experts and validated after the necessary amendments had been made. The approved interview instrument was circulated to the participating Deans/Executive Deans via email.

3.4. Data Collection Procedure

The period of data collection spanned two months, from mid-June 2020 to mid-August 2020, which coincided with the global Covid-19 pandemic, so data collection took place online through Microsoft Teams and Zoom. The restrictions imposed due to Covid-19 intercepted traditional face-to-face lecture platforms, and as such, the respondents were engaged in planning and formulating an urgent strategy to fully migrate to online lectures to ensure that the academic calendar was not affected by the lockdown. The disruption, therefore, meant that some of the participants who wished to participate couldn't as they were busy with the Covid-19-inflicted administrative workload. Overall, 70 out of a total of 188 Deans/Executive Deans across various faculties were able to participate in the interview.

3.5. Data Analysis Procedures

MS Teams and Zoom provide platforms for enhanced video recording. The recordings of all the interviews were documented as set out in the ethics clearance signed by all the participating universities. All video interviews were transcribed and 61 out of the 70 video recordings provided sufficient responses. These were analyzed using content analysis and presented using descriptive statistics.

3.6. Ethical Consideration

Prior to the commencement of the study, a letter of consent was written and signed by the ETDP-SETA to seek the cooperation and involvement of all learning institutions across the nine provinces in the country. The office of the University of Johannesburg (UJ) Research Chair for the Fourth Industrial Revolution also obtained ethical clearance from UJ to seek the informed consent of all the participating universities. Subsequently, clearance was granted by all the participating universities after the ethical conditions stipulated by each of the respondents' universities were met.

4. RESULTS AND DISCUSSION

This section presents the results of the findings based on the research questions relating to the strategy in place within the participating universities toward institutionalizing emerging technologies for teaching and learning. The analysis of the results focuses on the relationship between the universities and industry as well as the relevant professional associations for utilizing 4IR technologies in teaching and preparing university graduates for the world of work. The section concludes with the findings on whether universities had acknowledged the specific advice received from relevant industries and associations in the academic curriculum by practically integrating

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theory and practice into academic training. For inferential purposes, the results are presented based on the nature of academic fields in groups of faculties ranging from Education (EDU), Engineering and Built Environment (ENG), Science (SCI), Health Sciences (HSCI), Management Science (MGT), Law (LAW), Theology (THEO), Humanities (HUM), and other academic faculties (OTH), which comprises faculties of Agriculture and Mathematics, among others.

4.1. Formulation and Implementation of the 4IR Strategy

Considering the importance of implementing the 4IR in universities in this era, this study seeks to determine whether or not the respondents' institutions had formulated any strategy for 4IR implementation either at the university-wide or individual faculty levels. It is believed that strategy formulation facilitates the achievement of organizational goals.

Table 1. Formulation of an institution-wide 4IR strategy.

4IR strategy	Formulation of university-wide 4IR strategy								
	EDU [9]	ENG [6]	SCI [8]	HSCI [5]	MGT [15]	LAW [4]	THEO [3]	HUM [7]	OTH [4]
Separately formulated	2	2	1	0	3	0	0	2	1
Not formulated	4	4	7	2	8	3	0	3	1
Formulated as part of existing policy	3	0	0	3	4	1	3	2	2
Total responses	9	6	8	5	15	4	3	7	4
Separately formulated (%)	22	33	12	0	20	0	0	29	25
Not formulated (%)	44	67	88	40	53	75	0	42	25
Formulated as part of existing policy (%)	34	0	0	60	27	25	100	29	50

The result presented in Table 1 show that, at the time of the interview, the majority of the faculties had no 4IR institutional strategy in place, as indicated by the Deans/Executive Deans (>52%). Particular attention is drawn to the faculties of Science (88%), Engineering and Built Environment (67%), Law (75%), and Management Science (53%). Notably, these faculties were grossly unaware of the existence of any form of 4IR strategies in their respective universities. This indicates that the rate of response to the 4IR may slow down in this space. However, 18% of the Deans/Executive Deans confirmed that there is a separately formulated 4IR strategy in their institutions, while about 30% of the Deans/Executive Deans confirmed that the 4IR strategy was incorporated into the institutional policy rather than being formulated as a stand-alone policy statement. This result is in consonance with the findings of Aliu, Aigbavboa, and Thwala (2021) on the incorporation of the 4IR dimension into teaching and learning by universities. Only the faculty of Theology had a 100% response to the 4IR, and the reasons behind this could be attributable to the urgent need to hold religious programmes virtually and continually during the global pandemic. Generally, about 47% of the faculties have reflected a 4IR strategy in the form of either a separate policy or one that is entrenched in the current institutional policy. This reveals the rate at which South African universities are responding to the evolving landscape in the digital space.

