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Innovations in Teaching and Learning: Exploring the Perceptions of the Education Sector on the 4th Industrial Revolution (4IR)

Adekunle Oke [1,*] and Fatima Araujo Pereira Fernandes [2]

[1] Department of People, Organisations, and Practice, Robert Gordon University, Aberdeen AB10 7QE, Scotland, UK

[2] Department of Educational Leadership and Management, University of South Africa, Pretoria 0003, South Africa; fatima37990@gmail.com

* Correspondence: a.oke1@rgu.ac.uk

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Abstract: Business operations are undergoing drastic changes due to the disruptive effects of technology innovations; however, there is insufficient knowledge regarding the acceptability and consequences of the fourth industrial revolution (4IR) in the education sector. Using the Unified Theory of Acceptance and Use of Technology (UTAUT), this study explores the readiness of the education sector for 4IR. We adopted face-to-face semi-structured interviews to explore the views of 33 key stakeholders in the education sector, to understand the readiness and acceptability of 4IR in the sector. Findings show that the education sector, especially in Africa, is unprepared for 4IR, although there are indications for opportunities to harness the potential of the much-anticipated 4IR. Moreover, our study demonstrates a mutual symbiotic relationship between the education sector and technology innovations. The findings show that 4IR can facilitate students' learning experience and transforms the workplace, although there is a need to assess the learning environment, to understand the facilitators and barriers to 4IR diffusion. The findings indicate the opportunity for the education sector to harness the innovations associated with 4IR through research and teaching to enhance learners' experience; however, this may require a significant improvement in education curricula, as well as investments. The findings contribute to the theory and practice of technology in education and the limited literature on 4IR in the education sector, particularly in Africa.

Keywords: 4th industrial revolution (4IR); industry 4.0; technology innovations; higher education; workforce; teaching and learning

1. Introduction

In the past years, technology innovations are having unprecedented consequences on all the facets of our humanity and society, including business operations processes. There is now compelling evidence about the disruptive capability of technology transformation on business and human activities, especially in the service sector [1], and in facilitating teaching and learning [2,3]. For instance, businesses, such as Amazon and Uber, have created technology-enabled platforms that seek to reconcile the demand–supply side of their operations in satisfying the customers' need and expectations by disrupting the existing business norms and models. Moreover, social media platforms, including Facebook and Instagram, have entirely altered the fundamental building blocks of our society in the way we socialize and interact with one another, particularly with the increasingly young and dynamic population of "digital natives" [4,5]. Additionally, LinkedIn and other Massive Open Online Courses (MOOC) platforms are transforming the way professional information, including teaching and learning, is disseminated [6,7]. While digital technology is diffusing at an exponential rate across many sectors,

its ethical, pedagogical, and epistemological implications, especially in the education sector, remain questionable, especially with the topical fourth industrial revolution (4IR). Nevertheless, it is worth mentioning that the past three industrial revolutions are fundamental and instrumental to the current technological advances and economic productivity, although the current trend, including the future of 4IR innovations, remains unknown. According to Penprase [8], the early 1950s marked the foundation of the third industrial revolution, which was influenced by the advances in technology through the first and second industrial revolutions. As a result, industrialization took its stance in the global economy, and machinery was introduced in the form of computers, creating new and faster methods of channeling information and communication in the world of work, including teaching and learning [8,9]. For example, powers of technology, particularly through the third industrial revolution, with the power of computing and the internet, transformed the world of work, including teaching and learning, from huge stagnating mechanical machines to small hand-fitted smart devices [9–11]. According to Buckenmeyer [12], computer technology provides the opportunities that were not available prior to the third industrial revolution, to enhance teaching and learning through simulations of complex and time-consuming as well as dangerous scenarios.

Even though the current knowledge regarding 4IR is still primitive and naïve to many sectors, 4IR is now a buzz word and gaining traction across different sectors of the economy. Accordingly, 4IR, which is perceived as a fusion of many technologies and perceived to blur the boundaries between the physical, digital, and biological spheres [13], is now attracting increasing attention from policymakers, business practitioners, and academics. While the concept is increasing in importance and relevance across different sectors, there is no consensus on what it entails, and no specific definition is qualified to illustrate its attributes, despite its existence since the start of the 21st century [5,14]. Nonetheless, the second industrial revolution, with the discovery of combustion engines, and third industrial revolution, which was characterized by innovations in information and communication technology (ICT) and automated production, formed the basis for the rapid diffusion and penetration of 4IR. According to Lee et al. [14], any attempts to define 4IR should consider the integration of technical innovation and institutional innovation as the key building blocks, such that the interaction of human and technology (i.e., smart systems) are applied to increase operational efficiency, including teaching while enhancing socioeconomic and environmental performances.

Despite the advancement in technology innovations, the education sector has been reluctant in accepting technology to facilitate teaching and learning, although the use of robots in education, particularly in teaching science, technology, engineering, and mathematics (STEM) subjects, has been around since the 1980s [10]. Moreover, the use of technology has been predominantly limited to a didactic approach of teaching and learning, whereby teaching is facilitated with the use of a personal computer and the provision of electronic teaching materials. However, the use of digital technology underpinning 4IR is beyond the use of computer and e-materials and should be compatible with the learner-centered approach for it to be effective in enhancing students learning experience. With the exponential rate at which the much-anticipated 4IR is rapidly diffusing, we can only assume that it will have far-reaching consequences not only on the economy but also on our private and social lives, including the way we communicate and interact. For instance, the advent of technology innovations with the application of smart devices for various uses, such as social media, may reduce face-to-face social interactions [1,4] and could affect the acquisition of relevant skills. This may limit the possibility of acquiring and developing relevant soft skills, such as emotional intelligence, communication, and interpersonal skills, especially among the younger population. According to the World Economy Forum [13], the way the world of work is perceived has been changing since the first industrial revolution. Consequently, 4IR will introduce a drastic decline in demand for many jobs, including those that require manual skills and physical abilities, due to automation with the digitalization of operations process (see Table 1). However, Lee et al. [14] have argued that job specifications and professional competencies should evolve as 4IR is evolving in meeting the challenges and opportunities of digital transformation. It is, therefore, imperative to understand the meaning of

employability and its requirements from stakeholders' perspectives, because of its complexity and multidimensionality [10,15].

Table 1. Skills demand across sectors: 2018 vs. 2022.

Today: 2018	Trending: 2022	Declining: 2022
Analytical thinking and innovation	Analytical thinking and innovation	Manual dexterity, endurance, and precision
Complex problem-solving	Active learning and learning strategies	Memory, verbal, auditory, and spatial abilities
Critical thinking and analysis	Creativity, originality, and initiative	Management of financial, material resources
Active learning and learning strategies	Technology design and programming	Technology installation and maintenance
Creativity, originality, and initiative	Critical thinking and analysis	Reading, writing, math, and active listening
Attention to detail, trustworthiness	Complex problem-solving	Management of personnel
Emotional intelligence	Leadership and social influence	Quality control and safety awareness
Reasoning, problem-solving, and ideation	Emotional intelligence	Coordination and time management
Leadership and social influence	Reasoning, problem-solving, and ideation	Visual, auditory, and speech abilities
Coordination and time management	Systems analysis and evaluation	Technology use, monitoring, and control

Note: World Economic Forum (2018).

