

An Assessment of The Use of Quality 4.0 Trends in Higher Education Institutions in South Africa.

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Abstract

The fourth industrial revolution (4IR) has brought many changes in our lives, and we must adapt in different ways. Quality 4.0 is also part of the change. 4IR affected how organizations perceive quality; how has it affected the higher education sector in South Africa? This is the question this study attempts to answer. The study aimed to assess the use of quality 4.0 trends in higher education institutions in South Africa. To best achieve the study, The following objectives were listed: (1) To identify the most used quality 4.0 trends in higher education institutions in South Africa; (2) To highlight the respondents' perspective on quality 4.0 and finally; (3) To recommend ways to a successful implementation of quality 4.0 in higher education institutions. The study followed a quantitative approach using a questionnaire to collect data from 300 respondents mixed between staff and students from higher education institutions. Descriptive and inferential statistics were used to analyze data. To assess the reliability of the questionnaire, Cronbach's alpha was used. The study revealed that quality 4.0 is a relatively new field in South Africa, both on the business and academic levels. In addition, most of the respondents are not familiar with the quality 4.0 concept but are familiar with its trends. From the most used trend in higher education institutions, the top five were: Online social platforms (YouTube, WhatsApp, Zoom, etc.), IoT, Simulation, AR and Big data analytics.

Keywords

Quality 4.0, 4IR, Higher Education, and South Africa

1. Introduction

The fourth industrial revolution (4IR) has brought many changes in our lives, and we all must adapt differently. All sectors are affected by the changes from the new industrial revolution. Thus, the changes bring excitement for the latest technologies and new opportunities but also fear. The fear of the unknown, the fear of adjusting, and for some, the fear of losing their jobs and being replaced by machines (Xing et al., 2018). Education, one of the major sectors of a country's development, has also been affected by the new industrial revolution. Has this had an impact on the quality provided by higher education institutions?

1.1 Problem statement

The impact of 4IR can be felt in every aspect of our daily lives; the introduction of its technologies has added the 4.0 concepts to the affected sectors. Thus, sectors such as Healthcare are now referred to as Healthcare 4.0 when using technologies related to the fourth industrial revolution; Logistics 4.0, Education 4.0, and Manufacturing 4.0 are just a few examples of the new technology's impact (Winkelhaus, S. and Grosse, 2018), (Oke, A. and Fernandes, 2020), (Chaka, 2020), (Tortorella, 2020). The impact of 4IR on higher education has been subject to many studies (Oke, A. and Fernandes, 2020), (Penprase, 2018), (Mhlanga and Moloji, 2018). Research on the impact of 4IR on quality led to the introduction of Quality 4.0, which comes with trends for its successful implementation, but has there been a change in the quality of the education provided? This is the question this study attempts to answer.

1.2 Aim of the study

This study aims to assess the use of quality 4.0 trends in higher education institutions in South Africa.

1.3 Objectives of the study

The following objectives of the study were listed: (1) To identify the most used quality 4.0 trends in higher education institutions in South Africa; (2) To highlight the respondent's perspective on quality 4.0 and finally, (3) To recommend ways to a successful implementation of quality 4.0 in higher education institutions.

1.4 Scope of the study

This study focuses more closely on quality 4.0 in the South African higher education institutions. It is limited to the perspectives of staff (instructors) and learners only. This is because they are the major players when referring to education.

1.5 Value of the study

This study shows itself as valuable as it contributes to the body of knowledge on the impact of 4IR in the higher education sector in South Africa. The findings of the study will enrich the existing literature on Quality 4.0. The recommendations provided can go a long way toward assisting higher education institutions in ways to improve the quality of the education provided.

2. Brief literature review

2.1 Definition of quality 4.0

The best way to define quality 4.0 is to understand the term quality better" first. Heizer et al. (2019) define quality as a generic term used by organizations when referring to a service or a product that meets or exceeds customer expectations. The Oxford dictionary defines quality as the standard of excellence of a product or service against a similar one.

Using the 4.0 concepts that emanate from 4IR, quality 4.0 is perceived as the use of 4IR technologies in the traditional quality aspect of a business (Radziwill, 2018). Zonnenshain and Kenett (2020) include that data collection is part of

quality, and they believe that one can only provide quality products or services when one take data-driven decisions. Using 4IR trends such as simulation, big data analysis, artificial intelligence, and the Internet of Things (IoT) can provide real-time data deemed necessary for Quality 4.0.

