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# Barriers Hindering the Effective Implementation of Industry 4.0 amongst Developing Countries -A Review

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## Abstract

The adoption of Fourth Industrial Revolution in education has greatly enhanced the achievement and retention of information. Although there have been greatest challenges in the implementation of Fourth Industrial Revolution within universities in emerging countries in this days and ages, hence it is necessary for higher education institutions in developing countries to adopt 4IR for amending inadequate educational infrastructure within the universities. This purpose of this article is to determine the barriers hindering the effective implementation of industry 4.0 in higher education institutions amongst developing. The findings of the study suggest that not only does the education sector in emerging countries face a number of challenges in adopting 4IR but also the need for government to invest in development of infrastructure to help enhance the education system. The data used in this research were derived from both primary and secondary sources. The secondary data was collected through a detailed review of extant literature. In contrast, the primary data was collected through a questionnaire survey distributed to Gauteng province students currently registered within the universities. Two hundred and two (202) questionnaires were received from the two hundred and fifty (250) sent out, representing an 81% response rate. In ensuring the reliability of the research questionnaire, Cronbach's alpha coefficient reliability was conducted on the scaled research questions. Findings from the research were analysed using descriptive statistics and exploratory factor analysis (EFA). Research findings were revealed as per related categories. For the barriers hindering the effective implementation of industry 4.0, findings revealed the following categories: lack of proportion in teaching & technology, inadequate funding of universities, poor network connectivity in some areas & basic understanding of the usage of mobile devices, lack of communication between stakeholders within the university, poor political interference of SRC, poor information & communication technology application approach, inadequate information & communication technology expertise and practice and not enough staff to operate the systems in universities. Since it has been identified beyond reasonable doubt that HEIs are encompassed with challenges centered on inadequacy in educational infrastructure and, arguably, skilled personnel, 4IR is therefore required.

## Keywords

Fourth Industrial Revolution, Barriers, Technology Enhancement, Developing Countries

## 1. Introduction

The fourth industrial revolution has its own pitfall with the improvement and the usage of new technologies. The 4IR is the present and evolving in which altering technologies and developments of such as the Internet of Things (IoT) and Artificial Intelligence (AI) are varying that way we leave and work. This indicates that the new technologies have the prospective to change student's life in a positive manner. On the other hand, the world should not oversee the risks and negative impacts of these new technologies. The first danger of industry 4.0 for education in inequality. Income sharing and inequality are social matters in developing countries. Inequalities in emerging countries is extremely a

debatable topic, and new technologically advances have the potential to impose this notion. There is a high risk of only the rich portion of the populace being able to have the funds for new technologies for educational purposes despite the fact the poor populace is left behind. This manifest with the implementation of the preceding third industrial revolution. Most of the people still have no access to uncontaminated drinking water, transportation and electricity, or the internet connectivity. The article will firstly explain and conceptualize the 4IR. Secondly, the challenges that affects the implementation of 4IR and the enhancement of technology will be identified. Lastly, the implications of overcoming the education infrastructural challenges will be identified.

The research approach followed in this article is quantitative in nature. A quantitative approach was adopted for this study, using a survey as the measurement instrument. Quantitative research requires objectively evaluating the data that consist of numbers trying to exclude bias from the researcher's point of view. Quantitative deals with the statistical analysis and numerical data to provide quantitative information (Lund, 2005). The main aim of research method chosen was to meet the objectives of this study, which are the identification of the challenges that affects the implementation of 4IR in educational institutions, the challenges in enhancement of technology and the implications of overcoming education infrastructural challenges.

## 2. Literature Review

### 2.1 An Overview of Fourth Industrial Revolution

Three years ago, 4IR was the central theme at the World Economic Forum (WEF) annual meeting, Davos 2016. 4IR and Artificial Intelligence (AI) have remained conspicuous each year and a lot of research documentation has come from this. At Davos 2019, the theme was "Globalization 4.0: Shaping a Global Architecture in the Age of the Fourth Industrial Revolution", based on the idea that we "are entering a fourth industrial revolution, where a new wave of technological progress will launch us into a new era of globalization" (Davos, 2016). Davos (2016), further stated that the 4IR, or "Industry 4.0" (manufacturing-focused), is the term popularized by the WEF for the current and developing environment in which disruptive technologies and trends are changing the way we live, work and relate to one another. Such developing technologies include artificial intelligence (AI), the Internet of Things (IoT), cloud computing, cyber security, the sharing economy, robotics, autonomous robots and vehicles, additive manufacturing (3D printing), cyber-physical systems, genome editing, block chain technologies, big data and analytics, virtual reality (VR), augmented reality (AR) and hybrid or mixed reality (MR). According to Haber, Juanes, Del Toro, and Beruvides, G. (2015), the fourth industrial revolution is the combination of complex machinery and devices with different sensors and software used to monitor the business result and predict it. Industry 4.0 concept employs machines and product when interacting with each other without controlled by a human. Kang, Lee, Choi, Kim, Park, Son, and Kim, *et al*. (2016), well defined the fourth industrial revolution as a developing innovation for optimized decision making. The interaction of digital and physical progressions in across geographical and business setting (Adler, Schmitt, Wolter, and Kyas. 2015). Hermann, Pentek, and Otto, (2016), defined the concept of 4IR as the coordination of people and machines for movement of goods, data, and services with a maximum degree of autonomy in decision-making.