The level of technology acceptance, due to its costs, perceived limited application, and lack of training, is considerably low, and its effectiveness is not well documented in the education sector [10,12]. The starting point in understanding the roles and relevance of 4IR in facilitating teaching and learning practices is to have adequate knowledge of different components of 4IR, using the current categorizations in the literature. According to Rüßmann et al. [15], there are nine pillars of digital innovation: (1) autonomous robots, (2) simulation, (3) horizontal and vertical system integration, (4) internet of things, (5) cybersecurity, (6) cloud, (7) additive manufacturing, (8) augmented reality, and (9) big data and analytics. The current categorizations of 4IR suggest that its adoption is not restricted to the use of a computer, especially in the education sector, and may involve other opportunities, such as the development of an ecosystem that may facilitate sharing of learning materials and data analytics to understand learners' teaching needs. While the 4IR components have many things in common, the sophistication of connected platforms, networks, and devices can exacerbate the process of establishing the inherent consequences of 4IR. Nonetheless, there is compelling evidence to suggest that 4IR will disrupt and change the current approach to many operations processes, including the way we conduct businesses and deliver services [10,15], although it presents an opportunity to improve on how we teach, learn, work, and interact.

While there are many discourses, interpretations, and conceptualizations of what 4IR entails depending on the discipline or sector, people mostly associate 4IR with technology [5,9]. In this present study, however, 4IR in the education sector is modeled after the World Economic Forum [13] and defined as the integration of human and technology intelligent systems that are fusing the physical, digital, and biological worlds with unprecedented consequences across different education disciplines, and pose significant challenges on how we learn, teach, and work. Based on the current knowledge regarding the utilities of technology, especially in the education sector [6,10], this study is designed to address some axiological questions for the education sector, especially in Africa, to exploit and embrace the benefits of 4IR, beyond the use of computers in teaching and learning.

2. The Gap in the Literature

According to the World Economy Forum [13], 4IR depicts technology revolution blurring the boundaries between the physical, digital, and biological spheres. When fully matured, particularly in the education sector, innovation can augment human skills through artificial intelligence, data analytics, and algorithm, to reduce efforts on time-consuming and complex tasks through modeling

and simulation. While the previous three industrial revolutions have impacted our society and contributed to the nations' economies, 4IR is more germane to our daily lives, including how we work and learn [2,8]. Nonetheless, the last three industrial revolutions culminated in mass production of education services through innovative curricular development and legitimizing online teaching with the establishment of many academic institutions around the world [3,8]. With computer-based learning, especially through e-learning, there is an opportunity to facilitate teaching and training anywhere and anytime, thus reducing operational costs and minimizing logistical issues that are often associated with face-to-face classroom teaching. According to Chang and Wills [3], using a blended learning approach, which is the integration of e-learning and classroom-based learning, could increase learners' satisfaction and performance by about 15% compared to only the classroom teaching approach. In comparison to the traditional face-to-face classroom teaching and learning, the internet and other forms of emerging technology facilitate competency-based and self-directed learning, while increasing the variety, including the speed at which information is provided to learners irrespective of their location [16,17]. Consistent with Beetham and Sharpe [18], digital technology is not only facilitating interactions between tutors and learners, but it also augments, as well as transforms, the teaching and learning process. With the rate of diffusion and acceptance of technology, especially in many production and service industries, scholars and practitioners in the education sector have questioned the effectiveness and efficacy of technology (see [16,19]), particularly online teaching, in facilitating teaching and learning.

Despite the positive prospects of technology in enhancing teaching and learning by changing the way learners experience studies, the nature of teaching and learning, particularly in higher education (HE), has not been effectively transformed through digital technologies [18,19]. For instance, Ng'ambi et al. [17] observed that teaching and learning, particularly in South Africa, remained practically static despite the use of mobile (smart) devices and social media. Although the use of technology to facilitate teaching and learning has been limited to digitization rather than and digitalization, the education sector lacks proprietary and exclusive rights to many available technology innovations and tools, suggesting that their design/use is unregulated by academic institutions [17]. Nonetheless, Rashid and Asghar [20] have shown the effectiveness of digital technologies in enhancing students' engagement and self-directed learning; however, they observed no significant effect of digital technologies on students' learning performance. While technology has changed the dynamic of teaching and learning over the last years, the question is whether the integration of technology into teaching and learning process has significant effects on teaching quality and/or enhancing learners' performance and experience. Using five different examples of interactive learning, the contribution of interactive e-learning method in improving teaching and learning experience has been demonstrated [21]. The study further emphasized the roles of students and tutors in presenting structured and organized e-learning that could improve learners' motivation, personal competency, and learning satisfaction. According to Chang [21], e-learning is more effective when there is an interaction between human and technology, by combining face-to-face learning and online teaching in a collaborative, blended, and flexible manner. However, the rate of diffusion of the current digital innovations is unprecedented and occurs at a faster trajectory compared to the past revolutions [22,23]. Moreover, many industries, especially service-related and particularly the education sector, are struggling to cope with the fast pace of digital innovations. With the lack of consistency in the application of digital technology in teaching and learning process [2,24], there is no convincing evidence for the possibility of organizational learning within the education sector.

While research in innovations, including 4IR, has extensively focused on computers, particularly in the manufacturing sector [15], only a few studies have examined the transformation of the service industry, and especially the education sector, through 4IR [25,26]. However, no known studies have examined the perspectives of key stakeholders who are the end-users of the innovations, to establish how 4IR can complement and transform the sector's operations. One of the exceptions in this realm is the study conducted by Henderson, Selwyn, and Aston [20], which examines the perspectives of

Australian undergraduate students regarding the roles of digital technology in university teaching and learning. Although their study showed that digital technology is enhancing students' learning experience, they observed that digital technology is not transforming the process of teaching and learning in the higher institution. According to Ng'ambi et al. [17], the use of technology, especially in Africa, is fragmented and focused on computer-aided or -assisted instruction (CAI) coupled with a lack of coherent policy on the roles of technology in the education sector. Moreover, there is a lack of knowledge regarding the motivations, barriers, and implications of the acceptance and diffusion of 4IR within the education sector in supporting the teaching and learning process [8,20].

Besides, our present knowledge is limited regarding the processes and approaches that the education sector, especially in Africa, can adopt to ensure that 4IR capabilities are augmented in teaching practices. Despite the possible contributions of technology to learners' development, such as through collaborative learning [17,23,26], no academic institutions are listed among the 50 leading innovative companies in the world, and none of the identified organizations is from Africa [22]. The challenge for the education sector is on how to produce graduates with creative ideas and relevant skills to operate in this digital world, while contributing to the organizational functioning and productivity if the education sector is not receptive to 4IR. It is high time the debate is shifted from computer technology and focuses on the transformation of the teaching and learning process, including the transformation of the education sector through digitalization by embracing 4IR. This shift in focus will not only allow the education sector to benefit from the technology revolution but will also provide the opportunity to address the dilemma regarding the roles and effectiveness of digital technology in teaching and learning.

One possibility is for the education sector to invest in algorithm, data analytics, and internet of things (IoTs) driven by 4IR capabilities and shift the roles of tutors and students in the teaching and learning process by providing real-time interventions with an opportunity to tailor (or personalize) teaching to learners' needs and requirements [2,19]. Rather than perceiving digital technology as a network of IT infrastructure, there is a need to conceive 4IR as a digital learning environment where learners are the central focus in that ecosystem through the "technology-enabled learner-centered" approach.