2.2 The evolution of quality 4.0

Radziwill (2018) suggested four stages (Fig. 1) that were related to the evolution of quality (from quality 1.0 to quality 4.0). Like quality 4.0, where the 4.0 refers to the fourth industrial revolution, the other concepts such as 1.0, 2.0 and 3.0 refer to the different industrial revolutions.

Quality 1.0 is related to the first industrial revolution. This was in the 18th century that was triggered by the invention of the water and steam power engine (Xu et. al., 2018). Quality during this period mostly involved visual inspection, where methods such as statistical process control (SPC) introduced by Walter Shewhart were used. During this period, the focus was only on ensuring that meeting the specified requirements was observed. Any deviation from the standard was considered a defect. The introduction of mass production triggered the second industrial revolution, leading to quality 2.0. The introduction of the assembly line by Henry Ford and the use of electric power were crucial in this revolution. More units were produced, which required new ways of conducting quality inspections. Thus, the key feature was the design of different ways to prevent defects. This was possible with Edward Deming's reaction chain, referred to as the PDCA cycle (Jagusiak-Kocik, 2017). Organizations could design quality control methods that allowed them to prevent defects way before production started. The use of computers and other electronics that had printed circuits and micro chips facilitated automation in the production (Petrillo, 2018), this was the introduction of the third industrial revolution leading to quality 3.0.

The fast-growing production rate led organizations to realize that quality is not just a departmental task but everyone's. Thus, there was a need to empower everyone involved at any production stage to use quality tools and minimize defects. Concepts such as Six Sigma and Total Quality Management (TQM) were developed in this period. The focus was to make quality everyone's concern which could be done by empowering them and equipping them with basic quality inspection knowledge. The introduction of current technologies such as fast and supercomputers, high internet debit (4 and 5G), and smart devices have brought the fourth industrial revolution (4IR) (Chou, 2018). This was more than just an organizational concern; it also involved the customers. In the current industrial revolution, organizations realize that customers participate in product and service development because they know best what they want. Hence, this required another approach to quality. Thus, the introduction of quality 4.0. This new quality uses all technologies and trends related to 4IR, primarily to collect real-time data, which is essential in designing products and services that are particular not to all customers at once but to specific customers.

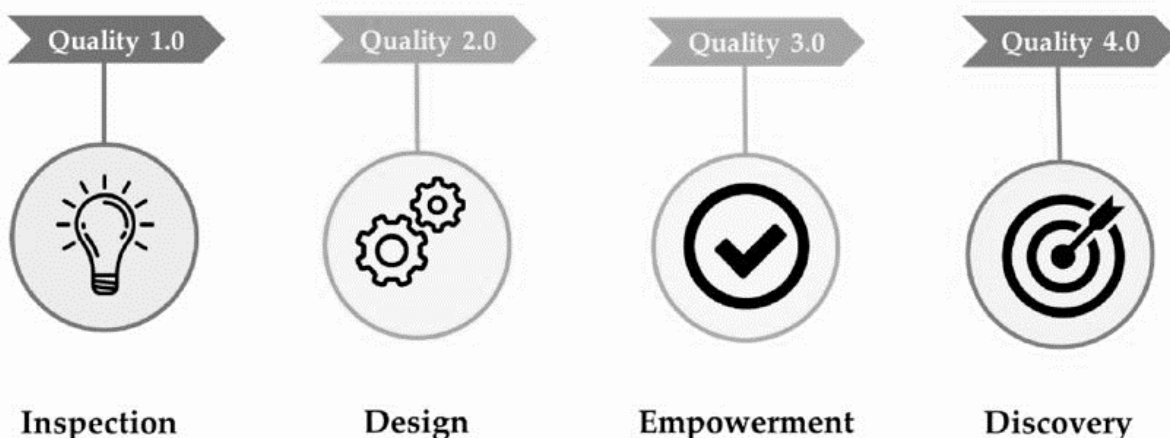


Figure 1. Evolution of quality (Radziwill, 2018)

2.3 Quality 4.0 trends

As explained in section 2.3, quality 4.0 is related to 4IR, thus the trends in 4IR are mostly the same as the ones in quality 4.0.