### 2.2 Funding Educational Infrastructure vs Implementation of 4IR

#### 2.2.1 Shortage of funds

One of the biggest challenges that affects successful implementation of 4IR in developing countries is the shortage of funds. Even though funding for education improved in the previous years, it is still insufficient for the full operational of higher educational institutions. According to Brown-Martin (2017), it has headed to increase higher educational institutions fee as well as the reduced research funding amongst others. Brown-Martin (2017), further stated that in order for new technologies to grow well in universities, considerable financial backing is required and the great is the cost for the establishment of training related to qualified lecturers and technological infrastructure.

#### 2.2.2 Socio-Economic Exclusivity

Another challenge with higher education institutions that might influence the successful implementation of the 4IR is the relegation of certain socio-economic individuals from taking part in the 4IR. Badat (2010), disputes that even though black student enrolments have improved since 1994, the gross participation percentage of blacks especially African and colored, South Africans continues to be considerably lesser than for white South Africans. Higher education institutions are perceived as being responsible for social justice and for producing equity and equitable conditions to contrary the damaging special effects of apartheid (Chetty and Pather 2015). The 4IR will require a new set of expertise for the future. PwC (2017), reports that 4IR technologies and their applications frequently need particular skills, beyond basic digital literacy.

### 2.2.3 Lecturers being Foreign to Technological Innovations

Regardless of the beginning of computerized stages as a method for information collection, global researchers have discovered that a large number of lecturers showed extraordinary support and positive opinions towards innovation, (Lei, 2009), pointed out that a large portion of lecturers were digital native. Furthermore, Lei (2009), stated that lectures still require introduction and skills to adequately utilize new innovation and computerized media for educating. Wei-Ying (2012), stated that lecturers need a day by day guidance in the incorporation with innovation. Cervera and Cantabrana (2015), recommended ICT as a basic influence to develop the higher education institutions. In addition, Hew and Brush (2007), also recommended innovation information and skills as a huge hindrance to effective learning in classrooms. Tsai and Chai (2012), stated that the absence usage of technological innovation can be a hindrance for innovation combination in education. Hew and Brush (2007), pointed out the three most obstructions affecting innovation: assets, lecturer's information and skills and instructor's natures and beliefs. This affirms detections of prior investigations, which refer to a scope of hindrances in innovation improvement including financial, mechanical, administrative and social obstructions (Kanie Suzuki and Iguchi, 2013). Advances in innovation have essentially improved instructor's capacity to make a useful reality for students by developing all over access to learning assets. Davies, Dean and Ball, 2013; Kim, Lee, Spector, and DeMeester (2013), revealed that the value got from innovation use for students learning is remarkable because of the scheming it has on students. Cut and Brush (2007), recognized university assets as an immediate driver of innovation combination in training as a significant comprehension of assets as an empowering influence or obstruction to effective innovation incorporation in universities. Carrasco and Torrecilla (2012), stated that the entrance to innovation is the proper PCs, and resulting utilization of those devices, good impacts on innovation reconciliation and student execution. Cambodia, Dotong, De Castro, Dolot and Prenda (2016), stated that equipment conflict, PCs, the absence of power, restricted understanding among students and learners' poor understanding of the advantages of these innovations to be a portion of the key hindrances to innovation.

## 2.3 Challenges in the enhancement of technology

The Department of Basic Education is Action Plan, the National Development Plan, and the White Paper on e-Education of 2004 list a quantity of challenges in terms of education and technological improvement. These challenges include:

- pinpointing which lecturers essential of pedagogic support;
- evaluating educational consequences accurately and on time;
- giving lecturers and students new 21st-century expertise;
- giving right to use the online communities of practice as well as online contented;
- making education more student focused, fresh and fun;
- enabling self-learning as well as discovery;
- encouraging critical thinking and exposure to new ideas; and
- Decreasing administrative burdens, e.g. marking tests absences (Meyer and Gent 2016).

