

Institutionalizing Technologies in South African Universities towards the Fourth Industrial Revolution

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Abstract—This study investigated the essentials for institutionalizing technologies for teaching and learning across the three categories of universities in South Africa in the 4IR era. The study adopted cross-sectional survey design. Online interview was conducted on Microsoft Teams and Zoom with the Seventy (70) Executive Deans/Deans in Twenty-two (22) out of twenty-six (26) South African Universities. Content analysis and descriptive statistics were employed for analyzing data. Findings revealed that the universities in the Republic deployed fifty-seven different technologies to facilitate their teaching and learning. Also, the sampled universities had supplemented teaching platforms with new technologies such as WhatsApp, Zoom, and MS Teams. The study established that most universities/faculties had provided training on an ongoing basis. Having overcome the initial resistance, it was found that the teaching staff is competent in using existing technologies for teaching. Results also revealed notable improvements in the standard and quality of teaching and learning with the aid of emerging technologies as evidenced by positive feedbacks from lecturers and students, and continuity with classes, even under-lockdown conditions. This diagnostic study has contributed to current research by identifying and assessing the response of South African universities to teaching and learning in 4IR era. The sustainability of academic calendar under lockdown is a proof that universities are prepared to implement the convergence between human and machines in this age. It was concluded that there is a need to have a national policy in place that deals with funding (special grant) to plug the gap in the digital divide. The major limitation of the study is that it focused on the Deans/Executive Deans and other key personnel in charge of implementing the 4IR in universities, taking no input from the students.

Keywords—higher education, fourth industrial revolution, South Africa

1 Introduction

The reality of the fourth industrial revolution had been brought to the fore by the global pandemic (COVID-19), which pervaded and disrupted all sectors of the world's economy in the year 2020, many institutions of higher learning across continents had witnessed a measure of hiccups. In response to the fourth industrial revolution (4IR), South African government had in 2019 launched a presidential

commission to leverage on the potentials of 4IR for capacity development and industrialization, among others.

As part of its obligation, the commission was charged with the responsibility of formulating technology-responsive policy and legislation to catalyze the republic from employment capacity of 16.1 million recorded in 2016 to 20.7 million in 2030 [1,2,3]. This is imperative following the concerns of 90 percent of South African CEO about lack of skills needed in various organizations across the country [4]. This situation [3, 5, 6] was pathetic and detrimental as the teeming youth population are devoid of the needed skills to move the country forward. Meanwhile, the shortage of skilled staff to drive the change stimulated by the 4IR had been because of the failure in the education system in the country [4, 3, 5]. Ignoring this important sector, which aids national capacity building in line with the goal of raising digital citizens, could be detrimental to national imperatives. The response of the institutions of higher learning in the country is crucial in this context. While the usefulness of the ever-evolving technologies as tools for advancing teaching and learning cannot be over-emphasized [7, 8, 9,10,11], a shift from the traditional mode of teaching and learning to either a complete technology mode of teaching or a gradual blend of the traditional and the use of technologies seemed to have been greeted with mix feelings among the academics, especially in the emerging economies [12,13,14,15,16,17]. This is clear in the number of higher education institutions that have embraced the online teachings in developed economies as against emerging economies [18,19,16]. At the moment, there is a dearth of empirical evidence on the experience of universities in South Africa in assimilating and institutionalizing technologies for teaching and learning. As a result of the research gap, which was created by the dearth, this study sought to investigate the experience of institutionalizing technology for teaching and learning across all three types of South African universities. The study is imperative as its outcome will provide reliable data and information that would enable policy-makers and relevant stakeholders to take steps in advancing education in the country in the era of the fourth industrial revolution.

The research questions addressed by the study on the use of technologies for teaching and learning include investigating the availability of technologies, staff training, competence of staff, new acquisition of technological tools to keep abreast of teaching and learning, and value derivation from the new procurement of emerging technologies. The rest of the paper is subdivided into literature review, the methodology, results and discussion, summary of findings and policy implication of the study and conclusion.

2 Literature review

In the world's history, nothing else seems to bring about further transformation in the knowledge industry than technology. It is a double edge tool for discovering and creating knowledge [19,20]. Not only do technologies promote learning, they serve both as basic tools and the medium for transmitting it. Before the global pandemic, efforts made by various universities, either by a few visionary techno-savvy

academics or by the university administrations, had been met with multiple reactions [19, 21,22]. The need to implement technologies in teaching and learning in the era of the fourth industrial revolution is a global concern. As a result, this diagnostic research adopted an exploratory approach to literature review aimed at investigating the theme of the study, focusing on peer review journals which addressed specific research objectives of the study. Existing relevant studies within South Africa are considered alongside other emerging economies to address the current concerns within the education sector of the country [1,2,3,4,5,23,24,25].