4.2. Implementation of a 4IR Strategy within the Faculties

It is not enough to incorporate the 4IR in the policy statement as established in subsection 3.1. Therefore, this study seeks to determine the level of implementation of the 4IR strategy within the faculties under study. The Deans/Executive Deans were asked if they were specifically directed to embed the 4IR in their faculty's activities by their universities. The results are shown in Table 2.

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Table 2. Implementation of institutional 4IR guidelines at the faculty level.

Faculty activity	Institutional guidelines on faculty activities								
	EDU [9]	ENG [6]	SCI [8]	HSCI [5]	MGT [15]	LAW [4]	THEO [3]	HUM [7]	OTH [4]
Guidelines provided by institution	3	1	1	0	5	1	0	1	1
No institutional guidelines provided	5	2	6	2	7	3	1	5	2
Guidelines formulated by faculty	1	3	1	3	3	0	2	1	1
Total responses	9	6	8	5	15	4	3	7	4
Guidelines provided by institution (%)	33	17	13	0	33	25	0	14	25
No institutional guidelines provided (%)	56	33	74	40	47	75	33	72	50
Guidelines formulated by faculty (%)	11	50	13	60	20	0	67	14	25

While about 47% of the respondents had earlier indicated the existence of the 4IR strategy in their institutional policy (refer to Table 1), the vast majority of faculties had not received any guidelines from their institutions to embed 4IR in their activities. However, in the absence of any specific guidelines from the institutions, the consciousness of gaining relevance in the technology-driven era had stimulated about 25% of the Deans/Executive Deans to respond to the pervasive influence of the 4IR and had incorporated a set of structured activities in line with emerging technological innovations and advancement into their programmes within the faculty.

On the contrary, the results reveal an unwillingness of the faculty of Engineering and Built Environment and the faculty of Science to embrace any form of institutional guidelines to respond to evolutionary change and implement the 4IR in their activities. They preferred to remain open to innovation to enable them to respond in the best way possible rather than being stiffened by organizational policy. These faculties have taken the lead at the national level and in the global space, and some of them have records of favorable competition in the digital world (ETDP-SETA, 2021).

It is, however, noteworthy that the absence of institutional policies on the implementation of the 4IR could lead to a lack of direction, non-standardization of activities, and difficulty in measuring performance across faculties within the same university. While the current subsection focuses on the incorporation and implementation of institutional guidelines on the 4IR into the faculties' activities, the next subsection focuses on the learning content suggested by industry partners for inclusion in the curriculum by the institutions under study.

4.3. Engagement with Industry Partners and Relevant Associations

This subsection aims to ensure active engagement with relevant industries and the exchange of up-to-date information on industry practice. The respondents were therefore asked to provide clear details about whether their institution receives guidance from the advisory board and if their institution engages with the guidance. The advisory boards are primarily composed of industry partners and related associations.

With the exception of the Faculty of Theology, which was least engaged and influenced by the industry players (33%), the results in Table 3 show complete engagement and influence by industry in the faculties of Health Sciences (100%), Engineering and Built Environment (100%), and other academic faculties (100%). The Deans/Executive Deans indicated that having an advisory board is mandatory and that their meetings provide a platform for robust discussions on industry developments. This practice is in line with the emphasis on novel innovation blueprints for actualizing the integration of fundamental and applied research toward institutionalizing sustainable innovation (Saguy, 2011). A more important and practical aspect of the involvement of industry

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partners would be reflected in the number of industry ideas translated into actionable strategies incorporated into the university curriculum.

Table 3. Provision of guidance by industry partners and associations (Advisory board).

4IR guidelines	4IR guideline provision by industry partners and specialist associations								
	EDU [9]	ENG [6]	SCI [8]	HSCI [5]	MGT [15]	LAW [4]	THEO [3]	HUM [7]	OTH [4]
Guidelines were provided by the advisory board	7	6	5	5	12	3	1	4	4
No guidelines were provided by the advisory board	2	0	3	0	3	1	2	3	0
Total responses	9	6	8	5	15	4	3	7	4
Guidelines were provided by the advisory board (%)	78	100	62	100	80	75	33	57	100
No guidelines were provided by the advisory board (%)	22	0	38	0	20	25	67	43	0

4.4. Inclusion of Industry-Specific Guidance in the Curriculum

In addition to receiving relevant information and guidelines on the current practices in the industry, the respondents were also asked to indicate whether the advice received from the advisory board formed part of the current curriculum in their faculties. This involves practical translation and integration of specific industry knowledge into manageable teaching modules.