## 2.4 Overcoming Education Infrastructural Challenges

Gambhir (2008), stated that the inclusion process can try to help even though it will never achieve it completely. Inclusion education is all about varying and converting education system to accommodate all students, regardless of their strength and weaknesses (Engelbrecht and Green 2007). Schwab's (2016), demonstrated that the industry 4.0, normally depicted as 4IR, the notion has knowingly changed the numerous ways within the higher education institutions in developing countries, utmost mainly, education as well as learning meetings. Furthermore, Schwab's (2016), pointed out that a "new technology" revolution that would change the way humans interrelate in the world today is stimulated by "emerging technology breakthroughs, covering wide-ranging fields such as artificial intelligence (AI), robotics, the internet of things (IoT), autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing".

The government took in to consideration the necessity to advance superiority of education over the use of ICT. Because of this, Maitlamo (2007), recommended that ICT curricula, projects as well as applications that can offer learning and supervision be adapted to encounter the nation's requirements of education. Leteane and Moakofhi (2015), pointed out that government is playing a huge role in enhancing the quality of education as they have presented ICT basics in secondary schools and an essential course in higher education institutions. In addition, Leteane and Moakofhi (2015), opined that government schools starting in primary schools to tertiary are also provided with PC's laboratories, where learners together with instructors can make effort to enhance their ICT abilities. Eze, Adu, and Ruramayi (2013),

stated that the combination of ICTs in education offers a few advantages: sharing of assets and learning conditions just as the advancement of collective learning and a general move towards more notable student self-governance. Mereku (2015), pointed out that innovation coordination is providing PCs and a web association; it includes the launch of learning exercises with academically educated use regarding ICT apparatuses. The accompanying computerized devices have been referred to regarding ICT mix in the study hall: word processors, information projectors, PowerPoint spreadsheets, web crawlers, intelligent whiteboards, portable advancements, PDAs (messages, web journals, recordings and so on.), tablets, texting, digital recordings, CD-ROMs, Wikipedia, reenactments, movements and digital books (Assan and Thomas, 2012; Mooketsi and Chigona, 2014; Govender, 2014; Molotsi, 2014, Krauss, 2014; Tamim Mereku, 2015; Lorenz, Banister, and Kikkas, 2015; Batchelor and Olakanmi, 2015, Borokhovski, Pickup, and Bernard, 2015), demonstrated that ICTs are being utilized in the study hall, in any case more top to bottom information is required towards understanding the classes of innovations utilized and how this encourages teaching method and substance information. Tamim *et al.* (2015), pointed out that an absence of self-viability of lecturers and misunderstandings concerning why professors are not drawing in with ICTs in the classroom show that there is a misinterpretation that by essentially placing this innovation in the hands of students, educational access issues will be settled and educational change will take place.

## 3. Research Methodology

This study explores existing literatures from published research journals and conference proceedings as means of secondary data, with the aim of understanding the situation of challenges that higher education institutions encounter in adopting 4IR for their activities in developing countries. This study reviewed literatures on Funding Educational Infrastructure vs Implementation of 4IR, Challenges in the enhancement of technology and Overcoming Education Infrastructural Challenges.

## 4. Findings and Discussions

### 4.0 Background Information of respondents

The respondents were students from university of Johannesburg highest percentage with 21.5 per cent, followed by students from Tshwane University of technology 21.5 per cent, university of South Africa has 19.8 per cent, University of Pretoria and Sefako Makgatho University has 10.7, Wits and Vaal University of Technology have 5.8 and other has 4.1per cent. While under the age group, Older than 45 years has 2.5 per cent, 41-45 years has 2.5%, 36-40 years has 3.3 per cent, 31-35 years has 15.7 per cent, 26-30 years has 57.9 per cent, 21-25 years has 15.7 per cent and 18 to 20 years has 2.5 per cent. Knowledge of 4IR, not at all familiar has 5.0 per cent, slightly familiar has 16.5 per cent, somewhat familiar has 17.4 per cent, moderately familiar 28.1 per cent and extremely familiar 33.1 per cent. Finally, under field of study of the respondents. Art, Design and Architecture has 7.1, Economic and Financial Sciences 5.0%, Education 10.7%, Engineering and Built Environment 57.9%, Health Sciences 83.3%, Humanities and Law 2.5%, Management 3.3%, Natural and Agricultural Sciences 0.8%, Occupational Sciences 3.3% and other 4.1%. Table 1, 2 and 3 below show the tabulated illustration of the respondents.