2.1 Basis for effective teaching and learning in the era of 4IR

The emerging technologies of the fourth industrial revolution are changing landscape in the education sector. Palanivel [23] noted that the technologies have enhanced the efficiency of smart education and had contributed to a shift from traditional education to smart education. Using technology in the classroom is student-focused, enquiry-based and changes the role of teachers to a coach, mentor and facilitator [24,25]. As pointed out by Resta and Laferriere [26], technology promotes collaborative work among students through peer interaction, and among academic staff and researchers. This produces more openness among peers [27,28,29].

Ghavifekr and Rosdy [30] contended that the technological tools are add-on supplements required for better delivery of lectures, and they are not meant to replace the teachers who are needed to facilitate teaching and learning. Both the teachers and the students derive benefits from integrating technology into teaching and learning. While the teachers strive for innovative, creative and effective approach for lecture delivery, the students also maximise the ability to engage with the available learning materials as well as explore other relevant resources to broaden their knowledge of the various subjects.

Ozdamli [21] and Rabella [31] emphasized teachers' technological knowledge and confidence in facilitating actual teaching as critical factors to consider in assessing staff competence. While perhaps instructors have a key role in implementing technology-based teaching and learning [32,33,34], evidence from literature has shown the effectiveness of training, and working with small cohorts of teachers in a collegial manner to plan and implement the use of the digital tool for teaching in the classrooms such that resistance to adopting such technology could be minimised [8, 35].

Hence, training of staff members to operate the new technologies, investment in the relevant technologies, and inclusion in the curriculum are the first stage of implementation of technology-based teaching and learning [36, 33, 37].

Digital nativity has stimulated the passion of the current generation students for learning with technology and a good number of students understand the skills they would require to appropriate the benefits of the fourth industrial revolution as they envisaged the impact of the era on their career [38,39]. Also, in terms of effectiveness, students can integrate previous and current learning systems as well as broaden their knowledge paradigm [30]. The availability of multifarious resources,

which could be accessed via the internet, personal possession of useful devices by students to carry on with learning outside the classroom, is paramount [32].

The various authors have emphasized the role of teachers as mentors and the need to promote creativity and encourage collaborative work among students, collegiality among teachers towards acquisition of necessary skills for advancing teaching and learning in the 4IR era across the institutions of higher learning [26-30,33-36].

2.2 Recent trends in emerging technologies

One tool for effective teaching and learning that affects students' learning experience is the use of video to engage students and over which students have control of the media [40, 12,41]. Using video-based flipped class instruction was also found to enhance teaching effectiveness and subject satisfaction in students [42,7,29]. Robotic technology helped to increase the scores of in and after-school programmes and promotes learning efficiency [43,20].

Mobile-based learning, using handheld devices, is another used technology that is affordable by students in most instances. It enhances accessibility to learning sites and materials with fewer barriers irrespective of time and location [44,45,29].

Learning with the 4IR technologies, such as augmented reality, proves to reduce extraneous cognitive load, improves learning achievements, and increase students' motivation compared to the traditional learning approach [8, 46]. Chin and Wang [47] found that Augmented Reality (AR) mobile touring improves students' ability to memorize the Slearning achievements. Rabella [31] argued that diverse backgrounds and strong mixes of skills, including technical, cognitive, metacognitive and socioemotional competence, which are needed to develop students for the era of the 4IR. Learners must take part in the process of knowledge acquisition, as they receive guidance by expert mentors either live or through computer programme, as a form of cognitive support [48,49,29].

The various authors had highlighted the place of technologies in enhancing in this sub-section. The impact of the various learning tools is irrespective of distance or location and such, they would motivate students to engage and learn as required [43-48,50,51].

2.3 Policy intervention

Evidence from country-based research and experiences had proved the central role of national policy in institutionalizing technology. Burns [51] and Cross & Adam [52] pointed out that educational institutions on their own cannot promote a country-wide practice of the use of technology without an approved national policy framework on the use of ICT in education.

Countries like Singapore and Britain have well-established national structure in favour of ICT and technology-based teaching and learning which could be referenced for providing leadership. Without such support, some observe that teachers who choose to use technology to aid teaching and learning have only done so on their own volition, while it cannot force several others who choose not to against their will.

Against this background, Burns [51] proposed motivating tutors as a veritable strategy to embark on successful technology institutionalization. Citing the cases of Netherlands, Britain, Singapore, and Korea, the incentive as a pay rise and promotion have been employed to encourage academics to engage with the students using appropriate technologies [53].

Afghan government implemented the practice of distributing one laptop per student in order to close the gaps between researchers' need and the need for a national appropriation of the benefits of technology [54]. This could be more relevant with South Africa where issues of competition, inter-institutional cooperation, public/private partnerships have been linked with poverty, inequality, illiteracy, skills development etc, which would cause compromise in the choice and emphasis of the national ICT policy to be adopted if a reasonable balance is envisaged [52]. While South African higher education seems to witness increased use of technologies to support teaching, the policy initiatives and institutional strategies for purposeful implementation are lacking [52].

