Proceedings of the 49th Annual Conference of the Southern African Computer Lecturers' Association

Programme Chairs: George Wells and Monelo Nxozi
Conference Chairs: Karen Bradshaw and Ingrid Siebörger

Proceedings Editors: Philip Machanick and Karl van der Schyff

Springer Proceedings Editor: Bobby Tait

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Chairpersons' Report

SACLA 2020 had originally been planned to take place from the 6th to 8th July, at the Mpekweni Beach Resort in Eastern Cape. We were quite far into our preparations with the venue, when the Covid-19 pandemic struck South Africa. By early April it was becoming apparent that holding an in-person conference might not be possible, although at that stage none of us had any idea of the disastrous effect the virus would have on our country and its people. On the 18th April 2020, before participant registration was opened, the organising committee made the final decision to hold a virtual conference instead. This was both a relief having actually made the decision, but also the start of a fairly stressful period in the sense that we had to restart the planning for a virtual conference, and familiarise ourselves rapidly with technology to support the decision.

We were most grateful to our three Sponsors, the Institute of Information technology Professionals, Rhodes University, and Pearson South Africa, who continued to support our virtual endeavour.

Given the worsening circumstances in our country, going virtual was obviously the right decision. We sincerely hope that all the participants felt that it was a worthwhile alternative, although we realise that the socialising and networking aspects of a face-to-face conference were sorely missed. We are however, confident that the dissemination of some excellent research was achieved through the online sessions.

Having to deal with organising a virtual conference certainly had its challenges. However, there were always solutions on offer, especially related to technical logistics, which was crucial to the success of the conference. We wish to thank the following committee members for their active involvement throughout:

Programme chairs:	George Wells and Monelo Nxozi
Technical logistics:	Billy Morgan
Sponsorship:	Stephen Flowerday
Webmaster:	Greg Foster
Proceedings:	Philip Machanick and Karl van der Schyff
Treasurer:	Caro Watkins
Secretary:	Michelle Coupe
Keynotes:	James Connan and Dane Brown
Springer volume:	Bobby Tait (from UNISA)

Thanks are also due to the keynote speakers, all the participants who joined the various sessions, and of course to the presenters without whom the conference could not have happened. In terms of engagement at the conference, 110 participants registered, with the maximum attendance at any one session being just over 40, and the average attendance being in the mid 30s. We look forward to meeting in person once again at SACLA 2021, which will be hosted by the University of Johannesburg.

Karen Bradshaw & Ingrid Siebörger (Conference Co-Chairs)

Programme Co-Chairs' Foreword

SACLA 2020, the 49th Annual Conference of the Southern African Computer Lecturers Association, provided a forum for the presentation and discussion of original research and practical experiences in the teaching and learning of Computer Science, Information Systems, Informatics and other related disciplines. The conference theme selected for 2020 was *TL;DR: Teaching the New Generation!* Due to the restrictions and safety concerns introduced by the Covid-19 pandemic, the conference was help online, using Zoom Webinar, from 6–9 July 2020.

Submissions included full research papers, short papers, and discussion papers. In addition to these, the conference also featured two keynote addresses (by Dr Helen Purchase from the University of Glasgow, and Prof Charles Young of Rhodes University), and two presentations by sponsors (IITPSA and Pearson). The focus of the primary track of the conference was on practical experiences in computing education at the tertiary/post-school level, particularly classroom innovations, novel tools for learning and/or assessment, and research investigating aspects of computing education. In addition, submissions were also invited for a secondary track focusing on general research in Computer Science and Information Systems, which was intended to assist early-career academics with a welcoming platform to present their research.

All papers, for both tracks, went through the same double-blind reviewing process, and each paper received three reviews. The Programme Committee was comprised of 33 international and national researchers (see below). We wish to record our thanks to the members of the Programme Committee who gave willingly of their time and expertise to provide very helpful and insightful reviews of the submissions.

A total of 53 papers were submitted, including one short paper and one discussion paper. After reviewing, 20 of the papers were accepted as full papers (giving an acceptance rate for full papers of 39%), five of the full papers were accepted as short papers, and the discussion paper was accepted (giving an overall acceptance rate of 49%).

After the conference, following a careful review of the full papers in the main track, 13 were selected for submission to a Springer journal for publication. The

remainder of the papers appear in this proceedings.

Our thanks go to all the authors and researchers who entrusted us with the results of their research and writing. Any conference is only as good as the work that is submitted for presentation, and we are deeply grateful for all who contributed, under the difficult circumstances of a global pandemic and national lockdown, to make SACLA 2020 a great success.

George Wells & Monelo Nxozi (Programme Co-Chairs)

SACLA 2020 Programme Committee

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Additional Reviewers

James Connan (RU)
Lynette Barnard (NMU)
Suné Van der Linde (NWU)

Message from the Editors

SACLA 2020 papers are from a diverse range of institutions; full papers that are eligible for the South African Department of Higher Education and Training subsidy are from:

- North-West University
- Nelson Mandela University (2 papers)
- University of Pretoria (2 papers)
- Walter Sisulu University
- University of South Africa
- University of Cape Town

Most of the papers were merged into the final paginated proceedings unchanged from the authors' laid out final copy; we thank the authors for promptly supplying this.

Authors whose papers submitted as full papers but accepted in the "short" category were not asked to shorten their paper; the distinction is in passing the threshold of peer review for a full paper, rather than length.

Philip Machanick & Karl van der Schyff – joint editors

Contents

Full Papers

Exploring essential software development skills for the South African job market

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Abstract. There is growing evidence of the IT skills gap and hard-to-fill IT vacancies. Greater alignment is needed between higher education and the IT industry in order to improve the software development skills of graduates. The purpose of this research is to determine which technical skills related to software development are most sought after in the South African job market. Web scraping and analysis with custom developed tagging and clustering software is used to obtain IT position information from a South African job portal for the Gauteng and North-West provinces. A total of 988 IT positions are filtered to produce a resulting set of 413 positions in software development only. Each record is evaluated and highlights 278 unique technologies. The results from the study include the current prevalent technologies and IT skills sought after in this section of the South African IT market. These results can be used to better align exit-level IT modules with industry needs. Current trends indicate that the greatest need is in areas of database administration and querying in SQL and web development skills in HTML, Cascading Style Sheets (CSS), and JavaScript.

Keywords: Software development · IT skills gap · IT higher education · IT market needs · Web scraping and analysis · Tagging and clustering software.

1 Introduction

The skills gap between higher education and industry is an ongoing problem, experienced in all fields of study. Previous research on the topic originated from a need to understand what caused employers to be displeased with a graduate's ability to make an effective contribution to the workplace [1]. Moreover, graduates are critiqued by employers if they exit university with underdeveloped skills, and are not employable [2]. A number of studies highlight gaps in the technical skills and soft skills of engineering, computer science, and information technology (IT) graduates [3–11]. A limited amount of research, however, could be found that specifies which current technical skills South African IT graduates should be

proficient in. In a survey conducted by professional bodies, Johannesburg Centre for Software Engineering (JCSE) and the Institute of Information Technology Professionals South Africa (IITPSA) [12], the authors indicate that the ICT skills gap is growing in South Africa and that we may need as many as 50,000 ICT practitioners in the short- to medium term. The survey results indicate that employment opportunities in the IT sector of South Africa are not necessarily sparse, but rather that employers have difficulty in filling their positions with skilled candidates. If technical software development skills that are currently in demand in the South African IT market can be identified, capstone modules in South African higher education IT curricula can include projects that address these required technical skills. The primary objective of this research then is to determine which technical skills related to software development are most sought after in the South African job market.

2 Central concepts and related work

2.1 The growing IT skills gap

An IT skills gap is experienced globally. A survey conducted by the American non-profit professional body, Computing Technology Industry Association (CompTIA), highlighted the widening IT skills gap in 2017 [13]. They emphasised that the cyber security skills gap was especially problematic as the importance of data security was growing across all sectors of the industry. In the international market [13], top IT skills gaps were identified in the fields of emerging technology such as artificial intelligence (AI) and automation, cloud infrastructure, cyber security, software development, and the management of big data. Also in South Africa, a survey highlighted the state of ICT skills during 2019 [12], where the results indicated 'hard to fill vacancies' in the South African ICT industry, such as software developers, computer network and system engineers, system analysts, security specialists, business analysts, and database administrators. The survey results further indicated that the most used programming languages in South Africa were Java, C#, and Python. In other South African research findings, employers deemed the ability of IT graduates to formulate queries in SQL crucial due to its wide-spread use [14], and that C#, Python, JavaScript, and system integration with databases were technical skills that IT graduates struggled with when entering the workforce [15]. An annual survey by the South African Gradate Employers Association [16], highlighted the top IT graduate employers in South Africa as Microsoft, Accenture, International Business Machines (IBM) Corporation, Deloitte, Amazon, and Price Waterhouse Coopers (PWC). Typical career paths followed at these companies are in software development, cloud architecture, cyber security, machine learning, business analytics, database administration, and IT consulting. Some of the preferred technical skills indicated by these companies on their career portals include C#, C, C++, Python, Java, JavaScript, and SQL. For the purpose of our research, we consider essential software development skills that form part of the growing IT

skills gap to include programming languages, database technologies, and related technical skills such as using design patterns and source control software.

2.2 Aligning higher education with IT market needs

There is a consensus internationally that universities are not preparing students for current IT vocations. University degrees may soon no longer be the solution, as motivated students can learn the underpinnings of information technology through freely available resources and focus on certifications and industry training instead [17]. This idea is supported through suggestions made in the CompTIA report towards bridging the skills gap – to provide on-the-job-experience such as internships, training through apprenticeships, early exposure to IT careers, recognised certifications, and improved evaluation methods to assess the skill levels of candidates [13]. Worldwide, the higher education sector is aware of the skills gap, and studies in multiple fields have aimed to identify suitable courses of action. A number of studies recommend the development of effective learning strategies to address the skills gap, and suggest that higher education should do more to ensure industry alignment in their curricula [1, 2, 18]. That being said, discipline content need not be sacrificed for the development of specific skills when an appropriate instructional method is used [7]. Even though recent academic debate is focused on bridging the gap between the learning and application setting, universities should not surrender too much authority of curriculum development to industry expertise [19]. The authors maintain that if education is tailored too narrowly for specific jobs, the skills can become inflexible, making it difficult to apply in new settings. This suggests that the curriculum should include generic teaching and learning strategies that can be adapted so that these technical skills related to software development can be trained in a flexible manner. In order to identify suitable approaches toward bridging the IT theory-practice gap in the future, we first need to determine which technical skills related to software development are most prevalent in the current IT market of South Africa.

3 Research methodology

This study attempts to quantify the IT skills gap (related to software development) in the market, specifically for the provinces in which the North-West University campuses are based (Gauteng and North-West). The reasoning behind this is to determine what the needs are for the section of the market that is most accessible to future IT graduates that are interested in becoming software developers. In this research, the IT skills gap is described as the lack of knowledge of technologies that are sought after for software development positions in the market - that graduates were not introduced to or trained in during their coursework. It is not feasible to cover all sought after technologies in a three-year degree, and more specifically, only in exit-level modules. By determining which IT skills are currently in demand, lecturers can attempt to add more relevant

technologies into the coursework without sacrificing discipline content. This in turn results in students that are better prepared to improve their skills once they start their respective careers. The research approach for retrieving information from job listings was to:

- perform a web scrape of a job listing portal for IT positions,
- filter the positions obtained to focus on software development only,
- tag positions with the technologies that are requested,
- apply a variety of algorithms to gain additional insight into the data and generate descriptive graphs and reports,
- analyse the data.

The web scrape is performed by using a custom script, and the filtering, tagging, reporting, and clustering are all performed using a custom written application.

3.1 Web scraping

The data is collected by performing an advanced search on the South African job portal PNet. All job listings that are grouped as being part of the IT and Telecommunications industry in the selected areas are scraped for their full text and metadata with a custom Python script. Urllib is used to scrape the data and BeautifulSoup4 is used to parse the data that was scraped. From the parsed data, each job listing is converted into a docx document for traceability, and is also loaded into a Pandas DataFrame that represents the full scrape. Once the tagging and filtering application is compiled, a session DataFrame is created to that tracks which job listings have already been filtered and tagged, and with which technologies they have been tagged in that filtering session. At this point the coding session only contains the IDs that link the session DataFrame to the scraped data.

3.2 Data cleaning

The data is filtered to remove all job listings that are not directly related to software development in the chosen provinces (by removing rows with unrelated job listings from the DataFrame session). The following are examples of job listings that were filtered out:

- Positions that were not technical in nature, for example, sales positions,
- Positions that were technical but that were not software development related, for example, network technicians and CCTV installation technicians,
- Positions that were incorrectly labelled in terms of their location,
- Positions that were predominantly administrative/support positions,
- Positions for project managers and scrum masters,
- Positions for business analysts and compliance auditors,
- Positions with a focus on network security only,
- Academic positions for lecturers,
- Positions that were incorrectly categorised.

Filtering is achieved by selecting the 'remove listing' option to remove a specific entry from the DataFrame session (see top left corner of the interface in Figure 1). The record is still kept in the scraped master data, as well as in document format, for traceability and auditing purposes. This allows for the base data to be reused for evaluating other requirements, such as quantifying requested soft skills, by simply creating a new session from the scraped data.

3.3 Technology tagging

While job listings are being filtered, the positions that are not removed are tagged to indicate which technologies were requested by the employer. The same custom developed application is used for filtering and tagging the data (depicted in Figure 1).

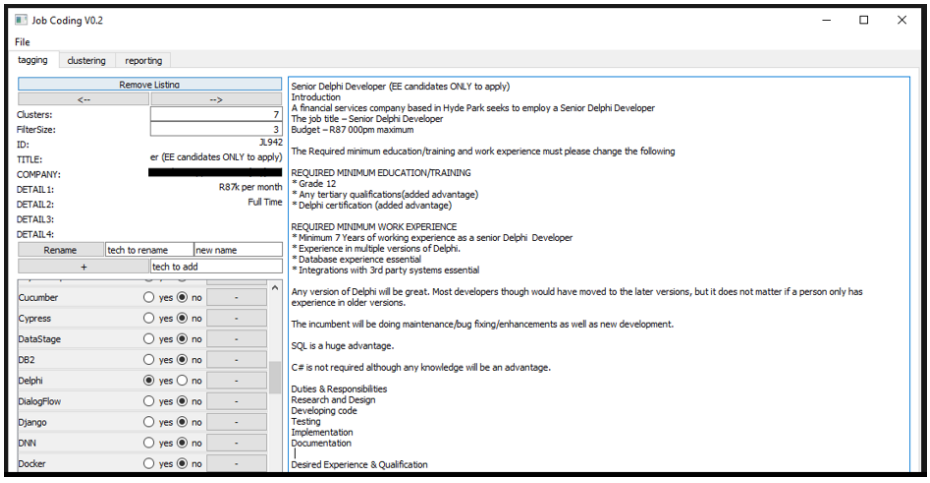

Fig. 1. Custom built tagging and filtering application

New technologies found per job listing are added to a taxonomy of technologies. This data is stored in the session DataFrame which has, as its column headings, the names of the technologies tagged, and in its rows, identifiers for the ID of the position. Figure 2 shows an excerpt of the session DataFrame. The ID of the row is the identifier that ties it to the scraped DataFrame and 'coded' tracks in the session DataFrame indicate whether the job listing has already been coded or not. The other columns in the DataFrame each relate to a technology that has been identified in the tagging process.