Table 1. Demographical illustration of background information of respondents

| Demographic Respondents Students | Percentage (%) |
|---|---|
| UJ | 21.5 |
| WITS | 5.8 |
| UP | 10.7 |
| TUT | 21.5 |
| VUT | 5.8 |
| SMU | 10.7 |
| UNISA | 19.8 |
| Other | 4.1 |

Table 2. Demographical illustration of background information of the age group

| Age Group | Percentages (%) |
|---|---|
| 18 years - 20 years | 2.5 |
| 21 years – 25 years | 15.7 |
| 26 years – 30 years | 57.9 |
| 31 years – 35 years | 15.7 |
| 36 years – 40 years | 3.3 |
| 41 years – 45 years | 2.5 |
| Older than 45 years | 2.5 |

Table 3. Demographical illustration of background information of the knowledge of 4IR

| Knowledge of 4IR | Percentages (%) |
|---|---|
| Not at all familiar | 5.0 |
| Slightly familiar | 16.5 |
| Somewhat familiar | 17.4 |
| Moderately familiar | 28.1 |
| Extremely familiar | 33.1 |

Table 4. Demographical illustration of background information of the field of study

| Field of Study | Percentages (%) |
|---|---|
| Art, Design and Architecture | 1.7 |
| Economic and Financial Sciences | 5.0 |
| Education | 10.7 |
| Engineering and Built Environment | 57.9 |
| Health Sciences | 8.3 |
| Humanities | 2.5 |

| | |
|---|---|
| Law | 2.5 |
| Management | 3.3 |
| Natural and Agricultural Sciences | 0.8 |
| Occupational Sciences | 3.3 |
| Other | 4.1 |

This section presents the results of section E of the questionnaire which determines the barriers hindering the effective implementation of industry 4.0 amongst developing countries. Using Cronbach's Alpha, the reliability recorded for this section is 0.961 above the stipulated 0.7 to show it is reliable. A definition is given for them to adequately capture the measured variables as shown in Table 4.

## 4.1 Descriptive statistics

Table 5 presents the mean item score (MIS) ranking and the standard deviation (SD) of the respondents' opinion on challenges facing HEIs in adopting 4IR infrastructure in South Africa. The respondents ranked the level of awareness using a Five-point Likert scale where: 1= Strongly disagree; 2= Disagree; 3= Neutral; 4= Agree; 5= Strongly Agree. Lack of proportion in teaching & technology was ranked first by the respondents with an MIS of 3.82 and an SD of 1.177; the inadequate funding of universities was ranked second by the respondents with an MIS of 3.81 and an SD of 1.099; Poor network connectivity in some areas & basic understanding of usage of mobile devices ranked third by the respondents with an MIS of 3.79 and an SD of 1.086; Lack of communication between stakeholders within the university was ranked fourth by the respondents with an MIS of 3.77 and an SD of 1.082 . In comparison, poor political interference of SRC was ranked fifth by the respondents with an MIS of 3.74 and an SD of 1.199. Both Poor information & communication technology application approach and Inadequate information & communication technology expertise and practice ranked sixth by the respondents with an MIS of 3.73 each and an SD of 1.213 and 1.172 respectively; Not enough staff to operate the systems in universities was ranked eighth by the respondents with an MIS of 3.71 and an SD of 1.141; Absence of community responsiveness & involvement was ranked ninth by the respondents with an MIS of 3.66 and an SD of 1.149; High costs of information & communication technology services ranked tenth by the respondents with an MIS of 3.65 and an SD of 1.189; 4IR infrastructure not amended and The stakeholders of the university tends to ignore information & communication technologies were both ranked eleventh by the respondents with an MIS of 3.62 each and an SD of 1.225 and 1.241 respectively; Students are overcrowded in classrooms ranked thirteenth by the respondents with an MIS of 3.51 and an SD of 1.358; Limited university resources ranked fourteenth by the respondents with an MIS of 3.49 and an SD of 1.383 while Staff members & students are both not technologically savvy ranked lowest in fifteenth by the respondents with an MIS of 3.44 and an SD of 1.237.