However, the recent involvement of South African government in seeking improvement in the level of education by balancing innovation with legislation shows possible quick transformation of the education sector in harnessing the benefits of the 4IR for national revolution. In this manner, the national policy framework advocated by the authors cited in this subsection would be instrumental in actualizing the changes [2,3,5].

2.4 Theoretical underpinning

This study was premised on the theories of social constructivism and diffusion of innovation. Social constructivism is a learning theory propounded by Lev Vygotsky which focuses on collaborative learning process in which the teachers employ teaching methods which are students-centered while the learners engage with learning and interact with one another with the intention to explore and share new knowledge among peers [26, 54, 55,29,56]. The theory of diffusion of innovation, as propounded by Rogers [57] suggests that adopters of innovation would portray indifference or lack of interest, resulting in resistance, especially when an innovation is perceived to be incompatible with the prevailing culture [58]. Rogers [57] provided deep insight into attitudinal responses of different stakeholders towards innovative changes affecting their interest. However, Skinner [59] and Kamaruzaman [60,56] noted that the speed of transformation is unprecedented, leaving little or no opportunity for the individual to make choices.

In recent time, introducing robotic teachers has changed the general orientation and age-long scope of technologies in education. With the prevalence of technologies for teaching and learning, learning by students does not require over reliance on tutors, rather, learners are provided with best instructional strategies which could be any of, or a combination of visualization, cooperative learning, inquiry-based and/or the use of technology to deploy effective teaching [61,28,29]. To gain the needed skills, it might be necessary for the educators and students to unlearn the old, under-carpeted skills and learn new concepts, theories, methods and strategies in order to give

priority to organized learning, training and development of the future workforce in line with the fourth industrial revolution as the bottom line.

3 Materials and methods

Prior to the emergence of the challenges posed by the 4IR and its associated technologies, the various education subsectors overseen by Education Training and Development Planning, Sector Education Training Authority (EDTP SETA) had engaged in regular assessment and upgrading of the human resources skills to meet the demand from the labour market within the South African economy. Findings from the various assessment had shown the need to reimagine the role of the education system, regarding institution of higher learning, to develop digital citizens as one of the key strategies for responding to the need of the era. This research was part of the effort of the EDTP-SETA to actualize this goal, and it focuses on investigating the essentials for institutionalizing technologies for teaching and learning in the educational institutions, the universities across the country.

3.1 Research design and validation of instrument

Survey design was employed for the study with the use of in-depth interview conducted to elicit first-hand information from the respondents. A well-designed interview guide was presented to the research unit of ETDP SETA for screening and check for appropriateness. The screening procedure brought about necessary amendment to the list of questions being vetted by experts, which were validated and approved for use. The questions focused on identification of the technologies at the disposal of the universities prior to the global pandemic, at the faculty level and on the competency of staff members in handling the technologies for teaching and learning during the global pandemic. The researchers were also interested in determining whether universities and/or the faculties embarked on procurement of new technologies to keep abreast with technological advances, as institutions relied on virtual teaching and learning during the lockdown situation. Other related questions addressed training of staff members to work on (operate) the newly acquired technology on one hand, as well as the relevance and value derived from the use of the newly procured technology.

3.2 Population and sample size

The population for the study comprised all the Executive Deans/Deans of Faculties in all twenty-six (26) South African Universities out of which Twenty-two (22) universities were purposefully selected. The sampled universities comprised the traditional, comprehensive, and technology. This was done to allow fair representation of all categories of the universities across the nine provinces, as well as all fields of specialization in the study. Thus, nine groups of faculties emerged which include the faculty of Education (FOE), faculty of Science (FOS), faculty of

Engineering and Built Environment (FEBE), faculty of Management Science (FOMS), faculty of Theology (FOT), Faculty of Health Sciences (FOHS), faculty of Humanities (FOH), faculty of Law (FOL), and, Other Academic Faculties (OAF). The other academic faculties include Agriculture, Arts and Design, Mathematics and Natural Sciences, and Information Technology and Governance. Each of the groups serves as the umbrella name for similar faculties across all the universities which took part in the research. Another reason for extending the research to the three different types of universities in the Republic was to enable generalization of the findings of the study. A total of 188 Deans of Faculties were contacted via their institutional email on the various institutional websites. After that, several emails were sent as a follow-up to secure their participation because the period of the interview was challenging and tasking for all the Deans. Some of them were in the mainstream of providing support at the national level to manage Covid-19 pandemic and, they were cumbered with strategizing for proper handling of the growing challenges of the time in order to rescue the academic calendar from distortion. Because of the uncertainties that pervaded the period, many of the meetings were rescheduled times and again. A total of 70 Deans were interviewed. An important uniqueness of the interview with most of the Deans of the faculties was that, they involved key staff members at the faculty level including the Deputy Vice-Dean Research, Deputy Vice-Dean Academic, Heads of Department, Faculty specialists in Technologies and Innovation, Human Resource Personnel, etc. This provided the benefits of gathering rich and relevant data from the designated staff members who were in charge of technological advancement in the various faculties and across all the universities.