3.4 Data clustering

Once all of the positions have been tagged in the DataFrame, a combination of unsupervised learning algorithms are used to attempt to find combinations

	ID	Coded	SQL / MS SQL Server	TSQL	C#	...	ESSBASE	Flask	Falcon	Pyramid	Cordova
3	JL4	True	1.0	1.0	1.0	...	0.0	0.0	0.0	0.0	0.0
7	JL8	True	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0
8	JL9	True	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0
9	JL10	True	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0
11	JL12	True	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0
..	...	...	...	...	...	...	...	...	...	...	...
970	JL971	True	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0
979	JL980	True	0.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0
982	JL983	True	1.0	0.0	1.0	...	0.0	0.0	0.0	0.0	0.0
984	JL985	True	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	1.0
985	JL986	True	1.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0

Fig. 2. DataFrame session that includes the ID, coded and technology columns

of technologies that are typically grouped together. This information can be used to identify a set of skills a graduate requires to meet the needs of a specific position in the IT market. What is meant by this is that the information can, for example, be used by graduates who are entering the job market to understand which technologies are often grouped together for a specific type of development job. They can then make an informed choice to up-skill in technologies that would make them more employable in their chosen field. For example, when reviewing Figure 6, it can be seen that the top technologies that are often associated with a C# development position include MS SQL, HTML5/CSS/JS, ASP.Net, and Angular.js. The algorithms used in the clustering process are Binary Matrix Decomposition, Mean Squared Error comparison, and the K-Means clustering.

Binary Matrix Decomposition provides a method of clustering binary data [20]. The implementation of the algorithm used is from the bmdcluster library for Python [21]. Due to the nature of the data collected, the binary matrix in the DataFrame is sparse (for example, in the session documented in this paper the DataFrame was filled 3 percent with ones, as opposed to zeros). Using the binary matrix decomposition algorithm, the sparseness of the matrix meant that the algorithm was vulnerable to the initialisation problem that most clustering algorithms are sensitive to. Additionally, the assumption was made that the job listings would not only fit into a single cluster. For example, consider the following situation: Candidate A has skills in C#, HTML5 and SQL and Candidate B has skills in Java, HTML5 and SQL. If a job listing requires HTML5 and SQL skills, then both candidates would be suitable, even if they have different skill sets. For this reason, the Binary Matrix Decomposition algorithm ran through multiple iterations and all of the classes of skill combinations were stored and compared to each other using a Mean Squared Error comparison. The Mean Squared Error comparison was used to group similar classes that were identified across the respective iterations together. For each class that was identified by the algorithm, all of the job listings that formed part of that class were queried to see what percentage of them contained each of the identified technologies that were tagged as being relevant. This data is depicted in a histogram for each class, and indicates the relevance (percentage) a technology has to that class (Figure 3).

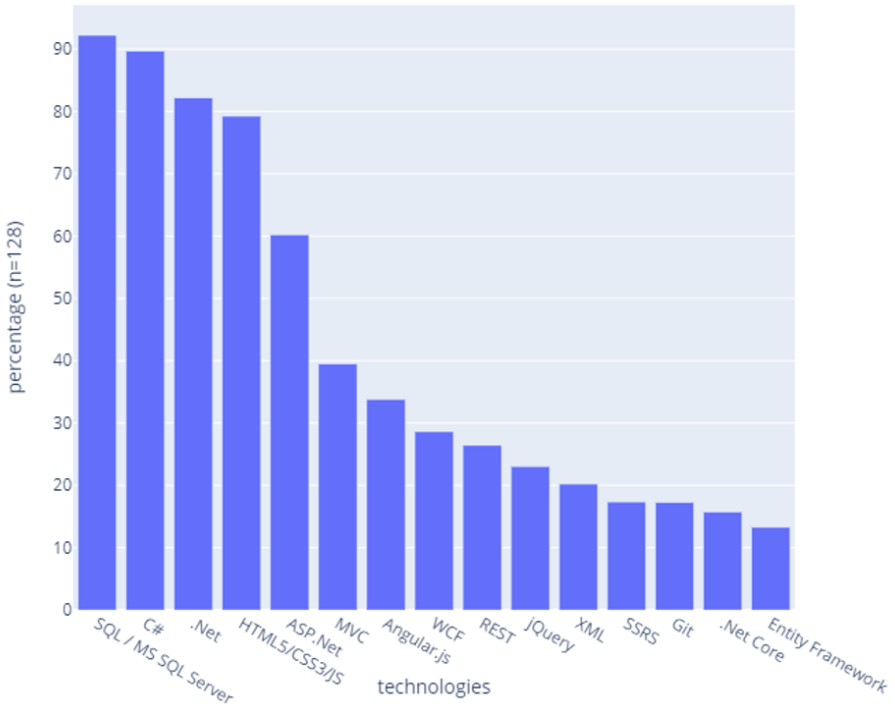

Fig. 3. Histogram indicating percentage relevance of technologies to an identified class

Due to the nature of the clustering algorithm, there were also classes identified from the data that did not have more than 50% representation for any of the technologies. These were grouped into a 'catch all' class where some listings were sorted into when they did not fit into other classes identified during the iteration. Classes where the two most prominent technologies did not reach at least 50% representation were discarded.

Mean Squared Error Comparison For this algorithm the classes that were output from the Binary Matrix Decomposition were compared by squaring the difference in percentage relevance of each technology and then taking the mean of this across all technologies. Classes with a difference score of less than 25 (5 percent difference) across all of the technologies were considered duplicates. To determine the final number of classes for each of the comparisons made, a count was kept of how many times each class had a difference score of <25. The class count was incremented by 1/n for each class once it had been compared to all other classes. For example, assume that 10 classes were found and three classes were considered duplicates. The classes that had no similarities to other classes would increment the class count by 1, where the three classes that were similar would each increase the class count by 1/3, resulting in a final class count of

8. The difference scores were stored into a new DataFrame with the rows and columns both referring to the classes.

K-Means Clustering Following the Mean Squared Error comparison, the DataFrame created ran through a k-Means Clustering algorithm (which is another unsupervised learning algorithm) which was used to group similar classes. The algorithm takes in a parameter that indicates the number of classes to be found which was obtained from the calculation made in the Mean Squared Error Comparison step. Once all of the classes had been classified, they were merged together by taking the mean of each of the technology percentage relevance as well as the class size to create a new class. Thereafter, the classes were finalised by creating histograms of the 15 most relevant technologies for each class and creating a report that shows all of the parameters used in each of the algorithms with all of the output class histograms.

3.5 Data analysis

In the analysis step, a number of reports are compiled so that meaningful information can be obtained from the data that has been filtered, tagged, and clustered. The custom-built application gives access to the following data for analysis purposes:

- Simple counts of the number of times each technology has been tagged in a job listing,
- The class histograms generated in the clustering step which indicates which skill sets are relevant to a portion of the job listings,
- Technology comparison reports that show the relative size of a number of selected technologies in the dataset,
- Technology association graphs that depict to which degree different technologies are coupled.

4 Results

For this set of results a single web scrape was performed on the 8th of October 2019. For the advanced filtering on the website, Table 1 provides an overview of categories selected. In total 988 job listings were scraped. From this step, using the filtering technique outlined in the methodology section, the positions were filtered down to 413 positions that were related directly to software development in two provinces. 276 different technologies were identified as being relevant to the market. Although all of the technologies appeared in at least one job listing, there were many that appeared in only one listing. After analysis, the technologies were grouped together manually into logical categories to simplify reporting. In this step, 20 categories were identified (Table 2) which were grouped together so that the number of times they were requested in the job listings could be compared. For example, programming languages were compared to determine their

relative popularity. The software allows for comparison in popularity between any technologies, however, so reporting can be done in any manner that is most sensible to the user. For the purposes of this paper, comparisons were done based on the nature of the technology.

Table 1. IT & Telecommunications categories selected for the dataset

Testing	IT-Project Management
Application Analysis	IT-Quality Assurance & Inspection
Applications Administration	IT-Training
Application Operations & Maintenance	Product Manager/ Functional or Business Analyst
Application Development & Programming	Network Operations & Maintenance
Data Processing	Organisations Programming
Data Warehousing	Network Administration & Security
Embedded systems/ firmware development	SAP Consultancy & Implementation
DTP / Graphic	SAP development
e-business & e-commerce	Software-Engineering
Database Administration	System engineering / consultancy
Hardware Design & Engineering	System Administration / Management
Helpdesk & Technical Support	Technical Editorial
Informatics	Telecommunication & Mobile Systems
IT-Architecture	Web design & Webmaster
IT-Consulting	IT-Management
Others: IT & Telecommunication	

Technologies that were either too niche to fit into one of the other categories, or were only an extension of a technology better captured elsewhere, were sorted into the 'other' category. For the sake of brevity only two of the technology comparisons are discussed.

Table 2. Twenty technology categories identified

Programming languages (32)	Web/Application servers (12)
Databases (17)	Enterprise software (17)
JavaScript frameworks (15)	Bug tracking (4)
Reporting technologies (6)	CI/ CL/ Package mngment/ Build automation (23)
Data analytics (11)	Mobile development (9)
Cloud (4)	DB integration, migration and management (15)
Web styling (3)	Protocol/Communication/Orchestration (29)
Software testing (18)	Desktop/ GUI development (8)
Web/API frameworks (24)	Version control and team productivity (7)
Graphical programming (5)	Other technologies (18)

4.1 Programming languages

There were 32 languages identified in the job listings. The comparison of how well they were represented in the dataset is shown in Figure 4.

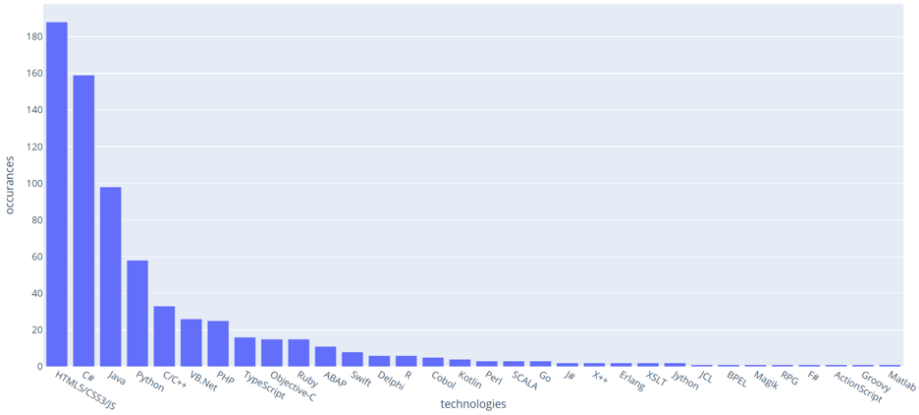

Fig. 4. Programming languages

The main languages requested were JavaScript, C#, Java, and Python. HTML5/ CSS was not tagged as a separate language because it was always requested along with JavaScript.

4.2 Database technologies

There were 19 different database technologies identified, but during analysis it was determined that two of the databases technologies were tagged differently depending on what the context of the job listings were. For example, SAP HANA and MariaDB were two technologies, but there was also one tag for 'HANA' and one tag for 'Maria'. As this was only one data point each, it made very little difference to the overall comparison done that can be seen in Figure 5.

A problem encountered during the tagging of the database technologies was that the terms SQL and SQL server were used interchangeably. From the context it was used in, it was clear that the listings were mostly referring to MS SQL Server, but it could also be that job listings were requesting SQL as a generic term for being able to use an SQL based querying language. As such it is clear that MS SQL server is the most sought after skill, but it is likely that the numbers are artificially inflated as some positions may only have wanted a generic understanding of SQL regardless of which database the candidate is familiar with. The vast majority of job listings required relational database skills.

4.3 Technology association reports

An additional report that was created was on the association between technologies. For this report a technology is chosen, and the top X related technologies are shown in an association graph. Figure 6 and Figure 7 depict the association graphs for C# and Java respectively, with their top 14 associated technologies.

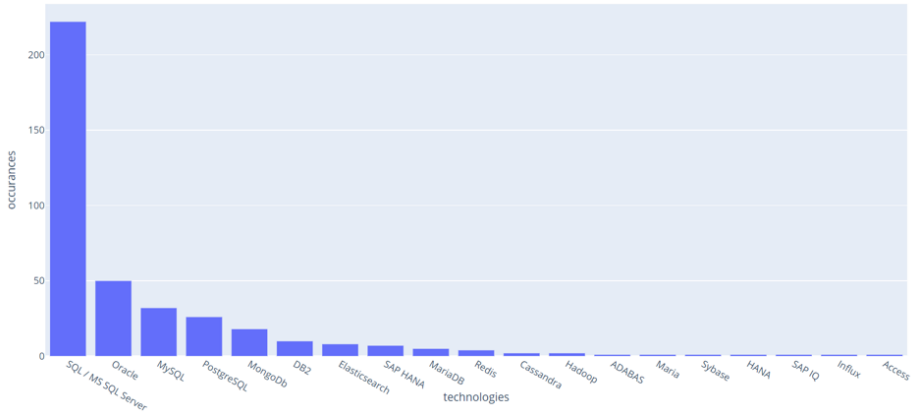

Fig. 5. Database technologies

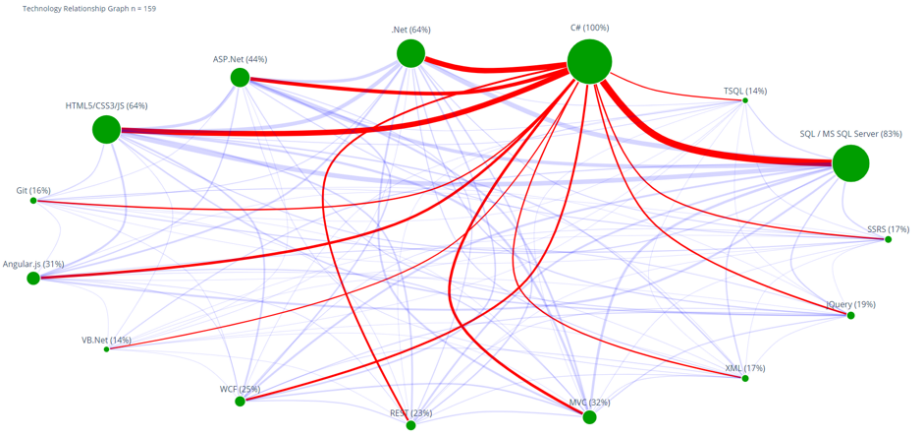

Fig. 6. C# association graph with top 14 technologies

4.4 Developer class reports

For the clustering reports the following parameters were set:

- Minimum rows per technology = 1
- Number of clusters for BMD = 7
- Minimum class size = 1
- Number of technologies to plot per class = 15
- Number of BMD iterations = 250

After 250 Binary Matrix Decomposition iterations had run and the Mean Squared Error and K-Means Clustering were completed, the final result was 69 distinct classes. Examples of classes generated are shown in Figures 8, 9 and 10.