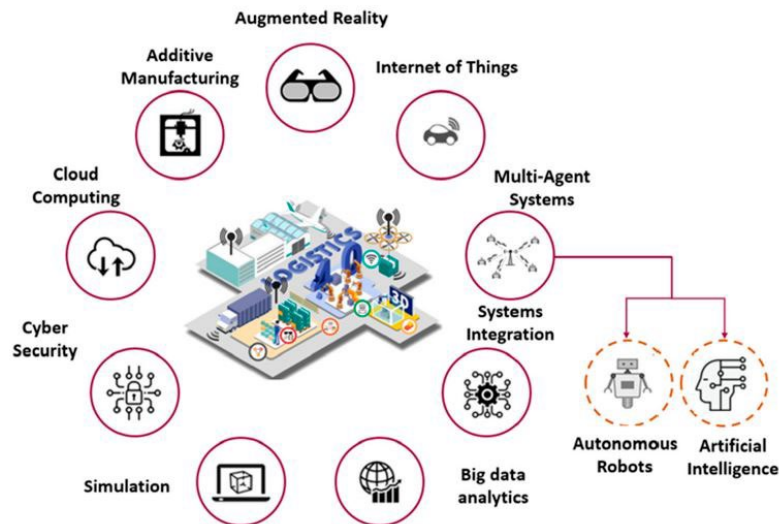


Figure 2 Industry 4.0 trends (Benotsmame et al., 2019)

Fig. 2 above portrays 4IR trends by Benotsmame et al. (2019). The authors portray nine main trends that go along the new industrial revolution. These include Augmented Reality (AR), the Internet of Things (IoT), Multi-Agent Systems, Systems Integration, Big data analytics, Simulation, Cyber Security, Cloud Computing and Additive manufacturing. Table 1 below portrays the 4IR trends and their contributions to quality 4.0.

Table 1 Description of 4IR trends and their contributions to Quality 4.0

Trends	Description	Contributions to Quality 4.0
Augmented Reality (AR)	This trend uses technologies and devices that combine the virtual and real worlds. The most common application of AR is video games.	Segovia et al. (2015), Skorokhodov, (2020)
Internet of Things	This trend is about using technologies that create a network of interrelated smart devices to collect real-time data. TVs, cars, computers, watches	Ahmed (2019)
Multi-Agent Systems (MAS)	This trend groups all machines and devices related to smart objects because they do not necessarily need human interaction. Autonomous robots and Artificial Intelligence are part of this trend.	Ibrahim and Morcos (2002), Bhatia et al. (2020)
Big Data Analytics	This trend refers to machines' ability to process vast information. This information is much valuable for decision-making in organizations.	Batarseh and Latif (2016), Rumsfeld et al. (2016)
Simulation	This trend mimics real-life situations in a controllable environment to facilitate decision-making. For example, this can be done using 3D Computer Aided Designs (CAD).	Brazil et al. (2019), Kliment et al. (2020)
Cyber Security	This trend is used for online security purposes. It helps design software and devices for organizations to protect themselves against cyber-attacks.	Radziwill, and Benton, (2018)
Cloud computing	This trend uses technologies that provide unlimited capacity to store data at a fantastic speed.	Ahmed and Mehta (2015), Kuo (2011)

Additive manufacturing	Most people refer to this trend as 3D printing; it is used during manufacturing by organizations when designing product prototypes and parts that are more complex and require more time and resources.	Alo et al. (2022)
Systems Integration	This trend allows organizations to use technologies such as sensors in production, construction, and daily business activities. The concept is wide and includes more than just the technological aspect of 4IR	Kim and Hwangbo (2018)

2.4 Quality 4.0 in South Africa

The concept of quality 4.0 is relatively new in South Africa, and few organizations apply it. Most applications of quality are still related to quality 3.0, which some companies still do not fully use. Nevertheless, some companies are on the right track (Likita et al., 2018) (Antony et al., 2018) (Rathilall and Singh, 2018). In terms of literature, most researchers are still on quality 3.0 concepts such as six sigma and TQM (Akinlolu et al, 2020) (Sonandi et al., 2021) (Aghimien et al., 2021). Few studies have been conducted under quality 4.0 (Siphoro et al., 2020).

3. Methods

3.1 Research design

The study used a quantitative approach. This approach has the advantage of providing data based on statistical methods. They are generally more reliable since they are not based on the respondents' feelings or perspectives (REFERENCES). The approach was also used because of its ability to collect data much faster.