Table 5. Descriptive analysis of barriers hindering the effective implementation of industry 4.0

| **Challenges Facing HEIs in Adopting 4IR Infrastructure** | **Mean** | **Std. Deviation** | **Rank** |
|---|---|---|---|
| Lack of proportion in teaching & technology | 3.82 | 1.177 | 1 |
| Inadequate funding of universities | 3.81 | 1.099 | 2 |
| Poor network connectivity in some areas & basic understanding of the usage of mobile devices | 3.79 | 1.086 | 3 |
| Lack of communication between stakeholders within the university | 3.77 | 1.082 | 4 |
| Poor political interference of SRC | 3.74 | 1.199 | 5 |
| Poor information & communication technology application approach | 3.73 | 1.213 | 6 |
| Inadequate information & communication technology expertise and practice | 3.73 | 1.172 | 6 |
| Not enough staff to operate the systems in universities | 3.71 | 1.141 | 8 |

| | | | |
|---|---|---|---|
| Absence of community responsiveness & involvement | 3.66 | 1.149 | 9 |
| High costs of information & communication technology services | 3.65 | 1.189 | 10 |
| 4IR infrastructure not amended | 3.62 | 1.225 | 11 |
| The stakeholders of the university tends to ignore information & communication technologies | 3.62 | 1.241 | 11 |
| Students are overcrowded in classrooms | 3.51 | 1.358 | 13 |
| Limited university resources | 3.49 | 1.383 | 14 |
| Staff members & students are both not technologically savvy | 3.44 | 1.237 | 15 |

## 4.2 Exploratory factor analysis

All the identified barriers were subjected to the Exploratory Factor Analysis (EFA) using the SPSS version 27 software. In carrying out the exploratory factor analysis, data suitability was assessed by inspecting the correlation matrix indicate the 0.3 and above coefficient value suitable for the factor analysis, as shown in Table 6.

Table 6: Correlation Matrix

| | **E1** | **E2** | **E3** | **E4** | **E5** | **E6** | **E7** | **E8** | **E9** | **E10** | **E11** | **E12** | **E13** | **E14** | **E15** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **E1** | **1.000** | | | | | | | | | | | | | | |
| **E2** | 0.734 | **1.000** | | | | | | | | | | | | | |
| **E3** | 0.644 | 0.766 | **1.000** | | | | | | | | | | | | |
| **E4** | 0.618 | 0.711 | 0.774 | **1.000** | | | | | | | | | | | |
| **E5** | 0.629 | 0.682 | 0.785 | 0.769 | **1.000** | | | | | | | | | | |
| **E6** | 0.620 | 0.672 | 0.736 | 0.707 | 0.774 | **1.000** | | | | | | | | | |
| **E7** | 0.579 | 0.620 | 0.715 | 0.670 | 0.759 | 0.738 | **1.000** | | | | | | | | |
| **E8** | 0.464 | 0.461 | 0.550 | 0.440 | 0.577 | 0.665 | 0.544 | **1.000** | | | | | | | |
| **E9** | 0.537 | 0.587 | 0.662 | 0.610 | 0.662 | 0.686 | 0.618 | 0.624 | **1.000** | | | | | | |
| **E10** | 0.581 | 0.660 | 0.667 | 0.666 | 0.761 | 0.751 | 0.706 | 0.596 | 0.651 | **1.000** | | | | | |
| **E11** | 0.661 | 0.726 | 0.747 | 0.804 | 0.701 | 0.703 | 0.683 | 0.552 | 0.672 | 0.687 | **1.000** | | | | |
| **E12** | 0.376 | 0.428 | 0.542 | 0.361 | 0.615 | 0.626 | 0.463 | 0.729 | 0.599 | 0.628 | 0.486 | **1.000** | | | |
| **E13** | 0.435 | 0.473 | 0.569 | 0.535 | 0.663 | 0.671 | 0.537 | 0.776 | 0.612 | 0.729 | 0.618 | 0.743 | **1.000** | | |
| **E14** | 0.469 | 0.460 | 0.468 | 0.472 | 0.651 | 0.655 | 0.572 | 0.755 | 0.573 | 0.661 | 0.557 | 0.679 | 0.791 | **1.000** | |
| **E15** | 0.427 | 0.430 | 0.544 | 0.446 | 0.639 | 0.613 | 0.518 | 0.672 | 0.563 | 0.668 | 0.459 | 0.676 | 0.710 | 0.686 | **1.000** |

The Kaiser-Mayer-Olkin (KMO) is necessary to indicate the adequacy of the value distribution, to proceed with the EFA. According to Pallant (2011:7) a data distribution measure <0.5 is not acceptable, while >0.6 is acceptable for EFA. Table 7 indicates that the KMO value is 0.943 and this means it is acceptable as it is above the acceptable 0.6_,

at the same time, while the Bartlett's test of sphericity shows the statistical significance in all variables with a value 0.000, which is less than 0.050 making them factorable. The correlation matrix table indicated the suitability of data for factor analysis as it revealed the correlation coefficient >3 supporting the KMO and Bartlett's test.