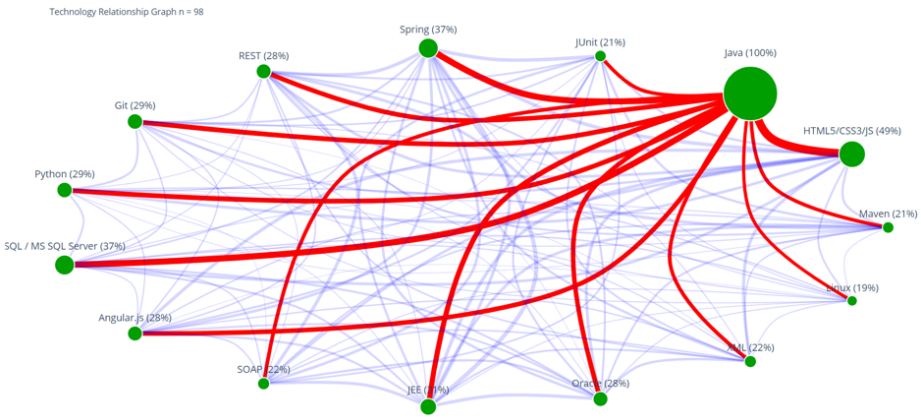

Fig. 7. Java association graph with top 14 technologies

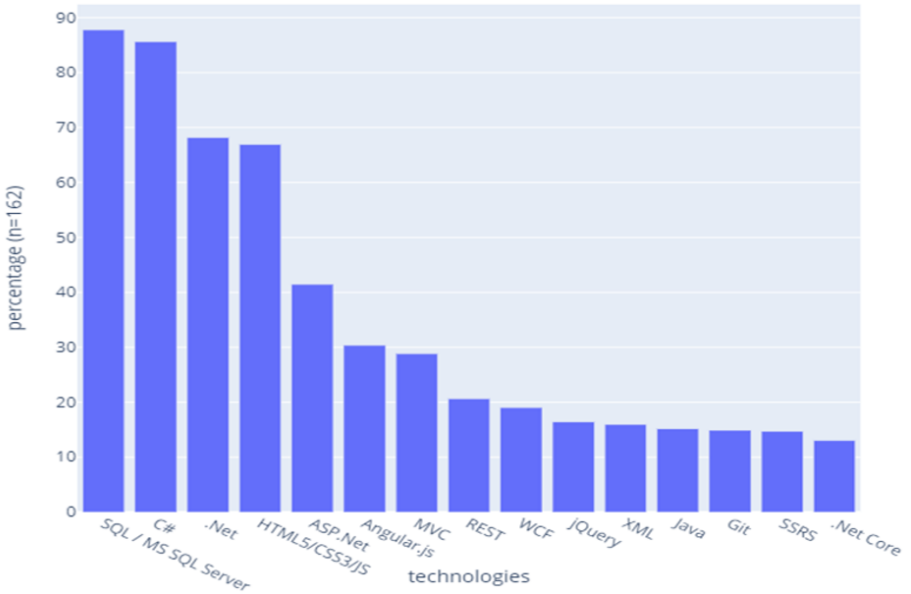

Fig. 8. A stereotypical C# developer class

Although many classes were grouped together in the clustering step, there were still some classes, which after review, looked fairly similar, as can be seen in Figure 8 and Figure 9. The differences between the classes were large enough to be distinct, but when reporting on all of the classes it makes more sense to group them by their top 5 technologies as an example.

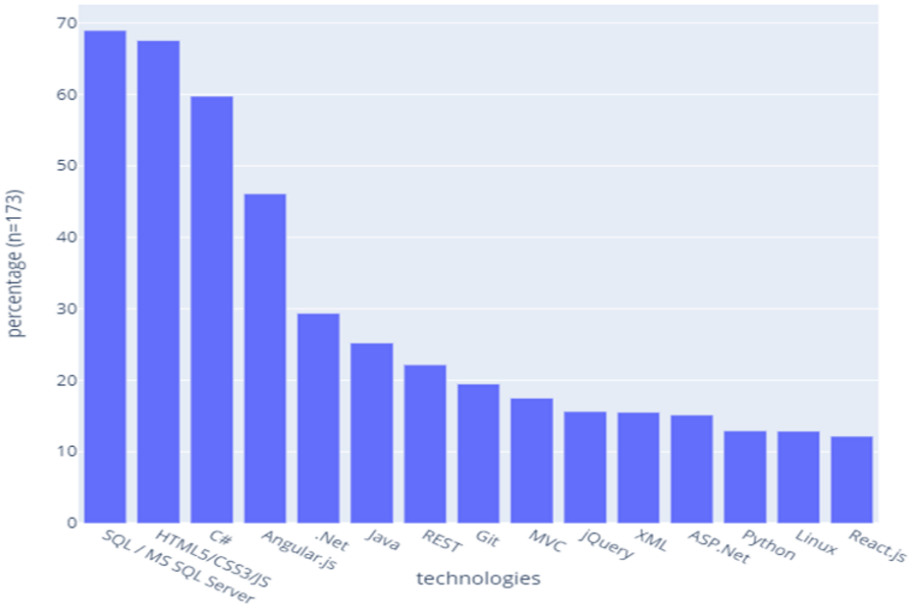

Fig. 9. Another stereotypical C# developer class

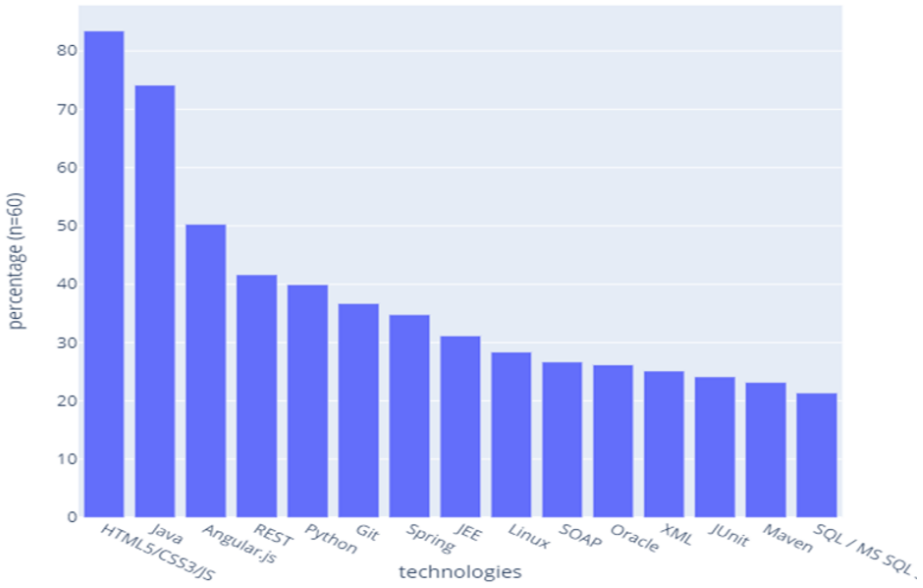

Fig. 10. A stereotypical Java developer class

4.5 Discussion

South African researchers have highlighted essential technical IT skills related to software development such as programming in Java, C#, and Python, formulating SQL queries, and software integration. In this study, the top software development skills that are most in demand currently in the Gauteng and North-West provinces of South Africa, (among others) are SQL/ MS SQL Server, HTML5/ CSS/ JavaScript, C#, Java, Angular.js, .Net, ASP.Net, MVC (design pattern), and Git (source control). It can be suggested that the skills that are currently most needed in the IT industry in these regions are database administration or integration in relational database systems and software development in web specific projects. This is supported by the fact that HTML5/CSS/JavaScript skills are the most sought after programming language skills. When referring to software development skills in Java, the association graph depicted in Figure 7 illustrates that a Java developer would typically need to be knowledgeable in HTML, CSS, or JavaScript as well. A C# developer would typically be expected to be knowledgeable in SQL or SQL Server based on requested skills (Figure 6). According to the related work and the research results, database skills in SQL and programming skills in C# and Java technologies are still high in demand for software developers. More emphasis is placed on advanced skills in using design patters such as MVC, and software development in Angular.js which is a front-end framework maintained by Google. Moving forward, the research results can be used to align IT higher education curricula with industry needs by addressing the skills required of software developers in the IT market. When developing these identified skills it is not implied that discipline content need to be sacrificed. This research is built on the expectation that flexible curricula can more easily change specific programming language requirements to adapt to the changing needs of the IT industry. The top sought after IT skills identified are not a surprise, as most South African universities do include coursework on these topics as part of their respective IT or computer science degrees. What is surprising, however, is that even though most South African universities include coursework on these specific skills, these job listings are still classified as hard to fill vacancies. It may be suggested that the future of IT higher education may lie in a combination of tertiary education and professional certifications for software developers to encourage best practice.

5 Conclusion

The primary objective of this research was to determine which technical skills related to software development are most sought after in the South African job market. This was achieved through a review of related work and a quantitative study of web scraping and analysis with custom developed tagging and clustering software used to obtain IT position information from a South African job portal. The data used was limited to positions in software development in the provinces of Gauteng and the North-West. Literature indicated that technical skills in software development languages and relational databases were typically

in demand in the South African IT market. According to the research results, specific software development skills in C#, SQL, Java, JavaScript, web design patterns and frameworks, and source control were found to be in demand in the current South African IT market. The novelty in this paper lies in the identified software development skills that can be emphasised for inclusion in South African higher education IT curricula. By identifying these skills which are most in demand in the IT market, two problems can be addressed. The first of which is that IT employers have hard to fill vacancies due to skills shortages in software development. The second being that IT graduates do not necessarily receive training in software development skills that are currently relevant and essential for today's IT job market. The identified skills in this paper can be included in exit-level modules or capstone projects to ensure that future IT graduates have completed projects using skills that are in demand. This approach would ensure a greater alignment between university education and industry expectations. Another novelty of this paper is the research approach taken. Web scraping available data on the internet is not a new approach, but research on useful algorithms used to extract valuable information from the data is limited. The paper presents a method of analysing the data, by illustrating how the data can be filtered, tagged, and clustered using three algorithms namely Binary Matrix Decomposition, Mean Squared Error comparison, and K-Means clustering. Using this technique, access to information such as number of occurrences, associations between data, and comparisons can be compiled from the data that was web scraped. The results in this paper are based on a first iteration of this approach. This research approach can be used in any field of study to perform web scraping and analysis of current market needs, which in turn, can inform related higher education instructional approaches.

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A Proposed Structure for Managing IT Diplomas' Programme Content in South Africa

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Abstract

Historically, Technikons offered IT diploma qualifications in South Africa. The Technikon academics formed an academic body called the Technikon Computer Lecturers Association (TECLA) to manage the various IT diploma programmes in South Africa. The members of TECLA, who were Technikon academics, met annually to discuss the IT diploma programmes and curriculum content. TECLA ceased to exist when the South African Government introduced new university structures in 2005 and amalgamated all Technikons and specific universities. These new Comprehensive Universities and Universities of Technology offer various IT diploma and higher IT diploma programmes. There is, however, no academic body which presently coordinates the curriculum content for the different types of IT diploma qualifications offered by the various institutions to ensure standardised curriculum content and quality assurance standards. In this paper, a South African IT Diploma Advisory Board (SAITDAB) is proposed that will be associated with the South African Computing Accreditation Board (SACAB). The purpose of this research study was to obtain the opinion of academics at institutions offering IT diploma programmes on the proposed establishment of the SAITDAB, who would draft a rationale and process for the creation of an initial Body of Knowledge for IT diploma and advanced IT diploma programmes offered by South African Universities.

Keywords: IT diploma programmes, SAITDAB, TECLA, SACAB.

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1 Introduction

National IT diploma programmes are considered equivalent to a foundation degree or the first two years of a bachelor's degree [9]. A diploma equips students with focused knowledge and skills in a particular field, such as IT. The aim of the IT diploma programmes is to enable qualifying students to analyse, design, develop and maintain, for example, web systems, database systems, programming products and communication networks for a business. Diploma programmes in South Africa are at NQF level 6, advanced diplomas at NQF level 7 and post-graduate diplomas at NQF level 8.

The current South African Higher Education (HE) landscape was implemented in 2005 and caters for three types of universities, namely Research Universities, Comprehensive Universities and Universities of Technology. Comprehensive Universities were established by the amalgamation of selected research universities with Technikons. Before 2005, Technikons were responsible for offering IT diploma programmes.

Prior to the restructuring of the South African HE landscape, the IT academics from the various Technikons in South Africa formed an academic body called the Technikon Computer Lecturers Association (TECLA). The members of TECLA met annually at a conference to discuss IT diploma curriculum programmes, industry liaison and related topics [19]. TECLA ceased to exist in 2005 when the South African Government introduced the current HE landscape. A new body, HEICTA (Higher Education Information and Communication Technology Association), was established in 2006 and was also involved with industry liaison and curriculum topics. For a number of years, it provided collaboration among IT departments offering the IT diplomas and liaised with industry. HEICTA gradually ceased to exist. The last HEICTA activity found on social media was in 2013.

Internationally, non-governmental organisations such as the Accreditation Board for Engineering and Technology, Inc. (ABET), accredit post-secondary education programmes in applied and natural sciences, computing, engineering and engineering technology. In several countries, national IT professional bodies, such as the British Computer Society [4], Australian Computer Society [3] and more recently the IT Professionals New Zealand [14] accredit university Information Technology (IT) related degree programmes.