3. Research Questions

Consistent with the Unified Theory of Acceptance and Use of Technology (UTAUT) [27], informed and practical experience of technology use is required for the education sector to understand the usefulness and performance of 4IR that may contribute to its acceptance. While the education sector has experienced some changes over the years, especially in science and technology [2,28], the sector is still reluctant in preparing and adapting to the current technology transformation [10]. However, Baygin et al. [29], in their conference paper, investigated the effects of 4IR on HE and concluded that 4IR offers an opportunity for HE in training qualified personnel. Moreover, Lamprini and Bröchler [30] adopted the concept of ecosystem thinking to argue for effective collaborations between stakeholders where education is expected to play a central and critical role in developing expertise and innovation within the ecosystem. Contrary to many studies on 4IR, Kamal et al. [31] designed and proposed a STEM education curriculum to enhance skills and knowledge in IoTs and blockchain technology. However, many available studies (see [17,21,32–34]) on technology innovations are discipline-specific and focus on computer technology, and no known research has explored the perceptions of the education sector, especially in Africa, in integrating 4IR, beyond the mundane use of a computer, into teaching and learning process. Considering that 4IR involves an aggregate of many innovations, beyond the experience of the last three industrial revolutions, and requiring innovative process models of technology-based learning with new strategic approaches [6,7], this study is designed to uncover the utility of 4IR and its acceptance in the education sector by exploring the following fundamental research questions:

(1) How and what is the level of preparedness of the education sector, especially in Africa, in exploiting and embracing 4IR in facilitating teaching and learning?
(2) What are the current perceptions regarding 4IR and its acceptance, particularly in disrupting the teaching and learning process, including how learners and tutors can be supported?

To answer these research questions, UTAUT (see Section 4) was adopted as the baseline model to explore and explain how the key stakeholders in the education sector conceptualize and frame the idea of 4IR and its utility in the education sector. Therefore, this study contributes to the existing body of knowledge in 4IR by presenting a holistic understanding of the roles of 4IR in facilitating teaching and learning by exploring the stakeholders' perceptions. While the study is not designed to investigate computer use in teaching and learning, it is designed to explore the views of key stakeholders in the education sector, regarding the disruptive capability of 4IR, given the experience in other sectors, including transportation and hospitality. Its overarching rationale is to understand the readiness of the education sector in accepting digital technology, including its costs, benefits, and consequences to the sector and its stakeholders. To achieve the goals of this study, we explored the views of the key informants in the South African education sector, using a purposive sampling approach whereby participants are deliberately selected based on the research questions [35,36]. Rather than the quantity, the quality and originality of the data from the participants are sufficient in achieving the purpose of this study, while addressing its research questions.

4. Theoretical Underpinning

Many theories, such as the theory of planned behavior (TPB) [37], the diffusion of innovation theory (DIT) [38], and the technology acceptance model (TAM) [39], have been used in empirical studies see [40–42] to understand people's behavior toward technology adoption. While authors have operationalized many theories, especially TAM and DIT, in their original form, studies have also modified the existing theories to explain the extent to which people are likely to accept and use technology [43,44]. Nonetheless, many of these theories/models are used to explain behavioral intention toward technology rather than the actual technology acceptance behavior [44,45]. For instance, Davis [40] conceptualized and operationalized two constructs as immediate antecedents of technology acceptance to validate TAM. According to Davis [39], perceived ease of use and perceived usefulness of technology are the fundamental building blocks for the users' intention to accept technology (Figure 1).

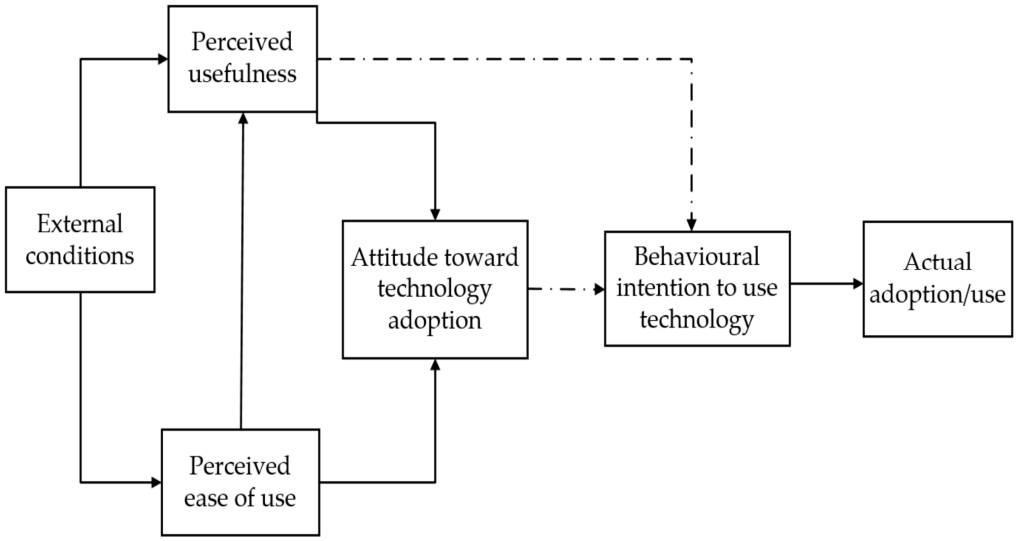

Figure 1. Technology acceptance model (Davis, 1989).

As presented in Figure 1, perceived usefulness and perceived ease of use are required for the education sector to form attitudes toward technology adoption and serve as a precursor to behavioral

intention, which determines whether the sector will embrace and accept 4IR, although perceived ease of use is a causal determinant of perceived usefulness [39]. Taken together, there is a strong intention for the education sector to adopt 4IR when it recognizes that 4IR and its components require less effort and are easy to use, while enhancing teaching and learning performance. In this study, therefore, perceived usefulness is conceptualized as the extent to which the education stakeholders, especially tutors, believe that technology would support or enhance their job performance, while perceived ease of use measures the stakeholders' belief-system regarding the level of difficulty or effort in using the intended technology [39,42].

However, due to the complexity and heterogeneity of industry 4.0, the three constructs in TAM may be insufficient, in all cases, to explain the perceptions of 4IR in the education sector, particularly in facilitating teaching and learning. As a result, the predicting power of a unitary theory, such as TPB and TAM, in explaining the use and adoption of 4IR in the education sector is limited, especially when assessing the utility of 4IR and its acceptance in the education sector. For example, Venkatesh et al. [27] extended the explanatory power of the existing theories by conceptualizing and operationalizing the unified theory of acceptance and use of technology (UTAUT) by combining eight different models/theories. According to the model, four factors are required to determine whether people are likely to accept information technology. These factors are performance expectancy, effort expectancy, social influence, and facilitating condition, although only facilitating conditions were conceptualized to have a direct effect on technology use [8,27]. Moreover, performance expectancy, effort expectancy, and social influence were conceptualized to have indirect effects on user behavior through behavioral intention, experience, voluntariness of use, age, and gender, which were the moderators. The UTAUT model is relevant and appropriate in this present study, given that many innovative and developmental ideas across different sectors have been previously transported to Africa, with little and no success. As a result, the UTAUT model that integrates eight different models from many philosophical worldviews [27,44] seems adequate in exploring the complexity of 4IR as perceived by stakeholders in the education sector. The model provides a basis for exploring the readiness and acceptance of 4IR in the education sector in Africa; however, we dropped behavioral intentions, due to its instability in explaining focal behavior [37,46]. It is intuitive to adopt the unified model's holistic views in explaining people's perceptions regarding 4IR, including the readiness and preparedness of the education sector.