Table 7: KMO measure and Bartlett's test

| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.943 |
|---|---|---|
| Bartlett's Test of Sphericity | Approx. Chi-Square | 2936.692 |
| | Df | 105 |
| | Sig. | 0.000 |

Table 8 shows communalities of all variables that are determined by their extraction with values that are not less than 0.300. This indicates that all variables fit well in their components and that there is no variance in variables. Factor grouping is valid if each of the variables do not have low extraction value. As indicated in the table all variables consist of values that are greater than 0.300.

Table 8: Communalities

| | **Initial** | **Extraction** |
|---|---|---|
| Staff members & students are both not technologically savvy | 1.000 | 0.645 |
| 4IR infrastructure not amended | 1.000 | 0.769 |
| The stakeholders of the university tends to ignore information & communication technologies | 1.000 | 0.796 |
| Students are overcrowded in classrooms | 1.000 | 0.801 |
| Poor information & communication technology application approach | 1.000 | 0.796 |
| Not enough staff to operate the systems in universities | 1.000 | 0.779 |
| High costs of information & communication technology services | 1.000 | 0.688 |
| Poor network connectivity in some areas & basic understanding of usage of mobile devices | 1.000 | 0.776 |
| Absence of community responsiveness & involvement | 1.000 | 0.639 |
| Inadequate information & communication technology expertise and practice | 1.000 | 0.747 |
| Limited university resources | 1.000 | 0.775 |
| Inadequate funding of universities | 1.000 | 0.767 |
| Lack of proportion in teaching & technology | 1.000 | 0.824 |
| Lack of communication between stakeholders within the university | 1.000 | 0.773 |
| Poor political interference of SRC | 1.000 | 0.713 |
| Extraction Method: Principal Component Analysis. | | |

Table 9 shows the total variance of all variables indicating the eigenvalues according to Kaiser's criterion. The first two components are reckoned as their values are above 1.0 which mean they meet the criteria under the initial Eigen value column. These two components explain a cumulative percentage of 75.265.

Table 9: Total Variance Explained

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings [a] |
|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total |
| 1 | 9.753 | 65.019 | 65.019 | 9.753 | 65.019 | 65.019 | 8.678 |
| 2 | 1.537 | 10.246 | 75.265 | 1.537 | 10.246 | 75.265 | 7.801 |
| 3 | 0.515 | 3.432 | 78.697 | | | | |
| 4 | 0.460 | 3.068 | 81.766 | | | | |
| 5 | 0.431 | 2.872 | 84.637 | | | | |
| 6 | 0.388 | 2.589 | 87.226 | | | | |
| 7 | 0.334 | 2.224 | 89.450 | | | | |
| 8 | 0.309 | 2.062 | 91.511 | | | | |
| 9 | 0.251 | 1.675 | 93.186 | | | | |
| 10 | 0.235 | 1.568 | 94.754 | | | | |
| 11 | 0.225 | 1.500 | 96.254 | | | | |
| 12 | 0.185 | 1.231 | 97.485 | | | | |
| 13 | 0.148 | 0.986 | 98.471 | | | | |
| 14 | 0.120 | 0.801 | 99.272 | | | | |
| 15 | 0.109 | 0.728 | 100.000 | | | | |
| Extraction Method: Principal Component Analysis. | | | | | | | |
| a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance. | | | | | | | |

Figure 1 shows the scree plot which revealed the factors with eigenvalues above 1 on the steep side of the graph, while factors with eigenvalues below one on the lower side of the plot.