The Seoul Accord [18] is an international accreditation agreement for professional computing and information technology academic degree programmes. The British Computer Society [4], Australian Computer Society [3] and the IT Professionals New Zealand [14], for example, are signatories to the Accord and are responsible for the accreditation of IT related degree programmes in their specific countries. The South African Computing Accreditation Board [16] was established in 2014 and will be responsible for the accreditation of IT related degree programmes offered at universities in South Africa. The SACAB intends to become a signatory of the Seoul Accord.

Currently there is no academic body or organisation that is responsible for the accreditation of IT diploma and higher IT diploma programmes in South Africa. The South African Computing Accreditation Board (SACAB) [16] proposed the formation

of a South African IT Diploma Advisory Board (SAITDAB) at the Southern African Computer Lecturer's Association (SACLA) conference in 2018 [17]. The aim of this paper is to report on a national survey that was conducted among Heads of Departments at Comprehensive Universities and Universities of Technology offering IT diploma and advanced diploma programmes concerning the proposed implementation of a SAITDAB.

The paper is structured as follows: In Section 2, the research problem and the research design are presented. The literature review in Section 3 reports on the various IT diploma programmes offered at South African universities and proposes the establishment of a SAITDAB. Section 4 reports on the different IT diploma programmes offered by universities in South Africa and Section 5 presents and discusses the results of the national survey. In Section 6, a discussion of the proposed structure and process for the creation of an IT diploma programme Body of Knowledge (BOK) is presented. Section 7 presents the conclusions of the paper.

2 The Research Problem and Research Design

Comprehensive Universities and Universities of Technology in South Africa offer various IT diploma and advanced IT diploma programmes. The universities offering the various IT diploma programmes formerly collaborated through bodies such as TECLA and HEICTA. The problem statement investigated in this study is that South African universities offering IT Diploma programmes do not presently collaborate formally on IT diploma programme development, standards and quality assurance.

The research objectives of this study are to:

- Propose the establishment of a South African IT Diploma Advisory Board (SAITDAB);
- Identify and record the IT diploma and advanced IT diploma programmes offered at Comprehensive Universities and Universities of Technology in South Africa;
- Conduct a survey amongst these universities to determine the support for the establishment of SAITDAB; and
- Propose a rationale and process for drafting guidelines for an IT diploma programme and advanced diploma programme BOK for South African universities.

The research design used comprises a literature review, an investigation into diploma offerings by tertiary institutions and a survey of HODs and academics at Comprehensive Universities and Universities of Technology (Appendix A). The research approach followed in the survey was the compilation of a questionnaire (Appendix A), that was distributed to the HODs of departments offering IT diploma programmes at 14 Comprehensive Universities and Universities of Technology. A total of 29 HOD's were identified using the SACLA HOD mailing list at the 14 universities. Seven universities completed and returned the survey request over a three-week period, following three requests for participation. The qualitative survey data were thematically analysed using AtlasTi.

3 Literature Review

3.1 Academic Programme Accreditation

The Seoul Accord [18] is an international accreditation agreement for professional computing and information technology academic degree programmes. It is a multilateral agreement among agencies responsible for accreditation or recognition of tertiary-level computing and IT-related qualifications, in their respective countries. Signatories include Australia, Japan, the United Kingdom, the United States and more recently Ireland, New Zealand and Mexico.

Internationally, organisations such as the IEEE [10] and the ACM [1] have provided curricula requirements or content for degree programmes in Computer Science [6], Information Systems [12], Information Technology [13] and other IT related fields. All curricula recommendations by the ACM [1] provide guidelines for undergraduate degree programmes in the fields listed above.

In related disciplines such as Engineering, the Engineering Council of South Africa is empowered by the Engineering Profession Act, 2000 (Act 46 of 2000), to conduct accreditation visits to educational institutions that offer Engineering programmes to determine whether the Engineering qualifications offered can be recognised by the Council for purposes of professional registration. The educational programmes considered for accreditation are degree and diploma programmes [7].

In South Africa, the accreditation of IT related degree and diploma programmes (the first accreditation initiative covering both types of programmes in the world) is managed by the SACAB [16]. The SACAB was commissioned by the Institute of IT Professionals South Africa (IITPSA) [11] and SACLA [17], which is affiliated to the International Federation for Information Processing (IFIP) and is a SAQA recognised professional body. The IITPSA is a member of the International Professional Practice Partnership (IP3) and associated with the Seoul Accord.

A generic national IT diploma programme is no longer followed by Higher Education Institutions (HEIs) in South Africa, as was done in the Technikon days (prior to 2005). Most Comprehensive Universities or Universities of Technology have tried to create more distinct and divergent IT diploma programmes to allow students access to the various fields in IT and to distinguish their programmes from those offered by other universities, although most do still have a focus on Software Development and Communication Networks.

3.2 Historic Role of SACLA, TECLA and HEICTA

The Southern African Computer Lecturers' Association (SACLA) [17] was established and held its first conference in 1971. SACLA is a formal association of people involved in the teaching of Computer Science, Information Systems, Informatics, Information Technology and related programmes at universities throughout Southern

Africa. The main activity of SACLA is an annual conference, where issues concerning teaching and research in IT education in Southern Africa are discussed.

At the SACLA conference AGM in 1984, held in Hluhluwe, Natal, South Africa, a heated debate took place between academics from universities offering IT related degree programmes and Technikons offering IT diploma programmes. This argument resulted in the academic members from the Technikons in South Africa disassociating themselves from SACLA and establishing a separate body with similar aims to SACLA, called the Technikon Computer Lecturers Association (TECLA) in 1989. Professor Rossouw von Solms initiated the formation of TECLA and was the first President of TECLA [19].

The members of TECLA met annually at a conference to discuss IT diploma curriculum programmes and related topics. The focus of TECLA was:

- An improved understanding of industry requirements for skills and qualifications of IT students;
- IT Diploma specialisation programmes;
- Defining IT diploma programme core competencies;
- Defining specialisation fields core competencies;
- Defining IT diploma programme deviation percentages content per IT diploma specialisation field;
- Only one institution was responsible for the SAQA registration of qualifications; and
- All institutions offered one or more of the registered specialisation fields.

The specialisation fields identified and offered by Technikons were:

- Software development;
- Business applications;
- Communication Networks;
- Web Development;
- Diploma in Multimedia;
- Intelligent Industrial Systems (including game programming);
- Support Services (Help Desk and Infrastructure Management); and
- Technical Applications.

TECLA ceased to exist in 2005 when the South African Government introduced the current HE landscape. A new body was formed in 2006 to replace TECLA, namely HEICTA (Higher Education Information and Communication Technology Association), which was also involved with industry liaison and curriculation [2]. Prof Bennett Alexander of CPUT was the president of HEICTA. Documentation on the functioning of HEICTA was found by the authors dating back to 2013. After this, HEICTA members have not met annually and currently all academics from all universities involved in IT education in Southern Africa, are members of SACLA. All institutions offering IT diplomas are now responsible for registering their own qualifications with SAQA.

3.3 The SAITDAB Proposal

SACAB [16] proposes the establishment of SAITDAB, as indicated in Fig. 1. The body will consist of members from universities in South Africa offering IT diploma programmes. SAITDAB will be responsible for the recommendation of IT diploma and advanced diploma standards, core competencies and curriculum content. SAITDAB will further assist SACAB in the accreditation of IT diploma and advanced diploma programmes at South African universities.

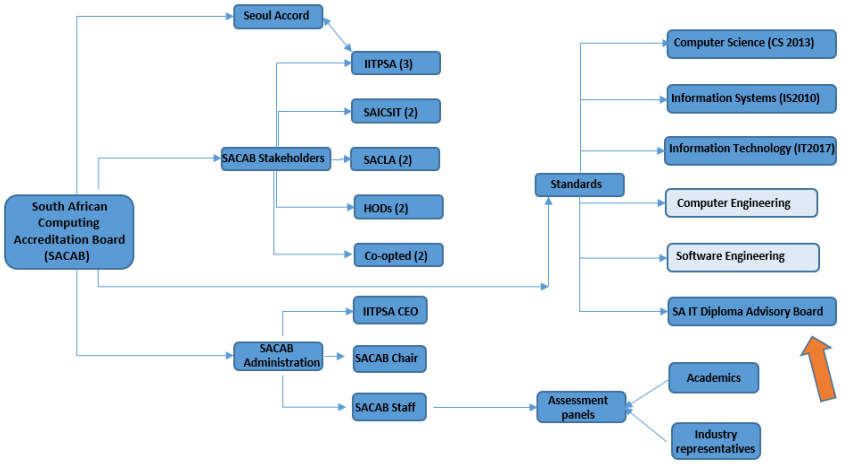

Fig. 1: Proposed SAITDAB Structure

3.4 Literature on IT Diploma Programmes

Internationally, an academic degree is a qualification awarded to students upon successful completion of a course of study in HE, usually at a college or university. HEIs commonly offer degrees at various levels, including bachelors, masters and doctorates, often alongside other academic certificates and professional degrees [4]. The most common undergraduate degree is the bachelor's degree, although in some countries there are lower level higher education qualifications that are also titled degrees (e.g. associate degrees and foundation degrees). These are similar to Higher Certificate (NQF level 5) and diploma programmes at academic level (NQF level 6) in South Africa [9].

Universities in South Africa offer IT diploma programmes specialising in various fields, such as Information Technology, Software Development, Communication Networks and Support Services (Tables 3 and 4). Nine HEIs offer advanced IT diplomas in South Africa, specialising mainly in Information Technology and Communication Networks.

According to the Nelson Mandela University [15], the academic emphasis on learning in a diploma qualification, is on a practical approach based on theoretical foundations. These qualifications are career focused. Diploma studies are offered on a

full-time and/or part-time basis but are generally offered over a three-year period. Industry training varies from programme to programme and can be anything from six months to a year. With a degree qualification, the emphasis is placed on an academic approach to a specified field of study or profession, such as law, pharmacy and architecture. Degree programmes are offered on a full-time or part-time basis over three to four years, depending on the type of degree programme. Certain programmes require industry training of about six to eight weeks.

4 South African Universities Offering IT Diploma Programmes

A desk-top study was done, using the websites of the universities listed in Tables 1 and 2, to determine the IT diplomas and advanced diplomas offered by each institution. Table 1 indicates the IT diplomas offered by Comprehensive Universities and Table 2 those offered by Universities of Technology. One Comprehensive University's departmental website only listed the names of staff members, with no details of qualifications offered.

Table 1: Comprehensive Universities in South Africa

Institution	School/Department	IT Diploma programmes offered
Nelson Mandela University	School of IT	• Diploma - IT: Communications Networks • Diploma - IT: Software Development • Diploma - IT: Support Services • Advanced Diploma – IT
University of Johannesburg	School of Consumer Intelligence and Information Systems	• Diploma - Business IT • Advanced Diploma - Business IT
University of South Africa	School of Computing	• Diploma - IT • Advanced Diploma - Information Resource Management
University of Venda		No information on website about IT Diplomas offered
University of Zululand		No information on website about IT Diplomas offered
Walter Sisulu University	Science, Engineering and Technology	• National Diploma in IT - Software Development • National Diploma in IT - Support Services • National Diploma in IT - Communication Networks

Table 2: Universities of Technology in South Africa

Institution	School/Department	IT Programmes offered
Cape Peninsula University of Technology	Informatics and Design	• Diploma: ICT - Multimedia Applications • Diploma: ICT - Communications Networks • Diploma: ICT - Applications Development • Advanced Diploma in ICT - Multimedia Applications • Advanced Diploma in ICT - Communication Networks • Advanced Diploma in ICT - Application Development
Central University of Technology	Department of Information Technology	• Diploma - Computer Network • Diploma - IT • Advanced Diploma - Computer Networks • Advanced Diploma – IT
Durban University of Technology	Department of Accounting and Informatics	• Diploma in ICT - Applications Development • Diploma in ICT - Business Analysis
Mangosuthu University of Technology	Department of Information and Communication Information	• Diploma in IT
University of Mpumalanga	School of Computing and Mathematical Sciences	• Diploma in ICT - Applications Development • Advanced Diploma in ICT - Applications Development
Sol Plaatje University	School of Natural and Applied Sciences	• Diploma in ICT - Applications Development • Advanced Diploma in ICT - Applications Development
Tshwane University of Technology	Department of Information Technology and Informatics	• Diploma in IT • National Diploma in IT: Communication Networks • National Diploma in IT: Support Services • Diploma in Informatics • National Diploma in IT: Business Applications • Advanced Diploma in Informatics

		• Advanced Diploma in IT
Vaal University of Technology	Department of Information and Communication Technology	• Diploma in IT • Advanced Diploma in IT
	Department: Process Control and Computer Systems	• Diploma in Computer Systems

A summary of the IT diplomas offered by universities in South Africa (Table 3) indicates that the most popular IT diploma specialisation programmes that universities offer are Software Development (n=6), Information Technology (n=6), Communication networks (n=5) and Support Services (n=3). The most popular IT advanced diplomas offered by HEIs in S.A. are an Advanced Diploma in Information Technology (n=4) and an Advanced Diploma in ICT: Communication Networks (n=2). A total of 26 IT diplomas and nine advanced IT diplomas are offered by 12 universities, indicated in Tables 1 and 2.

Table 3: Summary of the number of IT diplomas offered by universities in South Africa

IT Diploma offered	**Count**
Software / Application Development	6
Information Technology	6
Communication Networks	5
Support Services (Help Desk and Infrastructure Management)	3
Business Applications / Business IT	2
Multimedia Applications	1
Business Analysis	1
Informatics	1
Computer Systems, including Networking	1
Web Development	0
Technical Applications	0
Intelligent Industrial Systems (including Game Programming)	0

Table 4: Summary of the number of advanced IT diplomas offered by universities in South Africa

Advanced IT Diploma	**Count**
Advanced Diploma Information Technology	4
Advanced Diploma: ICT: Communication Networks	2
Advanced Diploma: ICT: Multimedia Applications	1
Advanced Diploma: Business IT	1
Advanced Diploma: Informatics	1
Advanced Diploma: Application Development	0

5 Results of the National Survey

The following section provides a summary of the responses received from seven of the twelve universities in South Africa offering IT diploma programmes. The survey (Appendix A) was sent to the 29 HODs offering IT diploma programmes at the 14 universities listed in Table 1 and 2. Seven universities, three Comprehensive Universities and four Universities of Technology, responded to the call for participation in the survey. The following paragraphs address each question in the survey.