5. Materials and Methods

The present study is designed to explore and explain the readiness of the education sector in adapting and embracing industry 4.0 and its disruptive capabilities, particularly in facilitating teaching and learning. This exploratory study is necessary considering the lack of existing empirical studies in this area, and particularly about Africa. The rationale is to provide the policymakers and other stakeholders a blueprint for strategic decision-making regarding the implementation and integration of 4IR in teaching and learning, while preparing learners for the world of work. The findings are expected to offer a holistic understanding of how 4IR and its components, including the connectivity of sensors, equipment, workpieces, and IT systems [15], could facilitate learning where tutors and learners are actively and interactively engaged seamlessly [47].

This study adopts a qualitative approach, using an interpretive worldview to explore and explain stakeholders' perceptions regarding 4IR, including its disruptive attributes in the education sector. This approach is a non-probability technique [48] that provides the study participants with the opportunity to construct meanings and interpretation of the transformation in the education sector based on their knowledge of 4IR. This approach is adequate in that generalization is not the primary focus of this study [35]; instead, its rationale is to understand the stakeholders' subjective views as they encounter teaching and learning.

This study used a two-wave data collection process to achieve the research goal, while answering the research questions. Initially, we identified and contacted key stakeholders that are working in the

education sector in South Africa, using purposive and convenient sampling techniques. We sent a consent letter, including the interview protocol, before the actual interview sessions. The approach provided the participants with an overview of the research themes and the opportunity to decide whether to participate in the study, while preparing themselves for the interview process. In-depth semi-structured face-to-face interviews were utilized, to explore and understand the participants' views and beliefs toward 4IR in the education sector. The process allowed the researchers to probe the participants' responses further, to generate additional questions for a deeper understanding of the research participants' worldviews [35] about 4IR. It is worth mentioning that we continued the recruitment and interviews until the saturation point, at the point where the interviews produced no new codes or information about 4IR [35,49].

In the first wave, 12 key informants (Table 2), namely 4 professors and 8 doctors (PhDs), participated in the study. The gender composition of the study participants shows that 5 women and 7 men participated in the study. In the second wave, 11 stakeholders with similar demographics as the first wave participated in the semi-structured interviews. All the study participants started their career in corporate organizations before moving to academia, and this qualified them as experienced and important stakeholders in the sector. In total, 23 key informants (Table 2) from the education sector participated in the data collection process. We consider the sample size to be enough, given that about 10 interviews are recommended for phenomenology studies [36], while around 12 participants are appropriate for interview-oriented studies [49].

Table 2. Participants' profile.

Name	Gender	Age Range	Highest Qualification	Areas of Expertise (or Department	Years in Academia	Years of Industrial Experience
First Wave						
Participant 1	Male	55–60	Associate Prof.	Edu-Engineering	>15	<30
Participant 2	Female	60–65	Dr.	Edu-Leadership	<7	<30
Participant 3	Male	30–35	Dr.	Edu-Foundational	<5	<15
Participant 4	Male	30–35	Dr.	Edu-Curriculum	<5	<10
Participant 5	Female	50–55	Dr.	Special Needs School	<4	<25
Participant 6	Male	55–60	Dr.	Research for companies	<4	<30
Participant 7	Male	60–65	Dr.	Edu-Language	<10	<25
Participant 8	Female	40–45	Dr.	Edu-Curriculum	<5	<15
Participant 9	Female	60–65	Prof.	Edu-Foundational	<15	<30
Participant 10	Male	45–50	Associate Prof.	Edu-Economics and Management	<10	<10
Participant 11	Female	30–35	Dr.	Edu-Early Childhood Develop	<5	<10
Participant 12	Male	60–65	Prof.	Edu-Leadership	<10	<30
Second Wave						
Participant 13	Female	25–30	Degree	Edu-IT	<5	<5
Participant 14	Male	45–50	Masters	Edu-Marketing	<5	<10
Participant 15	Male	45–50	Honors	Edu-Senior phase	<10	<15
Participant 16	Female	50–55	Honors	Edu-Assistant	>10	<15
Participant 17	Male	40–45	Honors	Edu-Special needs	<5	>10
Participant 18	Male	35–40	Masters	Edu-Econ and Management	<10	<10
Participant 19	Female	30–35	Degree	Edu-Foundational	>5	<5
Participant 20	Male	45–50	Prof.	Edu-Senior phase	<15	<10
Participant 21	Female	30–35	Degree	Early Childhood	<10	<5
Participant 22	Female	50–55	Prof.	Edu-Math	<20	<5
Participant 23	Female	50–55	Honors	Edu-Chief	<15	<20

The interviews were audio-taped, having secured the consent of the study participants, while assuring them of confidentiality and anonymity. We transcribed and coded the collected data, using thematic analysis [35,48], facilitated by NVivo 11, a qualitative data analysis software, where different themes that are pertinent to the goals of the study were identified. Prior to the formal data analysis, each transcript was read many times by the authors, to have a deeper understanding of the participants' views. The transcripts were later cross-checked with the interviewees, to establish that the contents

reflected their real perceptions on the utility of 4IR in the education sector and to clarify any ambiguities in the transcripts. This process was followed by the initial coding, using an open-coding [48] approach, by breaking the participants' views into different concepts and labeling the identified patterns, while defining and developing categories based on common attributes that emerged from the data. In this present study, the UTAUT model was used as a basis for data coding and the interpretation of the participants' views, to understand the current predispositions about the utility of 4IR in the education sector. Moreover, the first wave of the data collection process served as a precursor for the second wave; however, findings from the two phases were triangulated for a holistic description of participants views. This approach provided a more objective framework to understand and make sense of participants' opinions regarding the readiness and receptiveness of the education sector toward 4IR and its effectiveness in promoting teaching and learning. Using thematic analysis [35,49], we then performed constant comparisons of emerging themes and involved a 2-stage iterative process of the collected data through open coding. The codes from both waves were later examined and compared, to reveal associations to develop patterns within the data, in order to inform the final themes/patterns and ensure holism in the explanation of 4IR in the education sector.

6. Findings

This section reports the key findings of this study, based on the emerging patterns from the data, and represents the perspectives of the key informants regarding 4IR in the education sector. Considering that the use of technology has proliferated the fabrics of the society, disrupting, and even challenging human existence, the UTAUT model provided a lens to explain the perspectives of key actors in the education sector about 4IR.

6.1. General Perceptions of 4IR

Based on the participants' perceptions, the application of digital technology is gradually becoming a reality in many operations and services. However, the trends and consequences, including the future of technological innovations, especially in the education sector, remain unknown. Without understanding the full capability of the new digital technology, it is unlikely to estimate its application and consequences, considering the scale, scope, speed, and complexity of its disruptive attributes. Nonetheless, the findings suggest that education providers cannot be complacent; instead, they should be forward-thinking in evolving with the ongoing digitalization, especially in harnessing its predictive capability, so they are not left behind in this new adventure. For instance, participants expressed the following sentiments:

> "*Therefore, not getting stuck where we are, when we have a high LQ, a high learning quotient. We don't get stuck nor stagnate we should constantly exposing ourselves to new models, to new theories, to new ideas, to changes that are happening in our world in transforming teaching practices, so we should be receptive to this trend of 4th industrial revolution so as to catch up with the rest of the world*". (Participant 4)

> "*As a result of this perfect storm of technologies, the fourth industrial revolution is paving the way for transformative changes in the way we live and radically disrupting almost every sector of society. It's all happening at an unprecedented, whirlwind pace. To ignore this dramatic change would leave a society vulnerable to underdevelopment and regression*". (Participant 15)

6.2. Contributions of 4IR in the Education Sector

There is no doubt about the contributions of 4IR to the education sector, including recruitment, teaching, and learning, considering its influence in other sectors, especially in the manufacturing and service industries. There is a general perception among the study participants that 4IR will have both positive and negative consequences on the education sector, especially on teaching and learning, as well as employment. For example, one participant stated the following:

"4IR may have positive effects such as productivity, job creation and training. Living in sync with the time: modern technological instead of manual. There are also negative effects such as unemployment, poverty and social inequality. While the uneducated will be left behind, there will be demands on the educational sector for training and skills development". (Participant 13)

However, the study participants believed that the education sector, globally, should maximize its potential, particularly the use of artificial intelligence (AI) and analytics in enhancing learners' experience and employability through teaching and learning, which may require institutional reforms. For example, one participant said the following:

"Technology should be introduced, but some tutors are not keen in using the technology, such as smart boards although education sector would play a pivotal role in the diffusion of 4IR. Policies should allow the use of technology rather than papers whereby both students and tutors are forced to use technology by incorporating it into modules. For instance, the department of education should offer support, especially by supplying and equipping schools to embrace the use of smart devices, such as tablets and smartphones". (Participant 12)

Using UTAUT as a frame of reference, we see there are positive motivations to adopt technology in facilitating teaching and learning; however, the extent to which these intentions can translate to actual adoption/use behavior is a function of many factors (see Figure 2). According to the participants, these include the availability and accessibility, as well as the relevance of 4IR and its ease of use. For 4IR to be relevant and effortless, there should be an alignment between the pace of advancement in digital innovations and their application in the education sector. Consistent with Venkatesh et al. [27], the findings suggest a need for enabling conditions, such as social context and infrastructure, that might facilitate the adoption and use of technology in the education sector, especially in Africa (see Figure 2). For instance, participants expressed the following:

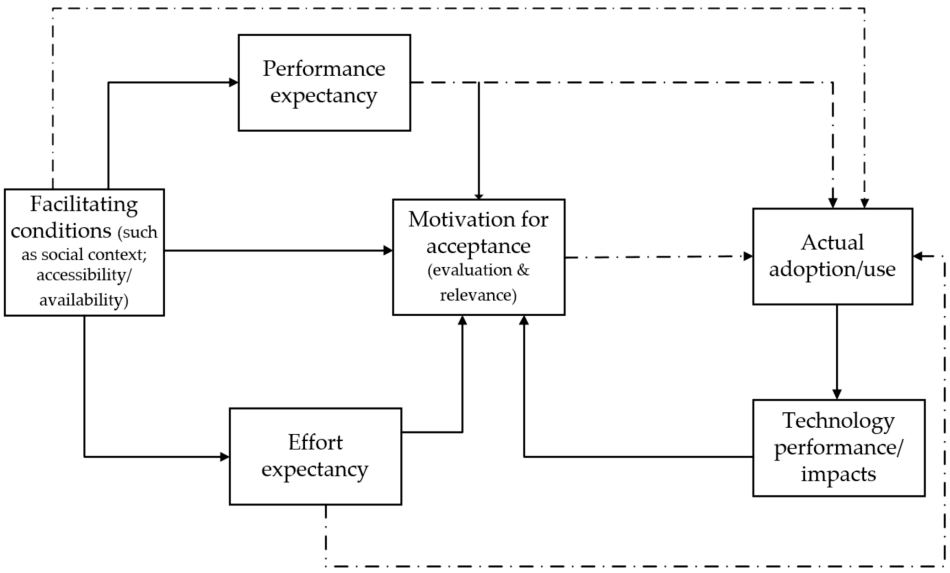

Figure 2. The proposed theoretical model.

"[W]hat we should ask is what the previous revolutions have brought to Africa in terms of development" and *"while the current technology innovations will have disruptive impacts on economy and education in particular, it is challenging if not impossible for Africa to keep abreast of the rapid speed of technological advancement and innovation"*. (Participant 1)

"Africa has always been a dumping ground for outdated and malfunctioning innovations, there is a slight trend in recent years when it comes to 4IR. Although South Africa is known as the leaders of

innovations in Africa, there is lack of opportunities for creativity and funding for innovations which may limit the applications of 4IR in teaching and learning. It is hard considering the level of poverty in Africa; people have ideas but no motivations and supports". (Participant 5)

"*The majority of African countries is still struggling with the 1st, 2nd, and 3rd IR; Africa is not ready for rapid changes yet. I feel, however, that some changes may improve their quality of life, but implementing 4IR must occur gradually*". (Participant 16)

Although the adoption of technology including its application is not similar across sectors and its value-adding capability is different from operation to operation, there are perceptions that the education sector is under constant pressure to be innovative and adaptive. There is a need for a state of equilibrium between digital technology and its application, as an ideal stage where the pace of digitalization is tailored to the social context and infrastructure for the education sector to facilitate teaching and learning. For instance, participants stated the following:

"*We live in the world of inequality and despite that our children are born into the digital age, many of them cannot utilize the available technology for learning. Many children are using mobile phones, taking pictures, accessing social media before they even start any form of formal education; the education sector should tap into this knowledge to develop learners by facilitating teaching and learning especially through the internet-enabled technology*". (Participant 8)

"*I think some schools in South Africa is ready to handle the challenges surrounding 4IR; teaching at quantile 1-3 schools already has a much big focus on technology where teaching takes place on computers and tablets. Aspects like coding and robotics are being included in the school curriculum which could enable learners with access to computers to do so much more with technology. But there are also quantile 4 and 5 schools that barely has paper to write on. These rural parts of the country still have to be reached with access to technology before we can fully embrace 4IR*". (Participant 20)

6.3. Education Sector and Industry 4.0

Performance and Impacts

Consistent with Figure 2 and based on the evaluation of 4IR, one of the major concerns of the study participants involves the performance and impacts of 4IR in facilitating teaching and learning. Although the participants consented that 4IR is inevitable, there are mixed feelings among the participants about its performance expectation concerning its roles and contributions in the education sector:

"*The fourth industrial revolution is inevitable and happens at the fast pace than any of the previous revolutions; however, the danger is that Africa may be left behind and exposed to the advancement 10 or 15 years after its existence*". (Participant 1)

"*I think slowly computers are dehumanizing us, [even though] you know, [they are] a wonderful thing to have. [. . .] I think there's a thin line between what we want in life and if you allow machines to take over, it is going to sacrifice your human life and rational thinking*". (Participant 6)

While there are perceptions that 4IR can add values to the education sector, the study participants also perceived that the sector could contribute to the progress and development of 4IR. There is an overwhelming perception that the relationship between the education sector and industry 4.0 is bi-directional. This performance expectancy [10,27] might increase the intentions to accept digitalization in the sector (see Figure 2) and could allow knowledge and skills to travel in both directions. In support of Xing and Marwala [5], our findings suggest that the ongoing revolution presents huge opportunities and challenges for education providers to be innovative in the way they conduct their operations processes:

"*Education has to be redefined, [and] with the technology, it is difficult to confine that definition to a particular space in that people may be anywhere and have access to learning*". (Participant 12)

On the other hand, the general perceptions indicate that the ecosystem of education, particularly in Africa, has remained unchanged for many years despite the advances in technology, especially with the introduction of the world wide web and smart devices. Participants said the following:

"*Current school curriculum does not equip learners with the right skills or education for the fourth industrial revolution. Computer science skills are at the center of this revolution; however, very few primary and high school learners have access to computers. Some learners reach Grade 12 without ever interacting with a computer*". (Participant 15)