3.2 Data collection

Both primary and secondary data were collected in the study. Primary data were collected straight by the researcher using a questionnaire. The questionnaire used a Likert scale with values ranging from "Strongly disagree" to "Strongly agree". The questionnaire was sent online to the respondents, allowing a faster collection of responses. Data were collected over two months, from June to July 2022. Secondary data were collected from previous literature on quality 4.0 and reports on higher education in South Africa.

3.3 Population and sample

Students and staff from higher education institutions in South Africa constituted the population of the study. A random sample of 300 respondents took part in the study. Respondents from higher institutions such as Universities, Colleges and Professional schools participated in the study. The questionnaire was distributed randomly, which allowed all respondents to stand the same chance of being part of the study.

3.4 Data Analysis

The study used a descriptive approach. Hence, descriptive and inferential statistics were used to analyze the data. The Statistical Package for Social Sciences version 28 (SPSS) was used to analyze measures of central tendencies such as the mean and standard deviation. The results obtained via Google form were also helpful in developing graphs portrayed in the study.

3.5 Reliability

The reliability of a study is the ability of its research instrument (Questionnaire in this case) to provide consistent results if used on repeated occasions (REFERENCE). Cronbach's alpha has been used to test the reliability of the questionnaire.

4. Findings

4.1 Respondents' higher institutions

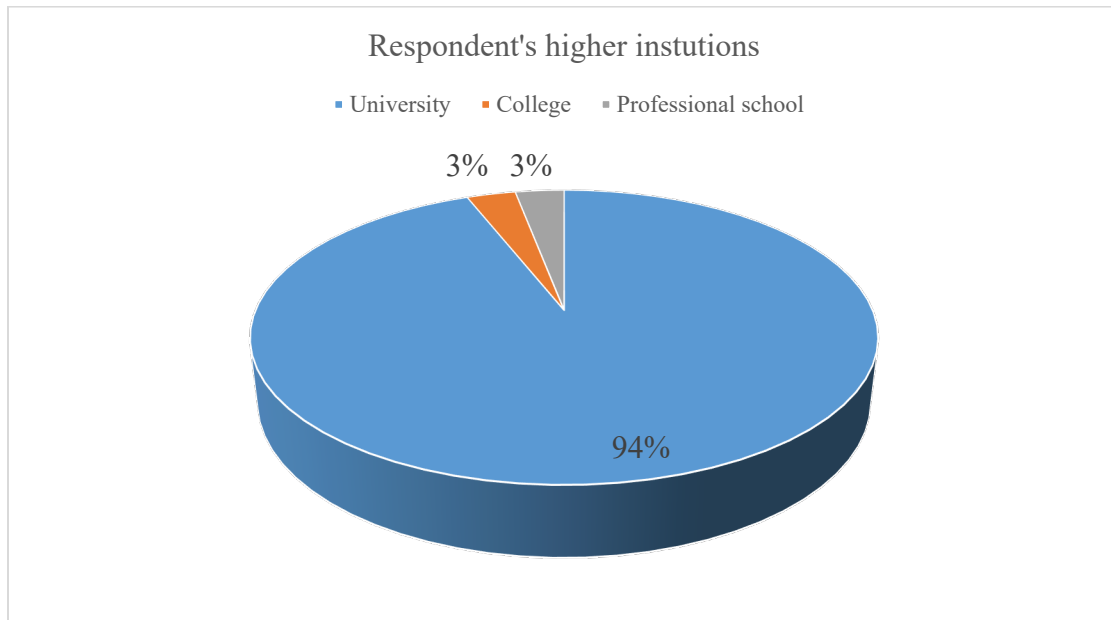


Figure 3. Respondents' higher institutions

Fig. 3 above shows that 94% of respondents attend University as a higher institution. This portrays the reality of the country's higher education system, as universities generally have more staff and students compared to colleges and professional schools. Additionally, the choice of these higher institutions is justified by the country's higher education sector, which lists them as higher institutions.