The respondents (Q1) indicated that they no longer offer National Diplomas and B-Tech programmes, but now offer Diplomas and Advanced Diplomas. The diploma programmes offered by some institutions, as indicated on the institution's website (Tables 1 and 2), did not always correspond to the responses received from academics who completed the survey. Academics at one University of Technology, for example, indicated that they offer a Diploma in Information Technology, focusing on Business Analysis and Software Development. However, the website of the university did not indicate this differentiation. One respondent indicated that they will only offer a National Diploma in IT – Business Applications and a Diploma in Informatics in 2020, including only one Advanced Diploma in Informatics. The website however indicated that the university offered additional diploma programmes.

The respondents (Q2) indicated that they decided on diploma programme offerings based on the "old" national diploma, resources available, input from industry and in some cases, on recommendations provided by an Industry Advisory Board. Four institutions indicated that they have a programme review committee, managed by the institution. One respondent indicated that their decisions were "based on the Higher Education Qualification Sub Framework (HEQSF) aligned framework" and the requirements of industry. One institution indicated that they initially (prior to 2005) used the National Diploma in IT as a baseline, however during the past decade, institutions decided individually on diploma programme offerings. The former Department of Higher Education (DHE) detailed National Diploma programmes which Technikons could present, if they chose to do so. They could deviate up to 50% from these programmes. The DHE has been replaced by the Department of Higher Education and Training (DHET). The DHE regulated National Diploma programmes via convenor bodies (as for the old Technikon system) but the DHET use the current HEQSF to assess diploma programmes.

The respondents (Q3) indicated that their IT diploma programmes are still based on the structure of the old national diplomas. The respondents further indicated that they have workshops with academics, stakeholders and curriculum specialists to advise on programme content. When new programmes are introduced, benchmarking on international curricula is used to provide guidelines. The use of the programme review committee at an institution further assists with decisions on programme offerings. Institutions indicated that a programme review committee, managed by the institution assists with programme structure and content. The Industry Advisory Board at universities further played a leading role in guiding decisions regarding programme content.

The respondents (Q4) all indicated that other institutions' websites and in some cases, academics, were consulted on deciding on the structure and content of diploma

programmes. One institution indicated they also investigated overseas university offerings. Another institution indicated that their diploma programmes are still based on discussions held at the TECLA and HEITCA conferences. International companies, such as CISCO, further provide "major input into the diploma programmes".

The majority (75%) of the respondents (Q5) indicated that they were not intending to introduce new IT diploma programmes in the next two years. One University of Technology is introducing a Post-Graduate Diploma (Information Technology) and another a Post-Graduate Diploma in Informatics in 2021. One Comprehensive University is introducing a Post-graduate Diploma in Cybersecurity. The major recurriculation of diploma programmes are presently been undertaken at some institutions.

One respondent (Q6) indicated that they have recurriculation exercises with industry advisors, academics and education specialists within the university, every few years. They make use of external examiners and moderators. Advisory Boards and alumni were mentioned as methods used to ensure that IT diploma programmes remain current. Four institutions indicated that they are currently planning to review their programmes. This exercise is undertaken every three years.

The Quality Promotion Unit (QPU) is used at some universities to ensure the quality (Q7) of the different programmes annually. The QPU conducts annual audits of the departments and qualifications offered. Consultation with the Industry Advisory Board, the use of external examiners and moderators for most subjects further assists with quality assurance. Employing academics with the relevant qualifications further assisted with quality assurance. The important role of the Industry Advisory Board was emphasised by most departments.

Generally (Q8), the respondents did not collaborate with other institutions to ensure the quality of the diploma programmes that they offered. The use of external examiners and moderators assisted in quality assurance of specific subjects. Most respondents indicated that they had attended the TECLA conferences and that it was an excellent organisation (Q9). The respondents indicated that if the proposed SAITDAB could fulfill a similar role, it would be an excellent initiative. The respondent from one Comprehensive university was unaware of the existence of TECLA.

All respondents (Q10) indicated that they would support the proposed SAITDAB. They further indicated that the recognition of qualifications offered by other institutions would be made easier and students would be able to transfer between institutions more easily. Students would also be able to complete outstanding modules through institutions offering distance education, such as UNISA. The respondents indicated that the proposed SAITDAB would assist in accreditation and review processes and guidelines for standardisation should further be provided. The responses included the following remark: "This would provide set standards and help with articulation".

All respondents (Q11), except one, indicated that they would support a national IT diploma and advanced diploma programme BOK as proposed by the SACAB. A national IT diploma and advanced diploma programme BOK will ensure a set of standards all institutions could adhere to, without losing the diversity of specific diploma programmes offered by institutions. The general consensus was the acceptance of a core IT diploma and advanced diploma programme BOK, with the "ability to be unique and different".

The benefits (Q12) of an IT diploma and advanced diploma programme BOK would ensure that institutions offer a recognised and accepted core programme, endorsed by all institutions and the SACAB. This will further assist with the employability of students and relevant standardised qualification offerings. The respondents generally wanted the ability to supplement the core IT diploma BOK with local industry requirements.

All institutions that responded (Q13) provided a list of names of academics that could serve on the proposed SAITDAB. The general comments (Q14) provided by all respondents included comments thanking the authors for the initiative. One respondent indicated that this is a "long overdue initiative". The respondents expressed a desire that their IT diploma programme offering "be different, offer local specialised content and be able to differentiate their IT diploma offerings from other institutions, based on local industry requirements".

6 Proposed Rationale and Process for Drafting an IT Diplomas' and Advanced Diplomas' Programme BOK

In South Africa, all qualifications offered by Higher Education Institutions must be approved by the Department of Education (DOE), the South African Qualifications Authority (SAQA) and the Higher Education Quality Committee (HEQC) before the institution can offer them. All programmes must be Higher Education Qualifications Framework (HEQF) compliant. The purpose of the Higher Education Qualification Sub Framework (HEQSF) [9] is to define the relationships between qualification types.

Internationally, organisations, for example the ACM [1], have made efforts to specify requirements or content for degree programmes in Computer Science [6], Information Systems [12] and Information Technology [13]. There are a number of additional Information Technology Body of Knowledge guides. These include the Canadian Association of IT Professionals' Guide to the Common Body of Knowledge for Computing and IT (CBOK) and the European Foundational ICT Body of Knowledge [5, 8].

All curricula recommendations (e.g. ACM [1]) prescribe core degree programme content, both specialised and generic. Institutions can then select additional modules from the elective modules specified to compile an institution-specific degree programme. The responses received from the survey strongly support the creation of a core IT diploma and advanced diploma programme Body of Knowledge (BOK). Elective modules for the specific diploma programmes, such as Software Development, Communication Networks, Support Services and Web Development can be incorporated by an institution to provide a differentiated diploma offering. As indicated in Fig. 2, all IT diploma programmes will have a common core first year. In the second-year, specialisation core modules are proposed for specialisation IT diplomas such as Software development, Information Technology and Communication Networks. In the third year, an institution can select elective modules for the advanced IT diploma in, for example, Information Technology or Communication Networks.

The rationale for such a core IT diploma and advanced diploma programme BOK is that it prepares students with the right combination of knowledge and practice, to enable them to design, implement, manage and support solutions for an organisation's information technology infrastructure and systems and give quality service to the people who use it. Information Technology is the emphasis on the technology aspects driving a modern business.

Graduates of an Information Technology diploma qualification will address the gap between understanding the information needs of business and implementing and developing new algorithms by having an organisational infrastructure and integration focus.

The IT diploma BOK must be drafted by the members nominated by each institution to serve on the proposed SAITDAB. The SAITDAB, in collaboration with the SACAB standards committee, must draft proposed core and elective modules for the different IT diploma and advance diploma programmes offered by HEIs in South Africa. The SAITDAB must function within the requirements as specified by the Department of Higher Education and Training (DHET).

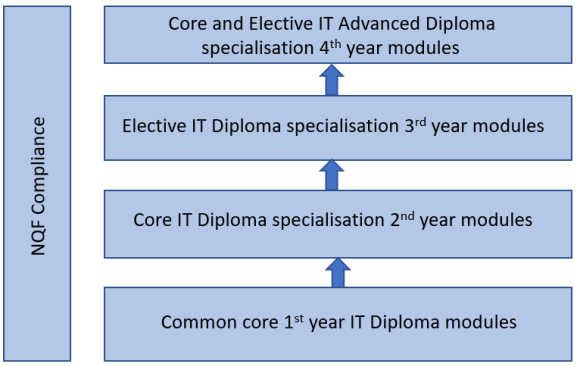

Fig. 2: Proposed IT diploma and advanced diploma programme structure

7 Conclusions

The accreditation of academic programmes is of critical importance to maintain the required academic standards and international recognition. The establishment of the SACAB and its association with the Seoul Accord, is important to provide internationally accepted degree and diploma programme accreditation in South Africa.

The research objectives of this study included determining the support for the proposed South African IT Diploma Advisory Board (SAITDAB) and proposing an initial mechanism for drafting and implementing an IT diploma and advanced diploma programme BOK for South African universities. In South Africa, four Comprehensive Universities and eight Universities of Technology offer IT diploma and advanced IT diploma programmes. Nine IT diploma specialisation programmes and five advanced IT diploma specialisation programmes were identified from the websites of the HEIs.

The summary (Tables 3 and 4) of IT diploma programmes offered by HEIs indicates that there are 26 programmes offered by twelve institutions and nine advanced

IT diplomas. The respondents indicated that generally no collaboration between institutions is taking place to ensure standards and quality assurance. Most institutions indicated that quality assurance is obtained through external examination and moderation of exit level modules.

The results of the survey indicated full support by the respondents for the creation of the SAITDAB. The membership of the SAITDAB must include representatives from Comprehensive Universities (Table 1) and Universities of Technology (Table 2), as such, representatives would be the best equipped persons for this task. The SAITDAB must further establish administrative guidelines for IT diploma programmes and draft a core BOK for the different IT diploma programmes. Evaluation criteria (a standards document) for accreditation purposes must be compiled and published by the SACAB, based on the work done by the SAITDAB.

The limitations of this study were that not all universities offering IT diploma programmes in South Africa responded to the three calls for participation in the survey. Further research will be required for establishing the SAITDAB and drafting of a document for the SACAB IT Diploma Programme BOK.

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Appendix A: HOD IT Diploma Survey

Proposed IT Diploma Advisory Board for South African Universities

A South African Computing Accreditation Board (SACAB) workshop for universities offering IT Diploma programmes was held at the SACLA 2018 Conference, chaired by Dr Sue Petratos and Prof Andre Calitz on the 20 July 2018. Representatives of six universities offering IT Diploma programmes that attended the meeting agreed on the establishment of a **South African IT Diploma Advisory Board (SAITDAB)**. Universities offering IT Diploma programmes were requested to inform Dr Petratos about programmes being offered. This survey is in response to the request made in 2018.

Institution Name: _____ Department name/School name: _____
Respondent (title, name, surname): _____
Email address: _____

Q1. What IT diploma and IT higher diploma programmes does your institution offer?

_____

Q2. How did your department/school decide on which IT diploma and IT advanced diploma programmes to offer?

_____

Q3. How did your department/school decide on the structure and content of the IT diploma and IT higher diploma programmes that it offers?

_____

Q4. Did your department/school collaborate or consult with any other institution when deciding on the structure and content of the IT diploma and IT higher diploma programmes that it offers? If so, what was the nature of the collaboration or consultation?

_____

Q5. Do you intend to introduce new IT diploma and/or IT higher diploma programmes in the

next two years? (Yes/No). If Yes, what programmes?

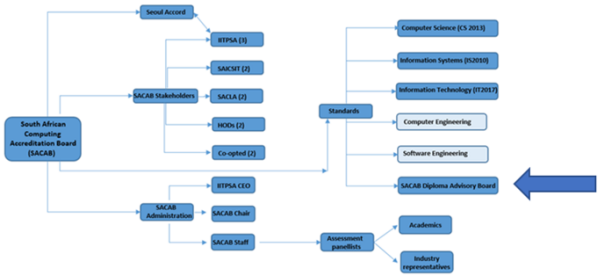
Q6. How does your department/school ensure that your IT diploma programmes remain up-to-date over time?

Q7. How does your department/school ensure the quality of the IT diploma programmes offered?

Q8. Does your department/school collaborate or consult with any other institution when ensuring
that your IT diploma programmes remain up-to-date over time, and ensuring the quality of the IT diploma programmes offered. If so, what is the nature of the collaboration?

TECLA (Technikon Computer Lecturers Association) was an organisation that organised an annual conference for members of Technikons that offered IT diploma programmes.

Q9. Did your department/school support the old TECLA? Yes/No (Motivate your answer please)



SACAB is proposing the creation of a national *South African IT Diploma Advisory Board (SAITDAB)* for Comprehensive Universities and Universities of Technology offering IT diploma and IT higher diploma programmes. This body, as indicated in the figure above, would be responsible for specifying the Body of Knowledge (BOK) for specific diploma programmes and quality assurance. The standards set by this body would be used for accreditation purposes by the SACAB.

Q10. Would your department/school support the proposed South African IT Diploma Advisory Board (SAITDAB)? Yes/No (Motivate your answer please)

Q11. Would your department/school support a national IT Diploma BOK as proposed by the SACAB? Yes/No (Motivate your answer please)

Q12. What benefits would an IT diploma programme BOK have for your department/school, in your opinion?

_____

Q13. Provide the contact details of person(s) who could serve on the proposed South African IT Diploma Advisory Board (SAITDAB).

_____

Q14. Do you have any other comments?

_____

Thank you for your participation.

Data Collection in an Information Systems Design Science Research Project

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Abstract. Design science research (DSR) is a popular research approach used in information systems for the design, development and evaluation of artifacts. There is some guidance in the literature on how to conduct DSR as an approach to find solutions for wicked problems. Some of the areas with which students who are involved in DSR struggle are the confirmation of the problem and design and evaluation of the artifact. Hevner et al. [1] presented their conceptual model for DSR in 2004 and in this paper we use this seminal work as guidance to illustrate where there is potential for inclusion of data collection activities to address these three areas of concern. We also indicate the nature of the data collection that can be used during these phases. Lastly, we use some cases studies to map the areas that we have identified to these case studies as illustration.