Table 4. Inclusion of industry-specific guidance in the curriculum.

Guideline inclusion	Inclusion of guidelines in the curriculum								
	EDU [9]	ENG [6]	SCI [8]	HSCI [5]	MGT [15]	LAW [4]	THEO [3]	HUM [7]	OTH [4]
Guidelines are incorporated in the curriculum	4	4	4	5	12	2	0	0	4
Guidelines are not incorporated in the curriculum	5	2	4	0	3	2	3	7	0
Total responses	9	6	8	5	15	4	3	7	4
Guidelines are incorporated in the curriculum (%)	44	67	50	100	80	50	0	0	100
Guidelines are not incorporated in the curriculum (%)	56	33	50	0	20	50	100	100	0

Table 4 presents the findings on the inclusion of industry-specific guidance in the curriculum. Some respondents indicated that suggestions from advisory boards regarding the academic curriculum are thought-provoking, some indicated that their universities and faculties have taken the lead in determining the best practice in evolutionary advancements, and others have bought into the inclusion of the industry-specific guidance in the curriculum when it comes to the technological advances. Those in the 4IR thought leadership space include the faculties of Science (50%), Education (44%), and Law (50%). These faculties determine their own best practice and share and stimulate its acceptance by the industry. They also incorporate the new changes and best practices into the curriculum to prepare students for the world of work. This practice is in line with the suggestion of Yende (2021).

Other faculties that had fully bought into the technological innovations affecting their fields include Health Sciences (100%), Agriculture, and Mathematics (others), among other academic faculties (100%). These faculties had completely incorporated the work-related content and suggestions from the industry and other relevant associations into the curriculum. This way, a curriculum targeted at performance improvements through teaching and learning would be achieved (Dattijo & Adamu, 2022; Saguy, 2011). Another group of faculties exists with

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certain peculiarities comprising Theology and Humanities. While these two faculties had taken no input from the industry players as part of the curriculum content, they exhibited different beliefs regarding this practice. The faculty of Theology (0%) in the Republic maintained that the decision to incorporate new technologies into the curriculum resides with the faculty leaders, thereby sitting on the fence. The faculty of Humanities (0%), on the other hand, remained passive and skeptical about bringing technology into the curriculum. The reason for such skepticism is the fear that machines might soon displace human experts if allowed.

Having established the influence of the university–industry collaboration on curricular review, it is expedient to examine whether universities are aware of relevant 4IR technologies required to produce graduates who are prepared for the world of work.

4.5. Awareness of Emerging Technologies

The Deans/Executive Deans were able to establish how the technical staff within the faculty conduct technology awareness as part of their function. It was confirmed by most of the respondents that the internal technical staff were purposely employed to serve as pioneers in technology innovation. They have largely assisted in identifying the technological role and supporting the faculties to facilitate new innovations. Knowledgeable personnel is key to the successful implementation of the 4IR in different fields of specialization (Mavidis & Folinas, 2022).

Table 5. Awareness of emerging technologies.

Awareness status	**Awareness of 4IR technologies**								
	EDU [9]	**ENG [6]**	**SCI [8]**	**HSCI [5]**	**MGT [15]**	**LAW [4]**	**THEO [3]**	**HUM [7]**	**OTH [4]**
The faculty is aware of emerging technologies	6	4	5	3	9	2	2	2	3
The faculty is not aware of emerging technologies	3	2	3	2	6	2	1	5	1
Total responses	9	6	8	5	15	4	3	7	4
The faculty is aware of emerging technologies (%)	67	67	62	60	60	50	67	29	75
The faculty is not aware of emerging technologies (%)	33	33	38	40	40	50	33	71	25

Table 5 presents the awareness of emerging technologies. The findings are that almost all the faculties are aware of 4IR/emerging technologies in their respective areas of specialization, with the exception of Humanities (71%). The faculty of Law (50%) is equally aware of emerging technologies that not only complement the role of human experts but could also play a similar role as human experts. New technology, indicated by various respondents, includes 3D printing, blockchain, robotics, virtual reality, clinical field tracking systems, the internet of things, and big data, among others. The Deans/Executive Deans revealed that the universities or faculties that were not aware of emerging technologies had less contact with industry partners despite the existence of advisory boards. Such faculties also had little or no close working relationships with industry associations (König, Jäger-Biela, & Glutsch, 2020; Moloi & Salawu, 2022).