3.3 Ethics clearance and data collection

Ethical clearance was got for the conduct of the research in all the institutions that took part. Prior to that, ETDP-SETA wrote and signed a letter of consent, which was sent to all the institutions as evidence that the research was conducted on behalf of ETDP-SETA. This was accompanied by a copy of the proposal for the study and an ethical clearance obtained from the University of Johannesburg. The original platform intended for data collection was face-to-face interview with the Executive Deans/Deans. However, the outbreak of Covid-19, which imposed local, national and international restriction to movement, caused a change of platform to virtual interview with the respondents via MS Teams and zoom as convenient for the respondents. Because of the administrative engagement with managing Covid-19 pandemic, some of the Executive Deans/ Deans could not take part in the online interview. However, 70 out of 188 of the respondents could take part along with their key personnel. The video recording of all the interviews was made and documented. However, the study focused on 61 of the 70 respondents who provided sufficient information required for the entire aspects of the interview.

4 Results and discussions

Based on the overall aim of the study, this section presents the results to determine and understand the Technologies available for teaching and learning; Competencies of staff members in using these technologies; the training provided to staff members by the institutions on the use of these technologies, as institutions ramp up the use of technology in order to meet the demands of the fourth industrial revolution. For reasonableness and for generalization of findings, data from the interview across the faculties and universities were analyzed and based on related fields and specialization.

4.1 Technologies at the disposal of the respective university faculty

The key motivation for this subsection of the research was to determine the technologies available for teaching and learning at each faculty in every university that took part in the interview. Researchers requested respondents to reflect on technologies at their faculty’s disposal for teaching and learning activities. The technologies available in the universities are presented in Table 1.

Table 1. Technologies at the disposal of the respective university faculty

Teaching and learning technology deployed	Technologies available for teaching and learning activities									Technology Deployed Total
	FOE	FOS	FEBE	FOMS	FOT	FOHS	FOL	FOH	OAF	
	[9]	[8]	[6]	[15]	[3]	[5]	[4]	[7]	[4]	
Cell phone	0	0	6	0	0	0	0	1	0	7
Computing Equipment/ Laptop/Tablet/iPad	3	0	2	6	1	1	1	4	1	19
Data/Wi-Fi	4	1	3	6	2	1	1	0	0	18
Document Cameras	1	0	1	2		0	1	0	1	6
Synchronised Learning Management System/Sakai	2	1	1	4	1	1	0	2	1	13
Learning Management System (Module Technologies)	5	5	2	7	1	2	4	2	2	30
Learning Management System (Blackboard)	3	4	4	6	1	1	0	2	1	22
Zoom	4	2	2	8	2	2	3	6	1	30
MS Package/ Microsoft Teams/BI Tools	4	4	1	14	3	5	2	4	2	39

Whiteboards broadcast	2	0	0	0	1	0	1	0	0	4
WhatsApp	3	2	3	8	2	1	1	4	1	25
YouTube/Videos (video studios and Peneulta video management system)	1	2	1	3	0	2	1	1	1	12
Supervision Room	1	0	0	0	0	0	0	0	0	1
Projectors	2	0	2	2	0	0	0	1	0	7
Google package/Google Meet/Gmail/Google doc	1	0	0	3	1	2	3	2	0	12
Podcasts	1	0	0	0	0	0	1	1	0	3
Camtasia	1	0	0	1	0	0	1	0	0	3
Screen-o-matic	1	0	0	0	0	0	1	0	0	2
Smart-board	1	0	0	1	0	0	0	0	1	3
Visualizers	1	0	0	0	0	0	0	0	0	1
Light board	1	0	0	0	0	0	0	0	0	1
One button studio	1	0	0	0	0	0	0	0	0	1
Virtual Reality	0	1	2	0	0	0	0	0	0	3
Telegram	0	1	0	0	0	0	0	0	0	1
Televisions	0	0	1	0	0	0	0	0	0	1
3D Printing/Lab	0	0	1	1	0	0	0	0	1	3
Augmented/Virtual Reality	0	0	1	1	0	1	0	0	1	4
Cloud Computing	0	0	1	0	0	0	0	0	0	1
Artificial Intelligence	0	0	1	0	0	0	0	0	0	1
Data Science Algorithms Technology	0	0	1	0	0	0	0	0	0	1
Cleanroom/high fidelity room/simulation lab	0	0	1	0	0	1	0	0	0	2
Atomic Layer Deposition	0	0	1	0	0	0	0	0	0	1
Unkempt Internet	0	0	1	0	0	0	0	0	0	1
Multimedia (twitter)/Outside broadcast unit	0	0	1	1	0	0	0	0	2	4
Servers Platforms	0	0	1	0	0	0	0	0	0	1