4.2 Respondents' year of study

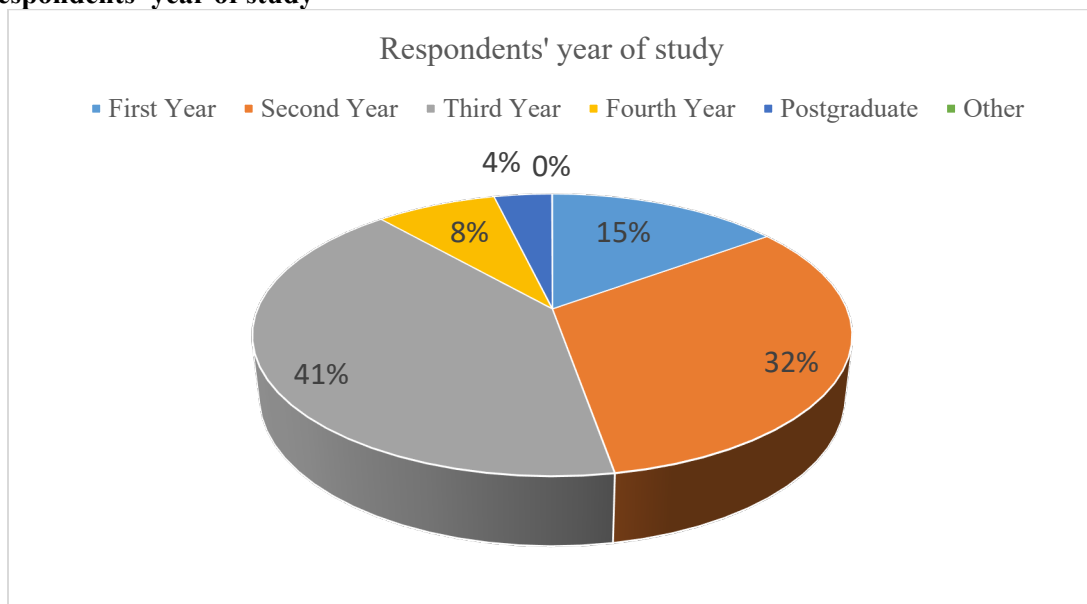


Figure 4. Respondents' year of study

The majority of respondents are third years, followed by second-year students scoring 41% and 32%, respectively, as shown in Fig. 4. As undergraduates, this group of students is generally the most active and aware of academic activities as they are more familiar with their institutions. First-year students tend to join the institutions and try to adapt to the new environment, while final years (fourth year) and postgraduates tend to focus more on completing their studies.