"*As a result of the speed in which this new revolution is coming, the education sector is failing to provide skills for the industry to make sure they adapt. As leaders in knowledge production, they are getting behind and not leading in this space; courses need to be redesigned to fit in with this revolution. Education alone won't be enough but skills especially technological ones, for example, coding will be a basic skill to be acquired by everyone*". (Participant 23)

However, some participants argued that the contributions of 4IR to education lie in its ability to transform learning, developing, and growing learners, including their skills while preparing them for employment. For instance, we observed from the participants' evaluation of the current system that learners are unable to apply the classroom teaching in addressing real-life issues. This is often the case in Africa, considering that the sector has been operating in silos, particularly in developing education curricula and teaching materials that can provide learners with quality teaching and learning experience. Participants noted the following:

"*Some would state that it is the ability learners to be learning, developing, growing, and agile. If the question opens itself to the South African education system and workforce readiness, most would agree that it (the current situation) is not fit nor suitable for any variations. In the South African higher education spaces and workforce, changes are inevitable and should be transformed*". (Participant 3)

"*With the 4th industrial revolution or what a view, there is possibility to transfer the knowledge and skills in addressing real-life issues such as in farming and security by equipping academic institutions and tutors. For instance, farmers could enhance their yield produce by understanding the devastating consequences of a heatwave when there was a forecast of heatwave*". (Participant 7)

However, the state of infrastructure and current legacy thinking about the roles of education, including the teaching and learning process, particularly in Africa, are limiting the contributions of education to 4IR. There is a need for education providers, especially HE, to redesign their pedagogical approaches by extending the current practices to 4IR, using the knowledge from other service industries. The application will allow learners to relate teaching and learning to the wider world such that students can cope with the requirements and pressure of the world of work which may be exacerbated by the advent in technology innovations.

"*I think that depends on the integration of tech into pedagogy. While there are good intentions about the use of tech, on the ground, the evidence is absent. Teachers and teacher education need massive upgrading to make technology education beneficial to student learning*". (Participant 13)

According to the findings of this study, the use of 4IR predictive capability, especially artificial intelligence (AI) and data analytics can transform the way learners are recruited and selected to different but relevant academic programs that are equivalent to their learning capabilities and career goals. Moreover, the participants believed that 4IR could transform the operations of teaching and learning by changing the way learners are engaged such that learning materials and teaching are

accessible to students irrespective of their locations, considering the remoteness of many African cities/town. The approach may involve students taking courses toward a qualification from multiple institutions (and departments) through e-learning rather than from a single institution. The change in teaching and learning will expose students to the opportunities of undertaking interdisciplinary courses from leading scholars outside their host institutions. This collaborative or cooperative learning will involve a synergy through the improvement of infrastructure and adoption education curricula for the benefits of all stakeholders across the entire supply chain network. Participants made the following relevant points:

> "*[T]here is an increasing opportunity for students to enroll for a qualification at a university in South Africa, but access to the internet coupled with the collaboration between universities would allow such students to engage in teaching from universities in Scotland, Europe, or America*". (Participant 10)

> "*Technology should be an enabler to improve students learning experience with the ability to bridge a distance and time gap. It should interact both synchronously and asynchronously to improve student learning, and consequently improve students' communication experience*". (Participant 14)

There is a need for understanding, standardization, customization, and active collaborations among the education providers and other stakeholders in terms of teaching and learning, including revenue generation, to bring this approach to fruition, while maximizing the capability of technology. As a result, this approach will foster a new pedagogical mindset and approach to education and toward learners' development. On this basis, the common goal of the education providers will be to develop learners and to prepare them for employment rather than focusing on revenue generation. By integrating the 4IR components into schools' curricula, the study participants perceived that education would contribute to the advancement of technology and allow the sector to accrue the benefits of 4IR.

6.4. The South African Education Sector and Industry 4.0

6.4.1. Facilitating Conditions

The findings of our study show an overwhelming agreement among the participants on the importance of 4IR, although there are many concerns regarding the state of education and employment in South Africa. Considering the current rate (27.1%) of unemployment in South Africa, there are significant infrastructural and educational challenges confronting the country and Africa as a continent. According to the findings of this study, there is a gap between the level of importance and deployment of the components of 4IR, such as AI, in facilitating teaching and learning in South Africa. Although there is a perception that technology, such as the internet of things and the cloud, can be inappropriately deployed to enhance teaching and learning, the education sector in South Africa requires overhauling and a significant amount of investments to provide facilitating conditions for the effective adoption of 4IR in the education sector. For example, one of the participants argued that the current online teaching is nothing but "paper and glass" where documents are only uploaded for students to access at their own pace and convenience.

> "*What we currently have in our education system is the paper and glass approach, and not the integration of technology". Therefore, "online learning should include interactive platform rather than uploading documents online. The interactive aspect of technology is more important when talking about the contribution of technology to learning*". (Participant 5)

> "*Although PowerPoints slides and papers are made available online through electronic blackboard where students can download the materials and post questions, using the system remotely is still a pain and very challenging due to the inconsistency in the service provision. Also, the education system should go beyond making the teaching materials available online; online teaching should be interactive and engaging, just like the classroom environment*". (Participant 7)

Rather than adopting a static system, participants suggested that any e-learning (or online teaching) should incorporate an interactive platform where learners could interact with their tutors in facilitating the learning process. This perception is supported by [47], who observed that mobile devices, when integrated with teaching and learning processes, particularly in providing assessment feedback, enhance students' motivation, including their involvement in collaborative learning. The interactive aspect of technology is more imperative when talking about the contribution of 4IR in promoting teaching and learning, although the existing tools, such as Blackboard Collaborate, can facilitate the process. Although there is a possibility to abandon the use of technology in facilitating teaching if it requires more effort [10,27,45], the infrastructure, including the social context of 4IR, should be enabled to reduce the complexity of embedding technology into teaching.

> "*The biggest challenge is the cost and ubiquity of data connectivity; the infrastructure is slow and unreliable and extremely expensive. We cannot expect our students, for example, to be permanently connected, when the data costs are prohibitive and the connectivity footprint doesn't reach them where they are—the mindset in Africa is prohibitive and educators are losing faith in the service provision*". (Participant 19)

As a result, 4IR will redefine the constituents of education, considering the difficulty in confining learning to a particular space, in that people may be anywhere and have access to learning with the advent of technology, especially through e-learning and virtual reality (VR). The current perceptions suggest that 4.0 is more than technology or the use of computers, and human capital development is essential to adapt and embrace the disruption of 4IR.

6.4.2. Social Context

Over the last years, many events, such as those instigated by the "#*FeesMustFall*" movement [17,50] and student-led protests by the "South Africa's born-frees" [51], have occurred, and these events were instrumental to a new social context of education and technology use in South Africa. As a result, the recent events in South Africa introduced a new way of thinking regarding teaching and learning, such that creativity in developing online learning (e-learning) context and content started gaining momentum. The education landscape is not only affected by the dynamic social background and disposition of these students but also by their perceptions that digital technology is a way of life rather than a tool to support their learning [19]. For instance, many residential universities are now entering the Open Distance Learning (ODL) space through online platform suggesting that education providers have no options other than transitioning to this technology. Our participants' views on this include the following:

> "*Many universities realized that if they were going to continue shutting down for extended periods of time, a lot of time would be lost. Without realizing the application and phasing into the fourth industrial revolution, creativity and development of online learning content have started. A new world of online learning erupted, [and] more and more residential universities are entering into the ODeL space through online provisioning*". (Participant 3)

> "*The education systems still work in a silo, and their targets and objectives are not geared towards the direction in which 4IR is moving. The education sector and systems are lacking in adaptability, flexibility, and agility that are required to thrive in 4IR*". (Participant 14)