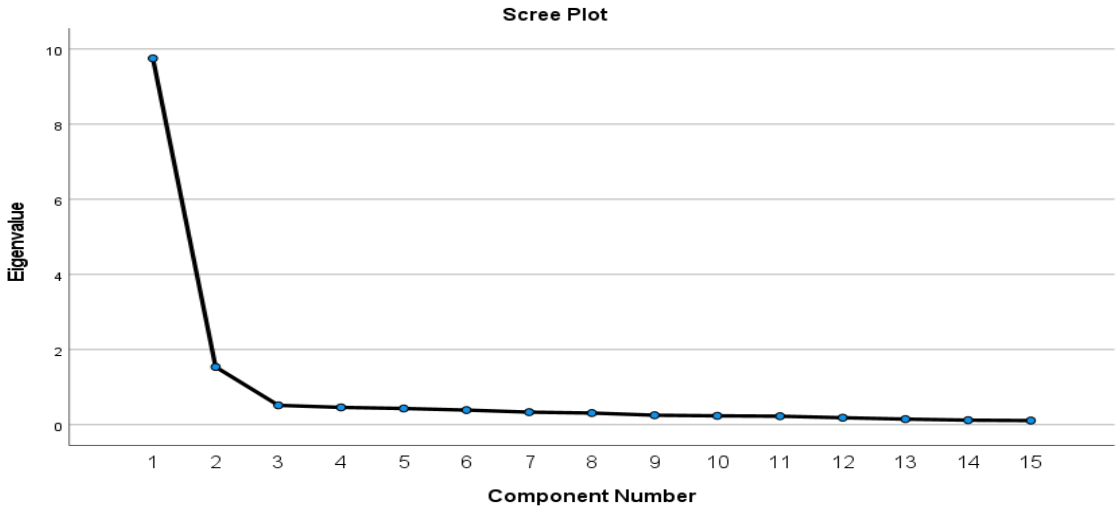


Figure 1: Scree plot on barriers hindering the effective implementation

Table 10 shows the pattern matrix with 15 variables that were identified from the literature and factored into two clusters and interpreted based on the inherent relationship of variables in that cluster.

Table 10: Pattern Matrix

| | Component | |
|---|---|---|
| | **1** | **2** |
| Students are overcrowded in classrooms | 0.966 | |
| 4IR infrastructure not amended | 0.948 | |
| The stakeholders of the university tends to ignore information & communication technologies | 0.861 | |
| Staff members & students are both not technologically savvy | 0.852 | |
| Limited university resources | 0.845 | |
| High costs of information & communication technology services | 0.725 | |
| Poor information & communication technology application approach | 0.679 | |
| Not enough staff to operate the systems in universities | 0.601 | |
| Inadequate information & communication technology expertise and practice | 0.515 | |
| Absence of community responsiveness & involvement | 0.496 | |
| Inadequate funding of universities | | 0.918 |
| Poor network connectivity in some areas & basic understanding of the usage of mobile devices | | 0.871 |
| Lack of proportion in teaching & technology | | 0.866 |
| Lack of communication between stakeholders within the university | | 0.859 |
| Poor political interference of SRC | | 0.830 |
| Extraction Method: Principal Component Analysis.<br>Rotation Method: Oblimin with Kaiser Normalization. | | |
| a. Rotation converged in 6 iterations. | | |

### 4.3 Naming of components/factors of the challenges facing HEIs in adopting 4IR for their activities

#### 4.3.1 Factor 1: Inadequacy of infrastructure

As shown in Table 10, ten variables are loaded in factor 1. These variables include 'Students are overcrowded in classrooms' (96.6%) '4IR infrastructure not amended' (94.8%) 'The stakeholders of the university tends to ignore information & communication technologies' (86.1%) 'Staff members & students are both not technologically savvy' (85.2%) 'Limited university resources' (84.5%) 'High costs of information & communication technology services' (72.5%) 'Poor information & communication technology application approach' (67.9%) 'Not enough staff to operate the systems in universities' (60.1%) 'Inadequate information & communication technology expertise and practice'

(51.5%) and 'Absence of community responsiveness & involvement' (49.6%). All mentioned variables in this factor can be said to relate to inadequate facilities in the institutions**.** This factor accounted for 65.019% of the total variance.

### 4.3.2 Factor 2: Inadequacy of funds

Loaded in factor 2 are five variables with 'Inadequate funding of universities' (91.8%) 'Poor network connectivity in some areas & basic understanding of the usage of mobile devices' (87.1%) 'Lack of proportion in teaching & technology' (86.6%), 'Lack of communication between stakeholders within the university' (85.9%), and 'Poor political interference of SRC' (83.0%). Therefore, with a total variance of 10.246%, this factor can be labelled as inadequacy of funds.

Table 11 shows the component correlation matrix with all clusters having values that are more than 0.300. This indicates that there is a strong relationship between all clusters.

Table 11: Component correlation matrix

| Component | 1 | 2 |
|---|---|---|
| 1 | 1.000 | 0.638 |
| 2 | 0.638 | 1.000 |
| Extraction Method: Principal Component Analysis.<br>Rotation Method: Oblimin with Kaiser Normalization. | | |

As shown in Table 12, a reliability test was done on all variable clusters using the Cronbach's Alpha. A minimum value of 7 is accepted. The table indicated that all the variables measured fitted well in the clusters they were loaded into as they all had a Cronbach's Alpha value above 7.