Information Screen	0	0	1	0	0	0	0	0	0	1
Facebook	0	0	1	1	0	0	0	0	1	3
Remote computer access	0	0	1	0	0	0	0	0	0	1
Bigbluebutton	0	0	0	1	0	0	0	1	0	2
Signupgenius	0	0	0	1	0	0	0	0	0	1
NexusLexus	0	0	0	1	0	0	0	0	0	1
Elibrary Resources	0	0	0	1	0	0	0	0	1	2
Adobe Connect	0	0	0	1	0	0	0	0	0	1
Bloomberg Terminal	0	0	0	1	0	0	0	0	0	1
Powtoons	0	0	0	1	0	0	0	0	0	1
IoT	0	0	0	1	0	0	0	0	0	1
Robotics	0	0	0	1	0	0	0	0	0	1
Sensor Jackets	0	0	0	1	0	0	0	0	0	1
Drone technology	0	0	0	1	0	0	0	0	0	1
360-degree camera/Go Pro Video Camera/Hi-Definition Camera	0	0	0	0	0	2	0	2	1	5
Literature and language facilities and software	0	0	0	0	0	0	0	0	1	1
Skype	0	0	0	0	1	0	0	1	0	2
Simulation assessment tool limiting assessor bias/Simulation Technologies	0	0	0	0	0	2	0	0	0	2
My progress App	0	0	0	0	0	1	0	0	0	1
Flipgrid/Fliproom	0	0	0	0	0	2	0	0	0	2
Cisco WebEx	0	0	0	0	0	1	0	0	0	1
Mytutor	0	0	0	0	0	0	0	1	0	1

Source: ETDP SETA Report (2021)

Results indicate universities deployed fifty-seven different technologies to facilitate their teaching and learning activities (refer to Table 1). These include Learning Management Systems (LMS), Microsoft (MS) Package, Google, WhatsApp, Camtasia, smartboard, Lightboard, Virtual Reality/Augmented Reality, Artificial Intelligence, Simulation Laboratories, High Fidelity Rooms, and Facebook among other technologies [62,16]. The most widely used technology across faculties and universities is the LMS, which includes different variants such as Moodle

technologies (30), blackboard (22) and Sakai (13) in most cases [63,56,64,65]. Contrary to the findings of Park and Jo [66] and [67] all the faculties under study used LMS (100%). The choice of the variant deployed by each faculty/university depended on the need and skill of the teaching staff, as argued by recent literature [68,7,29]. It was also clear from the study that academic faculties change from the use of one variant of LMS to another as deemed necessary. This is like the findings of Black et al. [64], Chaubey & Bhattacharaya [65], and Shugrygrin et al. [50]. Next to LMS is MS Package/ Microsoft Teams/BI Tools, which was used by about 64% (39) of the faculties which took part in the study. Other important technologies employed are zoom, which was used by 49% (30) and WhatsApp used by about 41% (25) of the faculties [69,70]. Among the very important but least employed technologies are Robotics, Sensor Jackets, Internet of Things, and Drone technology. These sets of technology require the expertise of relevant staff in handling them [17,16]. These results showed significant improvement in the number of technologies deployed by South African Universities within the last five years [67].

4.2 Competency of staff members in using the existing technology

The skills possessed by academic staff in using the relevant technology for teaching and learning are fundamental to the quality of education offered to both undergraduate and graduate students in the era of the 4IR. The purpose of this aspect of the study was to determine how competent the members of the individual faculties were in using the existing technology. To determine this, researchers requested the Executive Deans/Deans to reflect on the competence of staff members in using the technologies at their disposal.

The result in Table 2 shows that most Executive Deans/ Deans believe that the teaching staff is competent to moderately competent in using existing technologies for teaching. The other academic faculties (OAF) recorded the highest level of competence (100%); this was contrary to the findings of [71,22,16] in which case the teachers were less prepared for the new challenge. Next to this was the faculty of law with 75% record of competence and 25% moderately competence. Apart from faculty of Engineering and Built of Environment, which sits on the average of competence (50%) and moderately competence (50%), faculty members in the faculties of Health Sciences, Management Sciences, and Education were moderately competent. The respondents emphasized the centrality of continuous training provided on teaching and learning technologies under normal circumstances. This result is consistent with the findings of König, Jäger-Biela & Glutsch [71] and Vlachopoulos & Makri [34] on the competence of staff in Germany who could also adapt to online teaching in during the lockdown caused by the global pandemic. The success recorded in this study was in part attributed to the community of practices as pivotal in dispensing training to staff members that required it, similar to the practice in higher institutions in Europe [72]. The result also confirmed the findings of [34,17] which emphasized the impact of transitional faculty in enhancing the quality of online teachers' training. This is unlike the findings reported by Lillejord [73], where competence depends on enthusiasts, and [22], where teachers expressed dissatisfaction with migrating online.