Keywords: Design Science Research; Data collection and Design Science Research; Building the Artifact in DSR

1 Introduction

Hevner et al. [1] argue that design science research (DSR) 'creates and evaluates' information technology (IT) artifacts intended to solve wicked problems in organizations. Wicked problems include problems with unstable requirements and complex interactions among subcomponents of the problem and the solution. Furthermore, wicked problems are problems where there is critical dependence on human aspects such as creativity and teamwork [1]. March and Smith [2] argue that there are four IT artifacts that enable IT researchers and practitioners to find solutions for problems associated with information systems in organizations, namely *constructs, models, methods* and *instantiations.* Hevner et al. [1] also highlight the four contributions as artifacts but other work, such as that of Walls et al., includes *design theories* as an artifact [3]. Baskerville et al. [4] recently, in 2018, argued that we can distinguish between two types of contributions from a DSR project, namely design artifacts and design theories, which supports the view of other authors [5][3].

In a seminal work on DSR in 2004, Hevner et al. [1] argue that information systems (IS) research is conducted using both behavioral and design science research,

with behavioral research focusing on *development* and *justification* of theories and design science research focusing on *building* and *evaluation* of artifacts. They emphasize that the two are inseparable, since the goal of behavioral science research is truth and the goal of design science research is utility – and for IS research we need both. Following the argument that design theories are also contributions to DSR then emphasizes that during a DSR project one can use techniques used in behavioral science for construction and evaluation of one's artifact. Hevner et al. [1] support this notion by emphasizing that the DSR researcher needs to select the right techniques to develop and evaluate the theory or artifact. They furthermore emphasize that the techniques used for the building and evaluation of the artifacts can be derived from behavioral and empirical work. However, although they adopt as their guidelines a discussion on rigor (Guideline 5) and evaluation (Guideline 3), they provide limited guidance on the use of data collection, especially for the design phase of a DSR artifact that depends more strongly on the use of qualitative data for the development of the artifact. For instance, a framework that might consist of a combination of a model and a method might be developed from both the knowledge base and the environment. In this opinion paper we provide guidance using Hevner et al.'s [1] conceptual framework as provided in their seminal work on DSR to illustrate the use of data collection specifically to build and evaluate the artifact. This guidance is an explicit specification of value for design science researchers who need to understand how they can ensure rigor in their processes using DSR.

We first provide a discussion of the conceptual framework provided by Hevner et al. [1] in section 2, as well as a short overview of data collection techniques used in information systems. In section 3 we provide a discussion on the potential areas of using data collection in the conceptual framework to establish rigor. In section 4 we provide a set of steps through which data collection can be used in a DSR project, followed by some illustrations of how the researchers in three research projects did their data collection during the development and evaluation phases in section 5. The paper is concluded in section 6.

2 Background

2.1 The conceptual framework

Hevner et al. [1] presented a conceptual framework for understanding, executing and evaluating IS research based on a combination of the behavioral science and design science paradigms shown in Figure 1. The aim of behavioral science research is truth and research is addressed through the development and justification of theories that describe phenomena related to the objectives identified for the research project. On the other hand, the objective of design research is utility and the research entails building and evaluating artifacts related to the objectives identified for the research project. Hevner et. al. [1] base their framework on the premise that truth informs design and that design informs theory and they therefore assume that truth and utility are inseparable.

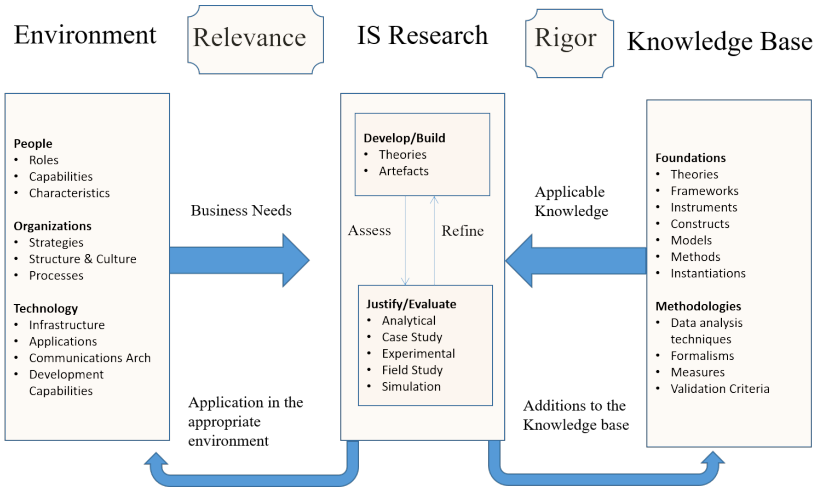

Fig 1: Information systems research framework (Hevner et al. [1])

The framework (Figure 1) describes the contextual *environment* of the research project such as people, organizations, and organizational technologies. Research relevance is achieved as the research project requirements are defined as business needs by organizational strategies, organizational structures, as well as roles and characteristics of people working within the organizations. The *knowledge* base refers to the scientific foundations (e.g. frameworks, instruments, constructs, models, etc.) and methodologies (e.g. evaluation guidelines, measures, etc.) that inform the research project. IS research is then conducted based on two complementary phases, develop and build, and justify and evaluate, guided by the articulated business need and anchored in applicable knowledge from the knowledge base. The development or building phase of IS research addresses wicked problems characterized by complex subcomponent interactions, critical dependence on human cognitive ability, unstable context-specific requirements and constraints, and may produce theories or artifacts as outputs. The justification or evaluation phase of IS research focuses on the application of rigorous evaluation methods (e.g. experiment, simulation, etc.) demonstrating the efficiency, effectiveness, utility and quality of the design artifact. An artifact may be optimized through a continuous process of assessment and refinement between the develop or build, and justify or evaluate, stages. Finally, the outcome of the research project contributes in terms of two areas: the design artifact and design construction or design evaluation knowledge.

The design artifact, e.g. methodology, prototype, expert system, etc. contributes in its application in the context where the organizational business need was identified. The design construction and/or evaluation knowledge contributes to the knowledge base through evaluated constructs, models, methods or instantiations that extend or improve existing foundations in the base of design science knowledge. In addition,

the development and application of evaluation methods or new evaluation metrics contribute to the base of design science knowledge.
By applying the proposed framework for IS research, a research project addresses the utility of a new artifact and presents the evidence in support of the research project outcomes. Hence, the research problem, the artifact and its utility must be presented in such a manner that the implications for both research and practice are clear.

2.2 Data collection

In considering Hevner et al.'s [1] conceptual framework, the DSR researcher in building the artifact can use data from the *environment* or from the *knowledge base*. In considering the environment the DSR researcher can use data collection techniques used by IS researchers in studying phenomena in organizations, including observation, interviews and questionnaires. In contrast, for considering the knowledge base data, collection techniques include a selection of theories for a theoretical framework and systematic literature reviews. The types of data collection techniques are summarized in Table 1 and their potential use is discussed in more detail in section 3. Some examples are given in section 4.

Table 1. Data collection techniques

Environment	
Observation	The focus of observation is on studying people's behavior. Saunders et al. [5] distinguish between participant observation, structured observation, internet-mediated observation and observation using videography.
Interviews	An interview is a goal-oriented conversation with one person or more people where the interviewer asks the questions and records responses from the person interviewed or from the group.
Questionnaires	A questionnaire is defined by Saunders et al. [5] as a method ensuring that each person who responds to the questionnaire is asked the same questions.
Knowledge base	
Theoretical framework	Eisenhart [6:205] defines a theoretical framework as "a structure that guides research by relying on a formal theory…constructed by using an established, coherent explanation of certain phenomena and relationships".
Textual analysis (hermeunetics)	Understanding text in order to understand meaning and the essence of experience [7].
Systematic literature review	A systematic literature review is defined by Okoli and Schabram [8] as a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners

3 Data collection in DSR

As mentioned, for this paper our focus is specifically on the building and evaluation of the artifact primarily from a qualitative perspective with the focus on both the *environment* and the existing *knowledge* to create the artifact. Although we will include some discussion on the evaluation in this paper, it will not be the main focus, since Hevner et al. [1] and other authors such as Pries-Heje et al. [9] offer extensive discussions on methodologies to do artifact evaluation. Our focus is rather on the design process and the data collection associated with the design process using Hevner et al.'s [1] conceptual framework as guideline. In the conceptual framework (also discussed in section 2) there are four potential areas of data collection to assist with the design and evaluation process (Figure 2), namely:

1. *Data collection area 1*: Establish the requirements from the problem domain for the building and evaluation of the artifact.
2. *Data collection area 2*: Consider the available knowledge contributions to assist in the building of the artifact.
3. *Data collection area 3*: Consider the available environmental practices already established that can assist in the building of the artifact.
4. *Data collection area 4*: Evaluate the artifact in a laboratory environment and, if possible, in the business environment to demonstrate the utility, quality and efficacy rigorously.

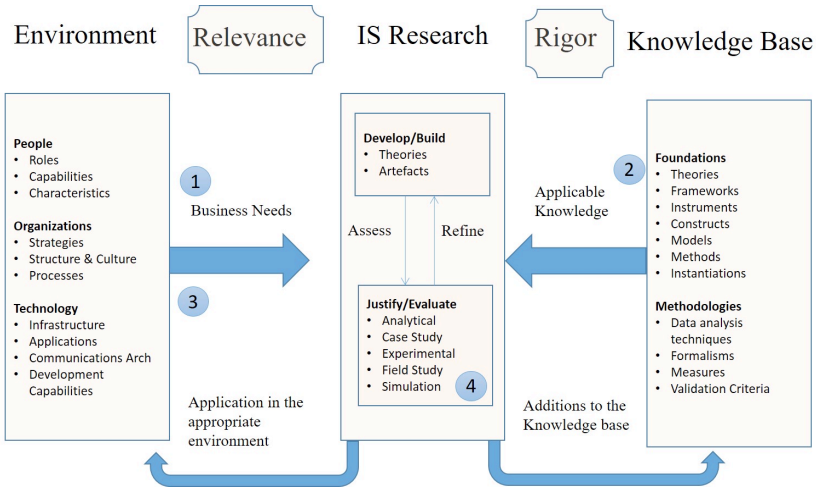

Fig. 2.: Data collection for design and evaluation of the DSR artifact (adapted from Hevner et al. [1])

3.1 Data collection during requirement elicitation

Wicked problems are the core of DSR projects and originate in the *environment* (indicated as "1" in Figure 1. Sources for identification of the requirements of a wicked

problem include outlets such as Gartner that publishes opinion pieces based on research done by them or cases that originate in organizations as concerns, which are then published, for example in popular media. These might even originate as research subsequent to previous research. The DSR researcher involved in the creation of the DSR artifact can confirm the business needs or requirements from the environment. The researcher may confirm the business need in the environment using as research strategy a case study or multiple cases. Confirmation of the problem is possible using any (or a combination) of the three data collection techniques presented in Table 1 under *environment* (observation, interview or questionnaire).

In research projects where the researcher is part of the organization or case study environment, observation is an option for data collection. Especially participant observation, where the emphasis is on the meaning of actions [5], can provide the researcher with an understanding of the way 'things' are being done and why specific problems are experienced. Furthermore, it should provide understanding of exactly what the problems are.

Alternatively, interviews with different members of the case study environment can confirm the nature of the problem and provide valuable input into what a possible solution should entail. The nature of an interview is that the researcher gets input from participants who understand the problem domain and could provide insight into a reality that exists independently of them [5]. The options relating to interviews are that one can interact with individuals or conduct group interviews, also known as focus groups, where the researcher collects data from more than one participant at a time. The researcher needs to understand the context of the investigation and choose between the two accordingly.

A third option for data collection is using questionnaires, which is ideal if one already has an indication of the problem and wants to collect more quantitative data indicating the frequency of the problem. Although it is possible to include open-ended questions in a questionnaire to gather data on opinions, it might not be the ideal tool for identification of requirements.

As mentioned previously, the output of the first data collection area is the requirements that enable the researcher to understand what is necessary in the development of the solution.

3.2 Data collection during design: knowledge contribution

After establishing the requirements for the artifact, the researcher starts with the design process. Design is a search process that uses heuristic search strategies in order to produce feasible designs that can be used in the organization [1]. As a first phase of the design process, the researcher is involved in investigations into the *knowledge* base and understanding the potential use of existing knowledge in developing a solution. We argue that at this stage the researcher will either use an existing theory and build a theoretical framework from which the new artifact will be developed, or the researcher may do a critical review of the literature and use existing knowledge by doing a textual analysis (hermeneutics) or systematic literature review (Table 1).

If the researcher uses an existing theory for development of an artifact, it may be done by first creating a theoretical framework. The theoretical framework is a "structure that guides research by relying on a formal theory; that is, the framework is constructed by using an established, coherent explanation of certain phenomena and relationships" [6]. For example, Hevner et al. [1] refer to the use of the technology acceptance model as an existing theory where the researcher can then create artifacts that should overcome the challenges predicted by acceptance.

As an alternative the researcher can do a critical review of the existing knowledge base by either doing a textual analysis (hermeneutics) or a systematic literature review where existing results from different studies are compared and data from these studies can be used in building the artifact. Although the approaches differ, one of the significant differences between the two is that for hermeneutics the researcher will tend to use existing literature and move from that to alternative literature, while the systematic literature review should be replicable so very strict search criteria are used, among others exclusion and inclusion criteria.

3.3 Data collection during design: environmental contribution

Another form of data collection that can inform the creation of the artifact occurs when the researcher is involved in data collection in the *environment*. The purpose will be to look at cases where some solutions are already being implemented for the problem under investigation and to collect data to be used in the solution artifact. Similar to the first phase of data collection that is done for the business needs, the researcher can use observation, interviews or questionnaires as data collection techniques.

Observation is ideal in cases where the researcher has access to the case environment(s) and can observe the way 'things are being done' and capture this as best practices in his solution for the artifact. Interviews (single or group) are ideal where the researcher needs to understand through interaction with the subjects in the case environment what they are doing to address the problem and how they are doing it. Although interviews may give the researcher more freedom to ask specific questions, this method might pose the danger that the researcher may lead the participants to his or her own views. Lastly, questionnaires might be an option where the researcher knows exactly what he or she is looking for and wants to establish trends. However, since this is a more quantitative form of data collection, there is a danger that if open-ended questions are not included the researcher might miss some important information from the participants.

The output of the observation or interview data collection activity is practitioner-based experience that the researcher may use in his or her own design through the identification of themes during the analysis of the data.