Table 12: Reliability of components/factors

| **Components** | **Cronbach's Alpha Coefficient** |
|---|---|
| Component 1 - INADEQUACY OF INFRASTRUCTURE | 0.956 |
| Component 2 – INADEQUACY OF FUNDS | 0.928 |

## 4.2 Impact Analysis using indicators

For the impact analysis, selected indicators used as variables to determine educational infrastructure and its challenged in adopting 4IR for their activities (Table 13).

Table 13: Challenges Facing Higher Education Institutions in 4IR for their Activities

| **Indicators** | **Mean** | **Standard deviation** | **Rank** |
|---|---|---|---|
| Staff members & students are both not technologically savvy | 3.35 | 1.263 | 1 |
| 4IR infrastructure not amended | 3.51 | 1.266 | 1 |
| The stakeholders of the university tends to ignore information & communication technologies | 3.53 | 1.279 | 1 |
| Students are overcrowded in classrooms | 3.37 | 1.391 | 1 |
| Poor information & communication technology application approach | 3.6 | 1.249 | 1 |
| Not enough staff to operate the systems in universities | 3.56 | 1.168 | 1 |
| High costs of information & communication technology services | 3.52 | 1.198 | 1 |
| Poor network connectivity in some areas & basic understanding of usage of mobile devices | 3.65 | 1.116 | 1 |

| | | | |
|---|---|---|---|
| Absence of community responsiveness & involvement | 3.54 | 1.191 | 1 |
| Inadequate information & communication technology expertise and practice | 3.58 | 1.209 | 1 |
| Limited university resources | 3.38 | 1.427 | 1 |
| | | | |
| Inadequate funding of universities | 3.7 | 1.159 | 1 |
| Lack of proportion in teaching & technology | 3.71 | 1.248 | 1 |
| Lack of communication between stakeholders within the university | 3.69 | 1.126 | 1 |
| Poor political interference of SRC | 3.64 | 1.237 | 1 |

### 4.3 Interpretation of Results

In the findings, the categories of educational infrastructure and its challenged in adopting 4IR for their activities in Gauteng higher education institutions. The respondents indicate that staff members & students are both not technologically perceptive detailing with 1.263 standard deviation in category-2, 4IR infrastructure not amended with 1.266 standard deviation has the greatest challenge. In category-3, the stakeholders of the university tend to ignore information & communication technologies developing resilient secondary materials markets with 1.279 standard deviation has the greatest impact. In categogy-4, Students are overcrowded in classrooms with 1.391 standard deviation has the greatest challenge of the implementation of 4IR within higher education institutions. In category-5 Poor information & communication technology application approach with 1.249 standard deviation. In category-6, not enough staff to operate the systems in universities 1.168 standard deviation. in category-7, High costs of information & communication technology services with 1.198 standard deviation. In category-8, Poor network connectivity in some areas & basic understanding of usage of mobile devices with 1.116 standard deviation. In category-9, Absence of community responsiveness & involvement with 1.191 standard deviation. In category-10, Inadequate information & communication technology expertise and practice with 1.209 standard deviation. In category-11, Limited university resources with 1.427 standard deviation has the greatest challenge in the adoption of 4IR in developing countries. In category-12, Inadequate funding of universities with 1.159 standard deviation. In category-13, Lack of proportion in teaching & technology with 1.128 standard deviation. In category-14, Lack of communication between stakeholders within the university with 1.126 standard deviation and in category-15, Poor political interference of SRC with1.237 standard deviations. The indicator-1 is considered the indicator having the greatest impact in the adoption of 4IR. Therefore, such challenge is considered the greatest hindrance for higher education institutions in the adoption of 4IR for their activities.

## 5. Conclusion

The 4IR is the latest industrial revolution, with an increased focus on ICT, technological advancement, innovation, and creativity. An overview of the 4IR were identified in this article, namely big data, AI, robotics, ICT, 3D printing, and quantum computing. A number of challenges were identified which affect the implementation of 4IR within higher education institutions such as staff members & students not technologically savvy, 4IR infrastructure not amended, students are overcrowded in classrooms, Lack of communication between stakeholders within the university, lack of proportion in teaching & technology, High costs of information & communication technology services, Limited university resources etc. The 4IR offers, among others, a greater opportunity for participation in the digital economy and collaborative partnership.

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