There is also a concern about the need to invest in the identified technologies in a pragmatic manner. It is, therefore, worthwhile investigating how universities identify the need for required technologies and how they seek to procure them. The process involved is the focus of the final subsection of this study.

4.6. Communication of Technology Needs with the Institutional ICT Department

In this section, the researchers sought to determine the process through which faculties communicate and source their technology needs. All the Deans/Executive Deans indicated the central role occupied by the

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Information and Communication Technologies (ICT) department in sourcing the right technologies and making prescriptions to relevant departments within the faculties. Additionally, the ICT department was identified as the liaison between the faculties and the university in compiling requisitions for procurement.

Table 6. Communication between faculties and the ICT support department on technology needs.

Category	Communication of the faculty's technology needs								
	EDU [9]	ENG [6]	SCI [8]	HSCI [5]	MGT [15]	LAW [4]	THEO [3]	HUM [7]	OTH [4]
The faculty's technology needs have been communicated	5	3	6	4	7	2	3	5	3
The faculty's technology needs have not been communicated	4	3	2	1	8	2	0	2	1
Total responses	9	6	8	5	15	4	3	7	4
The faculty's technology needs have been communicated (%)	56	50	75	80	47	50	100	71	75
The faculty's technology needs have not been communicated (%)	44	50	25	20	53	50	0	29	25

As shown in Table 6, a sizeable number of the faculties communicated their technology needs through the Dean or designated officer to the ICT support departments. This is the established procedure found in most public universities. The group of respondents who had not submitted any requisition to the ICT support department indicated that they were either satisfactorily equipped or were currently undergoing a technology screening process and were yet to finalize their decision on which technology to procure. It was also revealed that certain technology, such as learning management systems, is centrally procured and jointly utilized by faculties within each university. Additionally, the respondents emphasized the key role played by the Department of Higher Education with respect to funding huge projects with a special interest in 4IR technologies. Many of the faculties under study had been able to access substantial grants in support of innovative advancements in their various universities through this medium.

5. CONCLUSION

In a bid to implement the 4IR strategies through a university–industry partnership among South African universities, the level of awareness of emerging technologies that is crucial for teaching and learning, and the inclusion of industry guidance into the curriculum with the aim of preparing students for the future workplace, have been explored in this study. Notably, the respondents were largely unaware of the existence of any form of 4IR strategies in their respective universities and, as such, only a few institutions had 4IR strategies formulated and incorporated into their academic activities at the faculty level. However, the results revealed the unwillingness of the faculty of Engineering and Built Environment as well as the faculty of science to embrace any institutional guidelines for responding to evolutionary change and for implementing the 4IR as they believed that this could stiffen innovation. Instead, they preferred to remain open to innovation and take the lead both in the national and global spaces with competitors.

While some faculties were at the forefront in determining best practice as 4IR thought leaders, others had completely integrated the advice and suggestions from the industry and relevant associations into the curriculum for implementation. This feat was not without reference to the contribution of the advisory boards, which consist of industry partners, associations, and other academics within their faculties/universities.

5.1. Theoretical Contributions

In addition to the commitment of the universities' ICT units toward sourcing and procuring the necessary technologies, the Deans/Executive Deans also indicated regular access to project funding and substantial grants

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from the Department of Higher Education for 4IR capital-intensive projects and the procurement of 4IR technologies. This has implications for advancing and accelerating the pace of sustainable innovative development in the 4IR space through effective collaboration with the industry while the government plays the role of incentivizing universities to build sustainable wealth creation, as suggested by the triple helix theory, thus enhancing favorable competition within regional economic space as well as lessening the gap between the rich and poor, fulfilling a major national imperative in the Republic.

5.2. Limitations

The main limitation of this work is that its focus was on public universities in South Africa. Private higher education institutions were not considered. Also, data collection for this study took place virtually as a result of restrictions in movement during the study period due to Covid-19. This prevented the researchers from having onsite interaction to observe 4IR-related activities deemed to be ongoing at the faculty level in the various universities.

5.3. Policy Suggestion

The findings from the study revealed that a vast majority of the universities in South Africa did not formulate any separate strategy or policy on 4IR implementation. The has implications for focused and speedy implementation of the 4IR imperatives in the country. There is a need to encourage tertiary institutions to improve on this practice. Policymakers could also insist on the institutional formulation of a 4IR strategy in the near future as a means to align the demand of the 4IR with the current education system in line with the mission of the ETDP-SETA and the nation as a whole.

5.4. Future Studies

Future studies could focus on a composite picture of the higher education landscape in South Africa.

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