3.4 Data collection during the evaluation of the artifact

The last activity is the evaluation of the artifact, which is covered in more detail by authors in the literature. Hevner et al. [1] focus on evaluation as one of his guidelines

(Guideline 3) and emphasize the definition of appropriate metrics where the evaluation is complete once the requirements and constraints of the problem, as defined during the first data collection cycle, are met. They suggest observational, analytical, experimental, testing and descriptive design evaluation methods that include the execution of case and field studies. Venable [10] argues that evaluation can be done either as an artificial evaluation where the solution is tested in a non-realistic way or in a naturalistic way where it is tested in its real environment. In a further publication, Venable et al. [11] provide a framework for evaluation in DSR called the FEDS framework and argue that for artificial evaluation one will use either positivist or interpretive methods to prove a hypothesis or to understand an artifact and why it works. For naturalistic evaluation Venable et al. [11] argue that it is possible to do "case studies, field studies, field experiments, surveys, ethnography, phenomenology, hermeneutic methods and action research." In all these cases the data collection techniques in Table 1 are used, where the researcher might for instance study the use of the artifact in its natural setting through observation using action research or a survey can be done with questionnaires to determine the success of the artifact.

4 Data collection strategy choice for DSR

Using the conceptual model of Hevner et al. [1], we derive a four-step guide for including the data collection as part of a research design for a DSR project. The four steps that we propose are: (1) understand the data resources during the problem description, (2) select a data resource from the knowledge base as input into the problem solution, (3) decide if it is appropriate to use data resources from the environment as input to the problem solution, and (4) identify the data resources during the design of the evaluation strategy.

This strategy then uses the techniques as discussed in section 3 and it is possible to illustrate how these will be applicable in some popular design process models such as those of Vaishnavi et al. [12], as illustrated in Figure 3, and Peffers et al. [13], as illustrated in Figure 4.

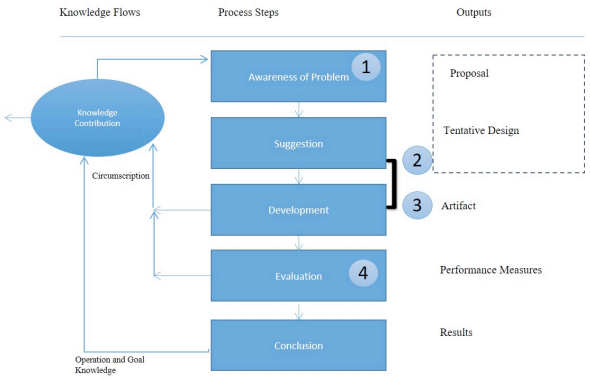

Fig. 3: Data collection using the method of Vaishnavi et al. [12]

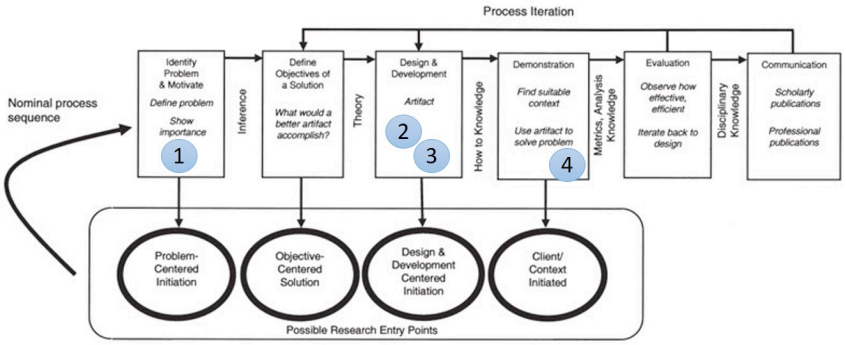

Fig 4: Data collection using the method of Peffers et al. [13]

In Vaishnavi et al. [12], Step 1 is used during the awareness phase to identify the problem and establish the business needs. The output is a set of requirements derived from the environment using observation, interviews or questionnaires. Step 2 and Step 3 are applicable in the suggestion and development phases, depending on the design of the specific project. Data collection is done from the knowledge base using literature-based techniques such as a structured literature review or a theoretical framework is built from existing knowledge. Lastly, data collection during the evaluation phase will contribute to the rigor and relevance of the artifact and depending on the evaluation strategy, can include empirical methods such as interviews, observation or questionnaires as part of the evaluation strategy.

Similarly, in Peffers et al. [14], Step 1 is applicable in the phase where the problem is identified and motivated, while Step 2 and Step 3 are pertinent during the design and development phase. These authors also include an evaluation phase where the fourth step, namely use of different data collection techniques for evaluation, is executed depending on the nature of the evaluation.

5 Case Studies

5.1 Case study 1: Development of a conceptual framework

Gerber [14] developed a conceptual framework for financial reporting in 2015 using DSR as overall strategy. The objective of his work was to "investigate how the use of ontology technologies, as utilised in computing, can contribute towards formulating a globally acceptable Conceptual Framework for Financial Reporting (global CFfFR)" [14:18]. His research strategy is graphically illustrated in Figure 5 with the different points of data collection indicated in the figure.

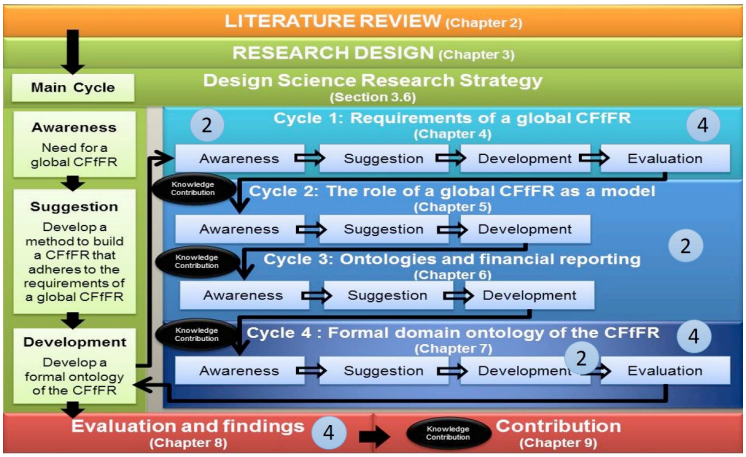

Fig. 5: A conceptual framework adopted from Gerber [14]

In the first cycle, Cycle 1, Step 2 stipulates that data collection is done from the knowledge base. Gerber [14] uses a systematic literature review as data collection technique to determine the requirements of a global CFfFR. Similarly, he collects data from the *knowledge* base in using an interdisciplinary research strategy for his second and third phases. Lastly, he uses ontology technologies as modeling technique to test the CFfFR against the assumptions and requirements and role of a global CFfFR (Step 4). In this step he uses the FEDS model provided by Venable et al. [15], as mentioned in section 4.

The *relevance* of the problem is situated in the need for a framework for financial reporting and the *rigor* is established both by using existing literature from the knowledge base, including the theory on ontologies, and by verification using the FEDS model.

5.2 Case 2: Big data-driven decision-making framework

Pillay [16:2] developed a big data-driven decision-making (BDDDM) framework to "support the incorporation of big data analytics into the decision-making process". In her work she used a three-phase approach based on the work of Vaishnavi et al. [12] to investigate the available decision-making models and motivate why she chose the data-driven decision-making (DDDM) model as suitable to adapt for big data analytics decision-making in banking. The data collection was conducted by doing an investigation into existing DDDM models and using a set of criteria identifying the best fit. The data collection was based on a critical evaluation of the existing theories and then using the DDDM model as theoretical base for development of her own model (indicated with 2 in the main phase of the development in Figure 6).

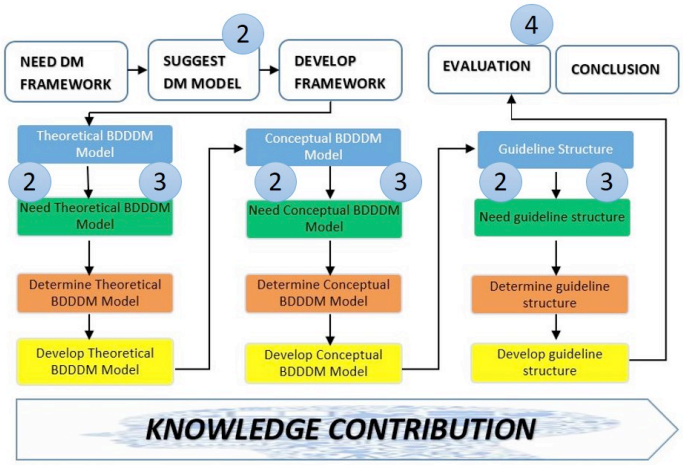

Fig 6: A three-phase approach for identification of the BDDDM from Pillay [16]

In all three sub-phases of her study she uses the model from the knowledge base and does data collection from the environment using structured questionnaires and semi-structured interviews (indicated with 2 and 3). Lastly, she does her evaluation in the main cycle by doing a proof of concept (which can be classified as an artificial evaluation with a laboratory experiment, since she did not implement her solution). She used a closed-ended questionnaire to indicate the usefulness of the model, using experts in different organizations as participants.

For her research, *relevance* was established in the awareness phase of her study when she described the problem of introducing big data analytics into the environment, in this case the banking domain. *Rigor* is rooted in the way that she conducted the research following a step-by-step process using existing theory and consulting the problem domain for input in the development of her framework.

5.3 Case 3: A change management framework

Tredoux [17] developed a framework for the implementation of enterprise resource planning systems to mobile user readiness in her PhD work. Her research design is presented in Figure 7. She used all four types of data collection in the different phases.

She used a case study in the awareness phase to confirm the problem that a framework is needed (indicated as 1 in Figure 7). In Cycle 1 of her thesis she used a systematic literature review to identify critical success factors that she used in the construction of her thesis. Although not illustrated in the research design in Figure 7, she also used theories from the knowledge base to construct her artifact, including change management and technology adoption theory. In Cycles 2 and 3 she used an action design strategy to develop her artifact, relying on a case study environment where she identified concepts to include in her artifact. She also used constructs derived during

the first cycle from the knowledge base in her suggested framework and existing models to guide her in the development of the framework. Lastly, she used a focus group (indicated with 4 in Figure 7) for evaluation. She only did a proof of concept, classified as an artificial evaluation.

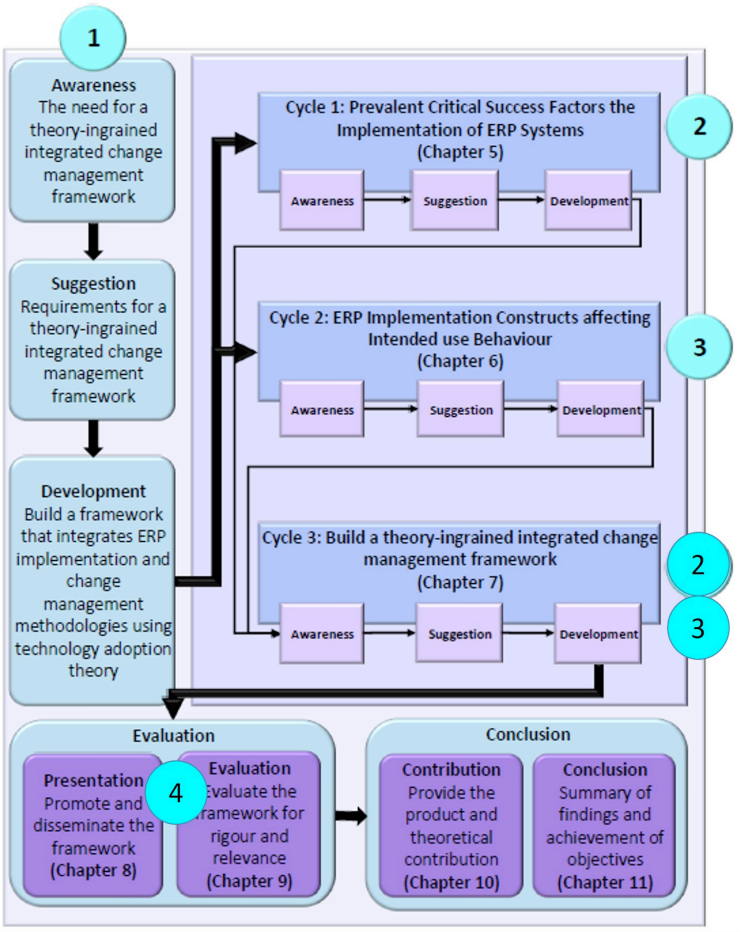

Fig 7: A change management framework by Tredoux [17]

6 Conclusion

In conducting DSR research the focus is on the development of the artifact. Although it is possible in some fields, such as computer science, to adopt mainly an abductive approach in creating the new artifact, it is not always feasible within the information

systems environment where the problems are usually larger in nature and not as contained. In an information systems DSR project we are often faced with the context of the problem needing a combination of techniques from behavioral science and design science to create a unique artifact as solution to the wicked problem. In this paper we provide guidance in specific areas where data collection can be used as part of the DSR project and also indicate how it can be used. We give an indication using Hevner et al.'s [1] conceptual framework of where the areas of data collection are, followed by a pertinent discussion on the *rigor* and *relevance* by using both the *knowledge* base and the *environment* during the design, development and evaluation of the artifact. In this paper we also give an indication of the data collection areas in popular process models for DSR, including those of Vaishnavi et al. [12] and Peffers et al. [18]. We lastly demonstrate areas of data collection in three PhD DSR research projects using the research design as guideline.

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Evaluation of Visually Impaired Students' Perceptions on Using a Learning Management System (WiseUp) at Walter Sisulu University

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Abstract: Many Universities have adopted using Learning Management Systems (LMSs) to assist in teaching and learning. As technologies become popular, less considerations on learners and lecturers who are Visually Impaired (VI) has been done. Researchers agree that technology is an essential tool to remove existing discrimination against visually impaired people by allowing them to participate fully in education. However, VI people face challenges to access information as a result of poor systems design. In some cases, assistive technology to aid mobility and retain independent lives within the online environment for the VI have been incorporated. The study considered students at Walter Sisulu University at one campus who are using a LMS called WiseUp. The participatory design research using prototyping was used as the research design of the study. 33 students who have different visual impairments and using WiseUp for teaching and learning were considered. Results show that very few visually impaired students engaged could navigate with less difficulties through the system, whilst majority found it very difficult to navigate. Others have grown accustom in getting academic information through peers. All students agreed that they find it difficult to read current font size and the choice of the colors is not in line with their needs. The University did not have assistive technology or a dedicated place for students with visual challenges at the time of the study. The study presents the perceptions of VI students at WSU when using WiseUp.