4.3 Respondents' awareness of quality 4.0

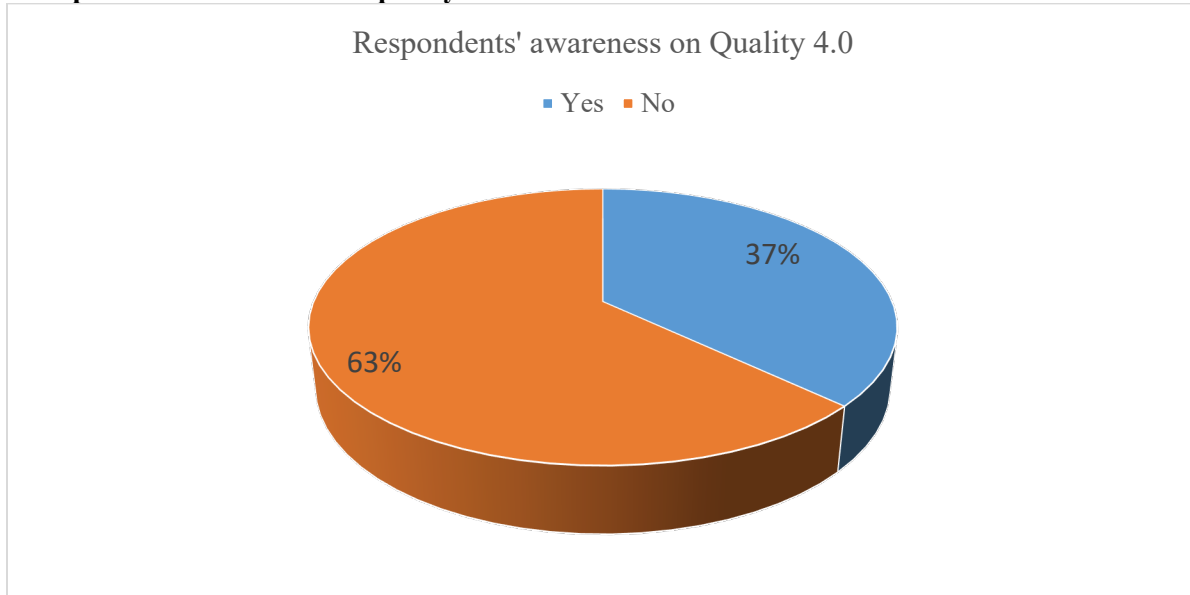


Figure 5. Respondents' awareness of Quality 4.0

Regarding the respondent's awareness of quality 4.0, Fig. 5 shows that only 37% of respondents are familiar with quality 4.0. This is alarming for higher education institutions since these data include staff members. This means that there must be a vast number of staff as well that are not familiar with quality 4.0. These results confirm the findings in the literature review on the use of quality 4.0 in South Africa.

4.4 Transition to online learning

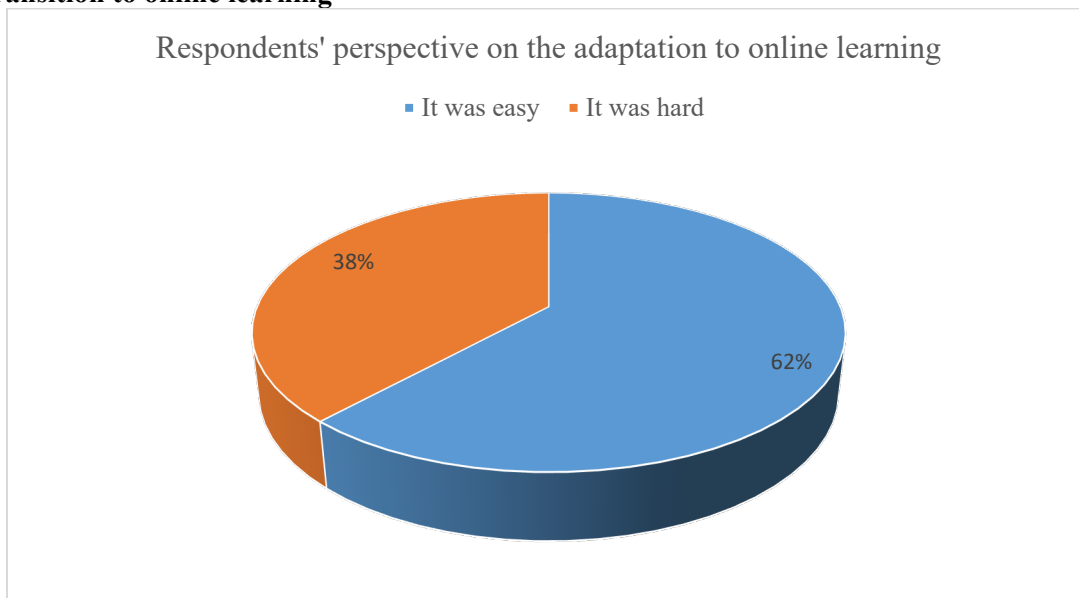


Figure 6. Respondents' perspectives on the adaptation to online learning

Fig. 6 shows that 62% of the respondents found it easy to adapt to online learning. Online platforms for learning are some technologies included in the quality 4.0 trends. Thus, it was essential to highlight the respondents' perspectives on their adaptation to the shift. This is an excellent indicator of the direction higher education institutions could take to implement quality 4.0 properly.

4.5 Use of quality 4.0 trends

Table 2. Use of quality trends in higher education institutions

Use of quality 4.0 trends in HE			
Rank	Statements	Mean	Std. Deviation
1	Lecturers use technologies such as YouTube, WhatsApp, Zoom, Moodle; Blackboard collaborate etc. to conduct classes.	4.02	1.129
2	We use the Internet of Things in our institution (Internet Interconnected devices and facilities on campuses such as buses, libraries, student residences etc...)	3.74	1.097
3	We use simulation as part of learning (3D Modelling and printing software, Computer-aided design (CAD), AutoCAD, etc..)	3.74	1.082
4	We use Augmented Reality (AR) as part of learning (advanced software and cell phone apps to learn)	3.69	1.145
5	We use big data analytics as part of learning	3.62	1.076
6	We generally use cloud computing as part of learning (Educational database, Google drive, Turnitin, etc...)	3.49	1.076
7	Most of the assessments are conducted online	3.38	1.119
8	We use autonomous robots and Artificial intelligence (AI) as part of learning	3.31	1.163