From our findings, we understand that the tools, the methods, the ideas, and the concepts that were in existence twenty years ago are undergoing a significant transformation in the way we teach and learn. There is a desire among the participants to support the education sector in positioning itself as consumers and producers of innovations such that a new social context is capable of sharing and transferring knowledge and skills between its members. Based on the participants' perceptions, the ongoing transformation may require changes in the South African HE strategies, including learning spaces and staff development:

> "*In the world of higher education in South Africa and in the world at large, we become highly aware and understand the impact of those changes on our space. We understand that the tools, the methods, the ideas, [and] the concepts that we used twenty years ago are undergoing a major transformation and major shaking in the way we understood education*". (Participant 12)

> "*My view is that, just like other revolutions, there is always a 10-year transitional period which has started. Africa is slowly adapting, and everyone in every sector is talking about 4IR. I believe Africa is ready, but it will take a while to be on par with the first world, due to the economic divide; those in the rural without access will take time to catch up*". (Participant 22)

For the HE to be effective and functional in this digital era while providing support services for the emerging social context, the sector, particularly in South Africa, must adapt and keep up with the current pace of technological innovations. There must be a transition from institutional approaches to deal with the challenges of large student cohorts and limited staff numbers that prevented student interactions, to the pedagogical innovations in facilitating teaching and learning. However, the emerging technology innovations, in the form 4IR, present many challenges to the education sector, not only to make teaching and learning accessible and efficient but also in preparing learners to the challenges of the world of work. There is a consensus among our study participants on the need for the education sector to be restructured and transformed in such a way to embrace and adapt to the advanced technologies. The following statement represents this well:

> "*Education sector has no choice but to go through this technological transition. One of the few examples where South Africa experience[s] the underpinning of the fourth industrial revolution is the impact on the education space and workforce. Therefore, the jobs that are done, the methods and models used, always need to have a sense of agility, the ability to move, the ability to learn new concepts, new ideas to shapeshift—our world is changing at a phenomenal rate all around us*". (Participant 5)

6.5. Motivations for Adoption

Moreover, we observed from our study that leaders in the education sector, and particularly in South Africa, lack motivations for 4IR and are ill-prepared for the opportunities and challenges of 4IR despite the establishment of an inter-ministerial task force to promote 4IR in South Africa. For example, Participant 9 stated the following:

> "*Leaders in the education sector are ill-prepared for the opportunities, values, and challenges of the 4th industrial revolution and its internet of things components. The education sector should be restructured and transformed in such a way to adapt to the disruption that may be associated with the 4th industrial revolution*".

In addition, we observed that the lack of institutional support, in terms of capacity development regarding the use of appropriate components of 4IR, especially in improving learning outcomes while providing constructive feedback, is a significant impediment to the digitalization of the education sector. This finding is consistent with Ng'ambi et al. [17], who reported barriers to the uptake of technology in HE and suggested the need for a cultural shift in embracing personalized learning through an open and participatory approach to teaching, learning, and research. One participant stated the following:

> "*The current school curriculum does not offer the skills or opportunities to engage 100% in the 4IR. Most of the Facilitators/Lecturers/Teachers/Tutors/Mentors/Coaches did not yet receive any kind of information/training/workshops on the opportunities, challenges and changes due to the 4IR*". (Participant 21)

However, another participant reckoned the following:

> "*[M]any universities in South Africa are currently leaning towards becoming an engaged University with the fourth industrial revolution with the recent mounting evidence across South Africa of a strong movement throughout our universities although the process is slow and older generation is more reluctant [. . .] but I think it is a very exciting movement, [and] universities in South Africa are expressing their commitment to engage with technology*". (Participant 2)

Although students are becoming more tech-savvy, and this should serve as a motivation for 4IR in the education sector, our participants expressed concerns among the older generation about their perceptions and attitudes toward technology, which may reduce the motivation for the education sector to adopt 4IR. The education sector's lack of motivation and its non-readiness for 4IR may affect the development of the requisite skills or workforce for the industry 4.0 regime, especially in Africa. According to the tenets of UTAUT [27], the difficulty in accepting and using technology increases with age, which may be associated with the challenges of processing complex information, especially among the technology laggards. Nonetheless, the use of technology in education has been extensively focused on how to address the issue of the digital divide, thus making education more inclusive; however, a high number of new entrants are mostly technology illiterate due to the lack of access to ICTs [17].

6.6. Acceptance of Industry 4.0

According to our participants, 4IR provides an exciting moment to all sectors, particularly the education sector, where universities around the world are expected to refine their strategic direction toward the learners' development while signing declarations that affirm their social responsibility. One participant noted the following:

> "*Universities are now refining their mission towards greater social relevance in developing and accepting technology capability, they're even joining national and regional networks to engage with other stakeholders [. . .] they're even signing declarations that affirm their education to social responsibility*". (Participant 2)

Our study argues that the role of the education sector is to be part of the development, the upliftment, and the enhancement of the countries of their affiliation while providing the required strong leadership for industry 4.0. This may require a strong acceptance and strategic approach to manage innovations in teaching and learning, as well as ensuring that any adopted innovative approaches are people centered. Although industry 4.0 requires a suite of technological developments, such as automation, artificial intelligence, the internet of things, and data analytics, the understanding of people's behavior toward different interconnectivity platforms is a prerequisite for its acceptance. It is necessary considering that the sector cannot transform without changing the current curricula to enhance teaching and learning, as well as in supporting students in and off the classroom settings.

Based on the participants' perceptions, the education sector, through teaching and learning, particularly in science and technology, including digital technology, should meet the societal needs. Considering that most funding is through society, many universities have started to reignite their social compass and their social mandates.

> "*Education sector should meet the society's needs if society is assisting in funding the education system and there should be an integration of 4IR into the mainstream education to increase skills and capacity development for national benefits*". (Participant 12)

While the quality of education being reduced in many countries, there is a perception that 4IR can enhance the teaching and learning performance, especially when facilitating conditions are in place to support its use. The participants argued for the need for a smart, innovative, and collaborative learning infrastructure to support teaching and learning, particularly in higher education. For example, one participant stated the following:

> "*There are three aspects which need to be considered when it comes to the readiness of South Africa: development of digital skills is pre-eminent; private partnerships are public powerful levers for development; and industries are being rattled digitally. South Africa appears to have the infrastructure in place to deal with the onslaught of 4IR. However, the initial costs of digitalizing its economy may or may not be recovered in future years*". (Participant 15)

However, there are feelings that technology will displace and replace humans, especially in jobs that require low-level skills, which may have detrimental effects on the social and economic stability of nations. The problem of redundancy is one of the major fears and anxieties expressed by our study participants in that there may be no requirements for tutors if teaching and learning are entirely digitalized, especially through online courses. This may affect the possibility of 4IR to become a norm in the education sector across the whole spectrum of its supply chain, especially in facilitating teaching and learning. Amid these changes, it is imperative to distinguish the challenges, the fears, and the reservations facing the university, lecturers, and students in the utilization of technology. One participant made the following statement on this subject:

> "*People are not ready, [and] South Africa is not ready; people are still struggling with basic things on computers; people use mobile phones but not smartphones—we still believe in reading on papers rather than electronic[s]. Most South Africans are not literate, and that is one of the fundamental challenges with 4IR, especially in the education sector*". (Participant 9)

> "*Considering the trend of technological advancement in other countries, especially in Western countries, students don't have to leave their comfort zone before they can access education and acquire qualification. [. . .] Africa should be able to tap into that; however, the issue of Africanization is another challenge in that it is slowing down the rate of acceptance and diffusion of innovation in the education sector*". (Participant 12)

This should be further explored in future research, to understand the extent to which jobs within the academic environment are at risk due to the diffusion and acceptance of technology in facilitating teaching and learning.