It interests the researchers to determine whether the existing technology in the faculties under study coped with the demand for teaching engagement considering the trend of technological advancement or that there were new procurements made to meet those needs.

Table 2. Competency of staff members in using the existing technology

Scale	Competency of staff members								
	<i>FOE</i> [9]	<i>FOS</i> [8]	<i>FEBE</i> [6]	<i>FOMS</i> [15]	<i>FOT</i> [3]	<i>FOHS</i> [5]	<i>FOL</i> [4]	<i>FOH</i> [7]	<i>OAF</i> [4]
Competent	4	3	3	4	1	1	3	2	4
Moderately competent	5	3	3	10	1	4	1	5	0
Not competent (Did not reflect)	0	2	0	1	1	0	0	0	0
Total Responses	9	8	6	15	3	5	4	7	4
% Competent	44	38	50	27	33	20	75	29	100
% Moderately competent	56	38	50	67	33	80	25	71	0
% Not competent (Did not reflect)	0	24	0	6	33	0	0	0	0

Source: ETDP SETA Report (2021)

4.3 Procurement of new technologies to keep abreast with technological advances

The reality of the 4IR requires keeping abreast of the changing landscape to ensure up-to-date engagement with teaching and learning in the institutions of higher learning. The researchers sought to determine whether the universities made any new procurement of technologies besides the existing technologies bought prior to the global pandemic in order to keep abreast with the demand of the time [74, 75,76].

It is important to note that the faculties which did not have enough tools to drive online learning were propelled to make new or additional procurements at the global pandemic outbreak to keep abreast of teaching and learning. This accounts for differences in the list of technologies already in existence in the universities and faculties prior to the pandemic. Although, some respondents showed they underutilized the existing technologies sometimes. However, all the underutilized technologies were put to use and some other needed technologies which were not in existence had to be purchased newly, as reported in Figure 1. This finding is consistent with [72] as most European Higher Education sped up the use of digitally enhanced teaching and learning. As a result, the academic calendar was maintained in all South African universities during the pandemic. This is unlike the experience of most other universities [77,78] as reported by UNESCO International Institute for Higher Education in Latin America and the Caribbean (IESALC) (2020) in which case, universities adjusted their calendar to accommodate school closure [79].

Another important investigation in relation to deploying technological tools for teaching and learning relates to the provision of training opportunities for staff.