Table 2 lists the quality 4.0 trends used in higher education institutions. The table ranks them as well based on the mean. The use of social media platforms such as Youtube, Whatsapp, Zoom, Moodle, etc. are the most used trend (Mean = 4.02). Lecturers use these platforms to conduct their classes. The second most used trend is IoT (Mean = 3.74). This trend gets higher education institutions to have interconnected devices and facilities on campuses, such as buses, libraries, students' residences and many more. This provides excellent insight to the higher education institutions as they can have a much clearer perspective on the students and staff's preferences and behaviours, which can help improve the service quality. Using the browsing data from the staff and students, institutions can have an idea of the most researched topics by students, for example. This can help in designing ways to assist them. The third trend was simulation, with a mean of 3.74. This trend had higher education institutions use technologies such as 3D modelling and AutoCAD to conduct classes. This allows students to understand better the concepts learnt in class with a more visual and practical perspective of what is happening. The last two most used trends were AR and big data analytics. Like Simulation, AR can be used for the same purpose, to improve the students' learning experience. Big data analytics, on the other hand, can be used for administrative purposes as they allow the institutions to manage their data better, interpreting them to have a clear idea of how students learn and staff perform.

Table 3 below summarizes the above findings.

Table 3. Top five of the most used quality 4.0 trends in higher education institutions

Top 5 most used 4IR trends
Online social platforms (YouTube, WhatsApp, Zoom, etc.)
IoT
Simulation
AR
Big data analytics

4.6 Reliability tests

The Cronbach's alpha results showed a value of 0.886, considered satisfactory for more studies as the minimum is 0.7 (REFERENCE). Additionally, Table 4 shows the Cronbach's alpha values of every quality 4.0 trend assessed in the

study, which was part of the items on the questionnaire. The table indicates that no value below 0.7 has been recorded. Thus, it can be confidently said that the instrument used was reliable and the study.

Table 4 Individual items Cronbach's alpha value

Statements	Cronbach's Alpha
The institution uses Technology to improve the overall Quality of services provided to students	0.916
Autonomous robots and Artificial Intelligence are used during some complex decision makings such as academic admissions	0.922
Big data analytics are used to prevent data loss by storing important information about students and staff	0.912
Advanced Reality (AR) is used to improve the Quality of education and different services offered in the institution	0.913
The Internet of Things (IoT) is used to improve the Quality of education and different services offered in the institution	0.910
Cloud computing is used to improve the Quality of education and different services offered in the institution	0.913
3D printing is used to improve the Quality of education and different services offered in the institution	0.915
Systems integration is used to improve the Quality of education and different services offered in the institution	0.910

5. Conclusion and recommendations

The study offered perspectives on using quality 4.0 trends in the South African higher education sector. A review of the existing literature showed that quality 4.0 is relatively a new field in South Africa, both on the business and academic levels. Nevertheless, the results revealed that even though most of the respondents are not familiar with quality 4.0 concepts, they are at least familiar with some trends that come with it. This is generally because quality 4.0 trends are similar to 4IR's. The literature identified nine trends: Augmented Reality (AR), Internet of Things (IoT), Multi-Agent Systems, Systems Integration, Big data analytics, Simulation, Cyber Security, Cloud Computing and Additive manufacturing. Not all these trends are used to the same extent in higher education institutions. The results revealed that the top five were: Online social platforms (YouTube, WhatsApp, Zoom, etc.), IoT, Simulation, AR and Big data analytics.

Although there is a need to commend higher education institutions on their involvement in adopting quality 4.0 trends, it is recommended that with the fast-growing technological rate, more should be done to keep up the pace. Developing institutions that are 4IR ready, raising awareness on quality 4.0, and empowering staff to use more quality 4.0 trends in their lecturing styles are a few recommendations higher education institutions should try to implement.

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Biography

Mr Eric Mikobi is a young academic and a PhD candidate in Quality Engineering at the University of Johannesburg. His research interest is centred around smart education and quality 4.0. He has made many contributions to international conferences such as IEEE, IAMOT and IEOM, where he got the best track paper in 2021 at the Monterrey, Mexico IEEE conference.

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