7. Discussion

The recent diffusion and rapid advancement in technological innovations suggest that the ways we live, work, and identify with each other are subject to some fundamental questions, in that the previous industrial revolutions introduced main societal changes with different challenges and opportunities for further innovations. Based on the findings of this study, the current knowledge regarding technological advancement, also known as 4IR, is insufficient due to its uncertainties and complexities. To understand the inherent complexities and to reduce the level of uncertainties when introducing 4IR and its components to facilitate teaching and learning, we proposed the theoretical model (Figure 2) based on the findings of our study with the knowledge from the UTAUT [27].

The disruptive technology of 4IR will have significant effects on the education sector, including the entire workforce, so it is, therefore, necessary to understand the facilitating conditions, including social context, availability, and accessibility (Figure 2) of 4IR and its components. However, there is an opportunity for the sector to harness the potential of digitalization in that many tasks, such as reasoning and decision-making, that are associated with teaching and learning will be challenging to displace by technology and may likely remain as human-oriented activities [11,14]. While many sectors are preparing for the consequences of the disruptive technology on their operations, the level of preparedness in the education sector is not encouraging. Despite the vast amount of potential and resources in Africa, our study shows that Africa is currently taking a back seat and is not ready for this drastic and exponential transformation. Participants made the following observations:

> "*For South Africa educator sector, the digital industrial revolution poses challenges and offers perhaps somewhat fewer immediately clear-cut opportunities for the education sector [. . .] due to the lack of internet access and coverage*". (Participant 6)

> "*Not that the technology is not there, but the universities and tutors are not well equipped in terms of knowledge development and usability of the available innovations*". (Participant 12)

> "*As things stand, I don't think Africa is ready. For example, in terms of the economic structure, the continent is still highly labor-intensive which implies that it relies heavily on the manual way of working, whereas at the heart of 4IR, there's a lot of automation through robotics, artificial intelligence, and machine learning. In terms of the education sector, Africa is still [lagging] far behind because even the curriculum being taught at most of the institutions of higher learning is not compatible with changes brought by 4IR*". (Participant 14)

There is no straight answer regarding the acceptance of 4IR in the education sector, and the current perceptions regarding 4IR are mixed. While many people are concerned about its potential effects, especially on employment, others are excited about the opportunities, such as flexible teaching and learning associated with industry 4.0. Either way, the current lack of readiness and preparedness on the part of the major stakeholders in transitioning to a digital-based education system commensurate with the thinking of industry 4.0 suggests that the sector may not fully capture the opportunities. On the positive side, millennials are gearing up to embrace 4IR, as is evident in other sectors and signifies the cusp of another era and thinking in the education sector; however, there is an urgent need to remove the institutional barriers to enhance the adoption of 4IR in the education sector.

Based on the study's participants, the education sector, especially in Africa, is not prepared to embrace and harness the potential of the current technology transformation; however, the extent of the disruption is difficult to establish. However, this exploratory study reveals that, for 4IR to be meaningful and productive, especially in the education sector, the technology should start and end with learners such that the curricula are designed to facilitate teaching and learning activities. This may require a drastic transformation in teaching and learning, including their underpinning behaviors, such that the education sector evolves as technological innovations are developing, especially across borders. Considering that the technology innovations are instrumental to new jobs and employability skills, education providers should strive to close the current gaps by ensuring that their students and graduates are ready for employment.

> "*If the 4IR is really to deliver on the promise of economic growth, job creation due to innovation, improved safety and security, better education, and skills transfer, Africa has to rapidly and immediately change its education focus. If according to current trends, close to 6 out of every 10 South African children have access to some sort of digital access, then it is encouraging to note 65% of children entering primary school today will end up working in completely new jobs that don't exist yet. This reality poses a serious threat to the readiness of the education sector to deal with this inevitable change*". (Participant 15)

According to Lee et al.'s [14] assertion, job specifications and professional competencies should evolve through 4IR such that the education sector has the capability to prepare learners through innovative business models for the challenges of 4IR and the increasingly changing job requirements.

While 4IR can contribute to teaching and learning based on the current knowledge in the literature, our study further argues that the education sector has more to offer in developing 4IR, such as training and development in technology-driven innovations. It may require a significant amount of investments in teaching and research development, including training and retraining of tutors and students, to provide appropriate tools and techniques for the transformation. According to the literature (e.g., [19,27]), online tutors should have requisite skills in facilitating and moderating online discussion for it to be useful, considering the difficulties in using technologies. Rather than investing in

a new workforce, the education sector may reskill and retain the existing workforce by increasing their productivity through digital transformation. For the education sector to remain competitive while adding values to its stakeholders and shareholders, this will require a new business model that will shift the operations of the sector to a more collaborative approach along the whole spectrum of its supply chain [11,52].

8. Conclusions

Using a qualitative interpretive approach, this study explored and examined the perceptions of key stakeholders in the education sector, regarding the readiness of the sector, especially in Africa, for 4IR. While the study shows the relevance of 4IR to the education sector, especially through artificial intelligence and data analytics, it further highlights the opportunity for the sector to contribute to the advancement of 4IR through teaching and research. However, the findings show that the education sector, especially in Africa, is ill-prepared for exploiting and embracing the opportunity associated with 4IR in facilitating teaching and learning. Although many institutions are introducing computers to support teaching and learning, we observed that 4IR is beyond the use of computers and has the potential to disrupt the way we teach, learn, and engage.

While our study has uncovered the current perceptions regarding 4IR in the education sector, its introduction and acceptance pose more questions about its utility, especially in becoming a normative tool. For instance, how can the sector leverage the power of innovations and technology transformation to facilitate teaching and learning for the benefits of all stakeholders, including society? How can the sector minimize the effects of disruption associated with the ongoing transformation? Nonetheless, this exploratory study provides further insights into the perceptions of key stakeholders in the education sector, regarding 4IR and how the sector could provide leadership in the transformational process.

We agree with other studies, such as [5,14,19], which suggested that digitalization is an integral part of our future, especially in facilitating teaching and learning. Using the proposed model (Figure 2), future research should build on the knowledge of this exploratory phase, to develop a more robust nation-wide quantitative study where all stakeholders, including students, tutors, and policymakers, are sampled, using a questionnaire design. For the fourth industrial revolution to be a success in enhancing teaching and learning in Africa, it should be perceived to improve performance, be effortless, be normative, and be facilitated by the current education situations in Africa. While there is an expectation that technology and education can transform, technology does not transform learning and literacy by itself, but only in conjunction with other social and economic factors. According to Warschauer [23], this should allow the education providers to focus their attention on what students should learn in the digital classroom.

As a result, the fundamental question is about the response of Africa, especially in the education sector, to the 4IR, including its disruptive capabilities, considering that many innovations have been transported to Africa in the past decades, with little or no success. The required approach may involve a holistic strategy beyond the current online "paper and glass" teaching and learning without students' interactions, as being practiced in many African higher institutions. Taken together, "[t]he 'revolution' is going to affect Africa whether we are ready or not, so if we don't embrace the idea and take baby steps in the right direction, we will be actively, and by choice, placing ourselves further behind the developed world. Our interaction with devices is going to change, [as] we will rely more and more on connected devices, be they wearables or smart devices in the home" [Participant 19].

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