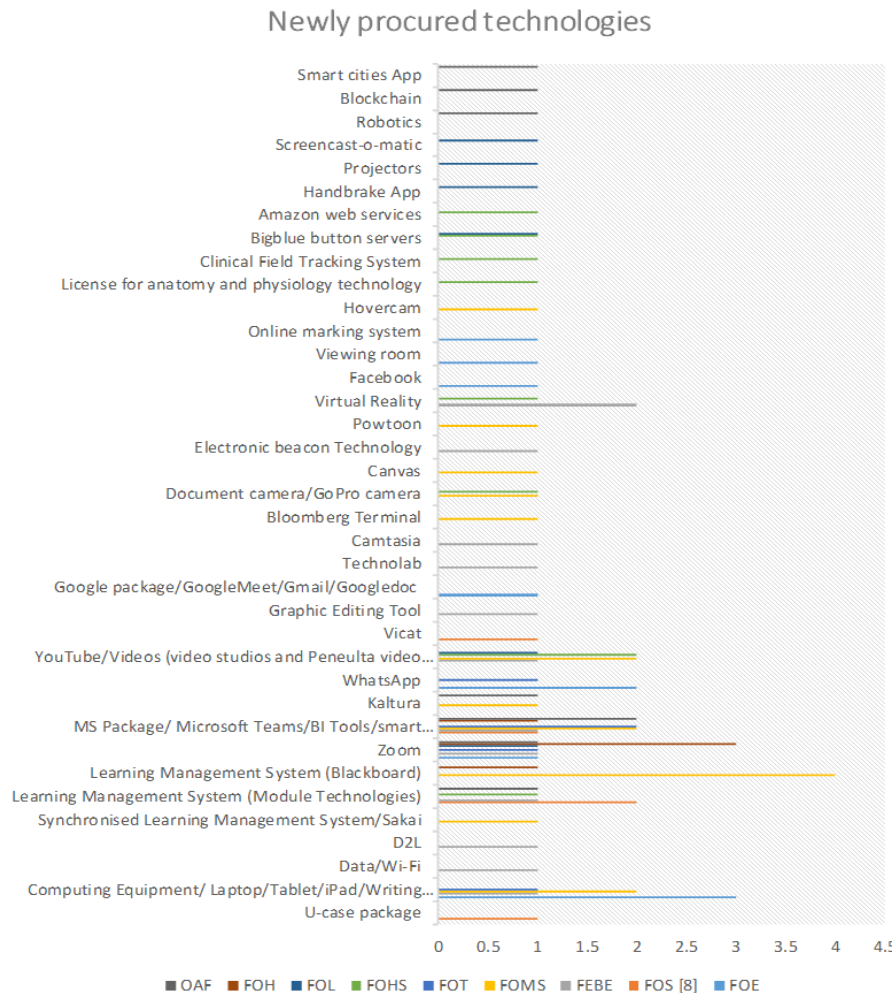


Fig. 1. Procurement of new technologies to keep abreast with technological advances (Source: ETDP SETA Report (2021))

4.4 Training of staff members to work on (operate) the newly acquired technology

The primary aim of the question around training was to determine whether universities had provided training of staff members on the use of the newly procured technologies or not. Researchers requested the Executive Deans/Deans to specify whether the training had been provided or not.

Most faculties, as seen in Figure 2, had provided training on the newly acquired technology to the relevant employees. The uniform practice as revealed by the Executive Deans/Deans is that training is provided steadily in all the universities across the nation. This is unlike the experience of universities in other African countries and beyond [80,81, 82, 30, 83]. It is noteworthy that the Faculty of Education and the Faculty Health Sciences excelled (100%) all others in training staff members because of certain peculiarities. Faculty of education seemed to uphold humanizing pedagogy practice, which places the student at the centre of education and ignites passion in teaching staff to gain the requisite skills and work very hard to ensure that students achieve the learning outcomes. This practice is exceptional and commendable in South African context considering the speed of change from the traditional system of teaching to complete online teaching and learning. This is impressive because pedagogy has been a major global challenge while implementing technologies for teaching in universities [80,33,84,81,85,86,87,28,22,16].

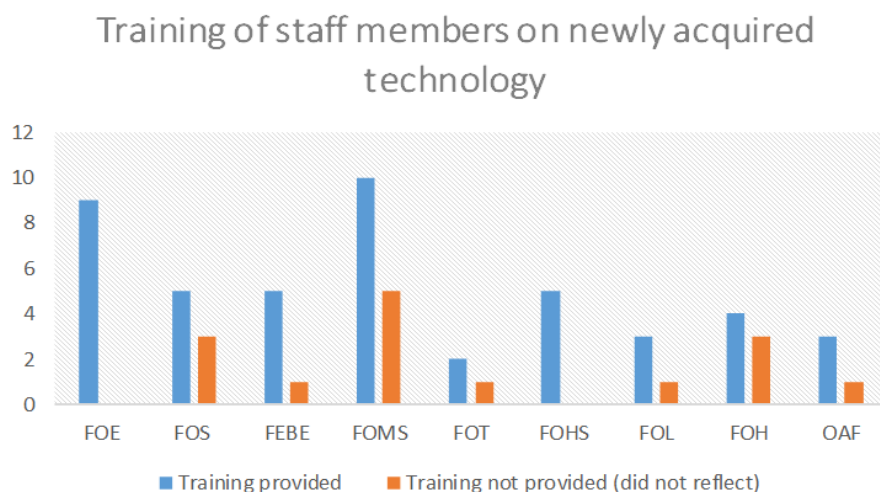


Fig. 2. Training of relevant staff to work with (operate) new technologies (Source: ETDP SETA Report (2021))

In addition, a vast majority of Health Sciences graduates deal with human lives. Staff training was of utmost priority to make sure students achieve quality learning outcomes and to equip them for the labour market. Collected data further suggest that training was not applicable where there was no information on training provided because those universities concerned had not bought any new technology. Further, it is imperative to consider the value derivable from the purchased technology to determine their actual worth.

4.5 Value proposition and relevance of the newly bought technology

Researchers requested the Executive Deans/Deans to discuss whether bought technology assists relevant staff members in delivering teaching and learning

effectively. This should determine whether the respondents saw the newly acquired technology as the value add to its teaching and learning process.

Table 3 shows that most Executive Deans/ Deans were convinced that the newly added technology has added value in their teaching and learning. The major themes that emerged from the interviews with Executive Deans/ Deans that derived value from the utilization of technology include the observed improvement in the standard and quality of teaching and learning which is consistent with the findings of [88,89] improved performance by students, positive feedback from lecturers and students [12,17,20], continuity with classes even under-lockdown conditions [14,72], reduction in cases of application for sick leave and missing scheduled assessments, and the ability to do more online than the traditional classes[17,41,56]. It is noteworthy that the Faculty of Theology and Faculty of Health Sciences experienced 100% value derivation from the use of the newly bought technologies. The finding here is like the findings of Zalata, Hamed and Bolbol [88] on the value derived from the use of technological tools for teaching and learning during the global pandemic by medical staff in Tin Zagazig university in Egypt. Papadakis and Kalogiannakis [20] had reported similar results with preschool students who were introduced to robotic and computational thinking at earlier age. The services of both faculties extended beyond the students' community during the condition of lock-down in which case, the Religious organizations in relation to FOT could conduct their spiritual services under the stringent rules and regulations on social distancing with the aid of technological tools [71,79] while more patients were reached under the same condition by trained students and staff of the Faculty of Health Sciences using various 4IR technologies such as Psychiatric videos and lesson plan app, Clinical Field Tracking System, License for anatomy and physiology technology, and Virtual Reality among others.

Table 3. Value creation of new technology in assisting staff members to deliver teaching and learning effectively

Training	Training of staff members on new technologies								
	FOE [9]	FOS [8]	FEBE [6]	FOMS [15]	FOT [3]	FOHS [5]	FOL [4]	FOH [7]	OAF [4]
Value created	6	4	4	11	3	5	3	6	2
Value not created (did not reflect)	3	4	2	4	0	0	1	1	2
Total Responses	9	8	6	15	3	5	4	7	4
% Value created	67	50	67	73	100	100	75	86	50
% Value not created	33	50	33	27	0	0	25	14	50

Source: ETDP SETA Report (2021)

4.6 Summary of findings and implications for the study

The study focused on implementing technology in South African Universities. Data collected through the study reveals that the Universities had procured a significant quantum of teaching technologies prior the global pandemic. Overall, the universities in South Africa deployed fifty-seven different technologies to facilitate teaching and learning activities. These include technologies such as Virtual

Reality/Augmented Reality, Artificial Intelligence, Simulation Laboratories besides other recent teaching technologies such as MS Package, Google, WhatsApp, Camtasia, smartboard, High Fidelity Rooms, and Facebook among others. These serve as evidence that the country is proactive in her response to the fourth industrial technologies [89,90]. It is also noteworthy that all faculties and universities in the country employ the learning management system (LMS) of different variants to promote teaching and learning. This could be because of its flexibility, as observed by [64, 65, 68, 89].

The executive Deans/Deans attest to the fact that teaching staff are moderately competent in using those existing technologies for teaching. This was consistent with the finding of [91]. This was made possible because they provided training on an ongoing basis as part of their response strategy for equipping academic staff so that they are ready to operate in a technology-driven environment. Another important practice upheld by the faculty of education in South Africa was humanizing pedagogy, which places the student at the centre of education, thus propelling the teaching staff to gain the requisite skills for ensuring that students achieve the learning outcomes.

Despite the various challenges associated with institutionalizing technology in the Universities, the major themes that emerged from the interviews with Executive Deans/ Deans that derived value from the use of technology include the observed improvement in the standard and quality of teaching and learning, positive feedback from lecturers and students, continuity with classes even under-lockdown conditions, and the ability to do more online than the traditional classes. These serve as motivation for the need for blended learning as practiced in most European Higher Education Area [72] Engaging students through online/virtual learning reduced the cases of application for sick leave from students, more students took part in scheduled assessments than usual. These highlight the benefits of employing appropriate technologies to teach remotely. Another key benefit across the country was the ability to save the academic calendar through out the lockdown period.

5 Conclusions

Overall, the study investigated the experience of institutionalizing technology for teaching and learning across all the four categories of South African universities. This was done by identifying and assessing the response of all the four types of universities across South Africa to the national imperatives regarding 4IR, which is key to the employability of the teeming youth population cum national development. The technologies deployed for teaching and learning had been accounted for alongside the state of the universities regarding staff training, competence of staff, new acquisition of technological tools to keep abreast of teaching and learning, and value derivation from the new procurement of emerging technologies among others. The ability of the Universities to migrate online during the study period losing no academic calendar implies that universities in the country are prepared to implement the convergence between human and machines in the era of the fourth industrial revolution.

The study concludes that while Universities are settled to adopt blended learning as the strategy to implement the convergence between human and machines in the era of the fourth industrial revolution, there is need to have a national policy in place that deals with funding (special grant) to plug the gap on digital divide for different cohorts of students. The major limitation of the study is that it focused on the Deans/Executive Deans and other key personnel in charge of implementing the 4IR in universities taking no input from the students. Another limitation could be because of the mode of data collection which was planned to take place face to face across the universities. However, with the outbreak of Covid-19, the research team could not proceed to the locations across the provinces but resorted to online media. A visit to each of the universities could have enable verification of the existence of some technologies deployed for teaching and learning.

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