Keywords: Visually Impaired, Learning Management System, Assistive Technology, System Usability, Participatory Design, Technologies for Visually impaired

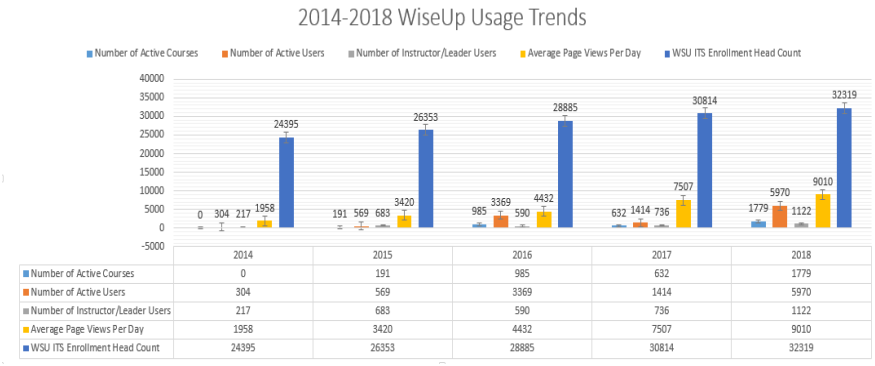
1. Introduction and Background

As technology evolves, many Information and Communication Technology (ICT) solutions have been experimented with and deployed. Within the education sector, Learning Management Systems (LMS) have been deployed, but the usage and adoption is still low. With the current technologies used by the universities for eLearning, there is an increased demand output rate expected by the university's management. LMSs in almost all universities, including rural universities, has gained popularity, and has extended nationwide. As the technologies become popular within the academic sector, less consideration of those who are Visually Impaired (VI) has been done. Both learners and lecturers who are VI face challenges in accessing and reading the content on the LMS due to different needs. System designers have not yet fully considered the needs of those who are VI. This has led to less usage and adoption of LMS and modern technologies by the VI people in universities. Walter Sisulu University (WSU) was targeted for this study. The university has adopted using

blackboard LMS that is popularly known as WiseUp. WSU had to meet the huge demands that came about as a result of a Merger in 2005 which implemented the LMS [1]. As the university covers a large geographical area of the Eastern Cape, the same qualifications are offered across different campuses [1]. Adoption of LMS has been necessitated by staff shortages and the need to minise travelling costs involved for the lecturers to move from one campus to another [1].

Coupled with that challenge, in 2009, WSU implemented WiseUp as an LMS to be used by all the campuses, i.e. Queenstown, Buffalo City, Butterworth, and Mthatha [2]. With the use of the LMS, lecturers can upload notes onto the system, upload assignments for the students, and the students can log in and download all the uploaded resources, depending on the course in which they are enrolled [1]. With an enrolment of over 30 000 learners, adoption of modern technologies has become a necessity [2]. Shwababa [1] highlighted that the university's strategic document states that the institution has a supporting department, the Centre for Learning, Teaching and Development (CLTD), that supports university academics in terms of monitoring and preparing those students with lack of writing skills, and also provide career advice where necessary, using e-learning management system [2]. On WiseUp, lecturers can issue learning and teaching material, give out and mark assignments online, check plagiarism of student's submissions, interact with students through social network platforms, and track and monitor student performance.

It is CLTD's responsibility to train lecturers and students on the use of WiseUp. WSU, as noted from data extracted from WiseUp logs against ITS student headcount enrolments, experiences extremely low eLearning usage and adoption, as demonstrated on Figure 1.



	2014	2015	2016	2017	2018
Number of Active Courses	0	191	985	632	1779
Number of Active Users	304	569	3369	1414	5970
Number of Instructor/Leader Users	217	683	590	736	1122
Average Page Views Per Day	1958	3420	4432	7507	9010
WSU ITS Enrollment Head Count	24395	26353	28885	30814	32319

Figure 1: WiseUp Usage Trends [2]

Over the years, as determined by the system 2014 to 2018, it is shown that highest usage is 9010, and the WSU enrolled 32716 students in 2018, which shows low adoption and usage of the LMS [2]. The evidence of the usage demonstrates that a lot needs to be done by the institution, in terms of the LMS usage. Although full statistics of VI users could not be established, it can be argued that if usage is this low before considering the perceptions of those who are VI, it is apparent that some interventions are needed.

All students at WSU rely mainly on online content, accessing WiseUp and text books provided for them on campus for information. It is important to build a welcoming environment in which visually impaired students feel valued, supported and a sense of belonging while designing inclusion programs [3]. Literature shows that learners with a greater sense of purpose are more involved in academic programs

and active in social interactions [4]. During post-secondary education, students with visual impairments face physical, mental and social challenges. Visually-impaired students require class notes in large font or audio formats, appropriate structures for achieving evaluation tasks and exams, and also access to assistive devices such as text enhancement software or text scanner reader [4].

The problem at hand is that as LMSs are implemented, less or no consideration of VI persons are catered for. The VI students are excluded from the design of a LMS yet they are expected to use the systems. As debates on the usage and adoption of LMS continue, a few studies are conducted to get the perceptions of those who are VI. This study answers the question: How can the LMS at WSU be designed to accommodate students who are visually impaired. This study focuses on only the VI students and only one WSU site in East London was considered. The study`s main aim was to get the views of VI students using WiseUp at WSU. The rationale behind this study is that as technology for the new generation is developed within the academic sphere, no one should feel left out. Software developers and graphic designers must understand the needs for VI learners. The article comprises of a number of sections including: literature on ICTs in education, the approach used, findings and recommendations proposed. The following section provides an overview of the current literature available on learning management systems.

2. Related Literature

This section presents current literature that is available on LMS, VI needs and technologies used by those who are VI. While e-learning has brought great opportunities for many students, it remains primarily vision dependent. It is well known that LMS can be an effective tool for facilitating teaching and learning, also it has been used by many institutions of higher learning around the world in both developed and developing countries. Despite the penetration of LMSs, they have not achieved the expected utilization levels in developing countries such as South Africa (SA) due to challenges such as poor connectivity, low internet bandwith, lack of access to computers, ICT illiteracy among users as well as underutilisation of some features by lecturers and students currently using LMS [5]. LMSs have become platforms for disseminating information and managing instructional content at universities [5].

Students with visual impairment need to have constant contact with the other university peers for information and the interaction should be continuous, successful and secure to help them feel linked and active [3]. A survey conducted in 2002 of 410 teachers and students with visual impairment using software and digital presentations revealed that the teachers were more comfortable with common technologies as compared to technologies explicitly aimed at students with visual impairment [6]. Accessibility by VI students is one of the challenges that hinders access to information without the assistance of sighted peers [7]. Based on the challenges, web designers have to meet the needs of students with visual impairment in developing an active and open e-learning management system [8].

Inaccessible learning management systems causes division in education where visually impaired students` equal access to public education is compromised [9]. As a result, the opportunity for visually impaired students is not the same as that of sighted students. Also, designers have very little knowledge of usability and lack of information on the best ways to identify accessibility issues quickly and easily to cater for all students in the university [10]. Visually impaired students often feel isolated because in particular, e-learning programs seldom take into account social elements that are also a concern. Students with disabilities need to build confidence by exchanging skills and knowledge [11].

2.1 Overview of visual impairment

The term visual impairment is clearly defined as the loss of sight which cannot be treated with medication or undergo medical operations, or either aided with visual lenses example; spectacles to magnify objects [12]. Visual impairment condition can limit a person's movement and reduce the rate at which a person performs normal activities due to the limitation in the range of sight [7]. Visual impairment can also be defined as a broad term that comprises of two categories which is blindness and low vision and these two categories are extended into Legal Blindness, Blindness, Low Vision, Congenital and Adventitious [6]. Dandona [13] defined visual impairment in terms of the common reasonable refractive correction or the person's present refractive correction in the healthier eye". In another study, low vision is defined as the condition that can limit a person's vision even with corrective lenses, the person can not see at a distance of 6 meters (20 feet) while an individual with normal sight can see at a distance of 18 meters (60 feet) [14]. Blindness and low vision are the most known world health problems because of the gradual increase in cases, decreased quality of life, and substantial economic productivity loss [15]. Visual impairment has the potential to negatively alter a person's life from all spheres, hence all sectors must rethink processes and procedures to accommodate affected individuals. Loss of sight can be caused by various reasons, for instance blindness discovered at birth, this condition commonly occurs as a result of prematurity, inheritable or genetic diseases, prenatal and perinatal infections and maternal substance abuse [16].

Visual impairment and blindness can affect individuals and the society at large because this condition limits individuals in doing their daily activities and improve their lives financially [17]. Many public health sectors in developing countries have been affected radically whereby approximately 80% of the population has some form of blindness [18]. As a result of the high number of individuals with various impairments, it is vital for designers to take their needs into condieration [19]. Low vision is sometimes used to describe the degree of sight at the range of 20/70 to 20/200 [20]. In some continents such as North America and most European countries they have defined legal blindness as "visual acuity where the range of sight is rated 20/200 (6/60) or less sight in the better view with assistive materials such as spectacles" [21].

2.2 Challenges of LMS and Visually Impaired

A person with visual impairment can fail to perfom normal daily activities for example, academic engagements, social interactions and career development [22]. Visually impaired people experience poor access to information, visually learning difficulties, reading difficulties and face difficulties in meeting the demands of general education classroom compared to other people with normal sight [22]. Social difficulties for visually impaired people are listed by Brandy [6] as follows; visually impaired people cannot participate in non-verbal signals (body language) from others, and they cannot distinguish the distance between objects or another person standing at a distance. A visually impaired person is usually advised to use recommended assistive tools to move around or recommended reading medium such as braille as a reading and writing medium [21].

Much work has focused on the superiority of the sense of vision [23]. Many of the most frequent problems encountered by sight loss by students include inaccessibility of websites, inaccessibility of learning materials and different special needs related to their impairment. Brandy [6] mentioned that "Web accessibility is the ability of a person using any user agent to understand and fully interact with a website's content", and to be truly inclusive, a website must be available to a wide range of users [19]. One of the most critical issues seems to be that e-learning programs are still not

designed to accommodate or be made specifically for students with vision problems. The guidelines for visually impaired web access are not suitably precise for the impactful layout of online resources for poor vision. Guidelines for the design of open teaching, learning resources and requirements, and guidelines for internet accessibility are also misaligned. Specific teaching aids developed specifically for students with visual impairments are required to ensure that students understand the concept taught [11].

The second issue is also that e-learning programs are generally built for sighted students and do not integrate vision impairment requirements for students [7]. Interaction in an e-learning environment needs to be more particular and wide-ranging for vision impaired individuals. Consideration of the differences in needs between sighted and visually impaired students is important. Sighted learners can view and quickly understand pictures, graphs, and charts, while students with impaired vision are unable to access them at all [7]. E-learning materials are not intended to be compatible with the variety of assistive technologies implemented, resulting in students with vision loss experiencing incomplete or incorrect translations or, at worst, no functionality at all [7]. Based on the challenges, web designers have to meet the needs of students with visual impairment in developing an active and open e-learning management system [8].

2.3 Requirements and Technologies for Visually impaired

In order to enable visually impaired person's movement, learning or using services provided from various sources, the methods that need to be considered are as follows; the person must walk in a clearer way to enable smooth movement, get reading materials which are designed in a way that visually impaired people can access, for example the document must contain Braille, large-print or magnified font, or audiotape format to listen to the recorded voice note; use a whiteboard with black felt-tipped markers to enable clear view; and also speak or read loud what has been written on the board [24]. Further case studies recommend visual impaired people to use mobile devices as assistive tools to enable them to receive information timely and enable them to interact with their family and friends. Mobile devices have been considered as an effective friendly tool because of the programmable keys that can alert an individual, vibrating function, and the possibility to assign an alert ringtone to a contact with caller identification through the ringtone [25].

2.4 ICT Usage for Visually impaired

In the recent decade, social integration has been regarded as a major problem in the lives of those living with disabilities in many societies and communities in the world [22]. Many countries have setup rules, standards and regulations to try to integrate their citizens with and without disability in order to remove discrimination against each other especially the visually impaired people and these regulations have been enforced to allow individuals with disabilities to take part in education, employment and the community [18]. Visually impaired people are recommended to use assistive technology to allow them to move freely and retain independent life to participate in all aspect of life like other people within the community [8]. Therefore, assistive technologies have been recognised as an important tool that aims to eliminate the gap between what visually impaired people want to do and what current social infrastructure helps them with [18].

To enable social inclusion, assistive technology solutions are recommended to be used especially by visually impaired people in order to eliminate the barriers they encounter that limit them from accessing economic, cultural and social life in the communities [11]. Assistive technology solutions explain the diversity according to

their range from very simple low technology devices to more complicated high technology solutions within the area of assistive technology applications. In order for impaired citizens to use a keyboard, large printed stickers need to be placed on the keyboards in order to allow visually impaired people to make use of the keyboard, the colour of the stickers is usually recommended to be white or black colour that will enhance the visibility of the printed characters [11]. The usage of LMS by VI students has been slowed by many challenges from accessibility to bad design. Some of the other LMS challenges include but not limited to unreliable networks, lack of pedagogical skills on lecturers, poor usability and user preferences [26]. In light of these challenges, several initiatives have been taken by researchers such as [27] to learn why LMS implementation fails in some universities in developing countries. The paper provides the findings and matches these to the current literature findings. It is clear the LMS design is currently not accommodating VI students needs.

3. Methodological Approach

Participatory research using prototyping was used as the research design for this paper. During the participatory design VI students were actively involved in the designing of the proposed LMS. The participatory design assisted in getting creative input to assist in proposing the new design for WiseUp at WSU. This approach was found appropriate as the study sought to incorporate the interests and concerns of the visually impaired students and stakeholder participation in the decision-making process throughout to assist the designers to take responsibility to address the questions and provide suggestions. Thus, qualitative research methods were used to capture the viewpoints of the VI students. Visually impaired students at WSU East London campus who are using WiseUp were targeted. 33 participants were considered through a random target sample. The participants' age range was 19-30 years. Only those who were using WiseUp and could explain their visual challenge were considered. We considered an online questionnaire, WiseUp demonstrations and participatory design.

Data was gathered through administering questionnaires, there were five multiple choice questions, two were open ended questions and six were close-ended questions which were explained face to face and distributed via WhatsApp to students. The interested participants were asked to complete the participation of interest form. This included the participant's details and mobile numbers. The participants were asked if they would like to join a WhatsApp group for the purpose of the study and all participants were willing. The questionnaire was designed without involvement of the VI students. This was to find out if the participants are affected by what is always deemed to be normal i.e questionnaire design. As a solution to involve the participants, participatory design approach was adopted. The participatory design was to complement the gaps found from the questionnaire. This was to allow the participants to contribute to the design of the proposed platform and give input. During the participatory design, learners were asked to draw and design prototypes that suit their needs. This was from interface layout, color selection and font types. The current LMS at WSU was considered and participants went through this platform to give comments of the menus. The comments were captured and used for the redesign.

Participation in this study was voluntary. Those who volunteered to participate were allowed to withdraw at any stage of the research process and had the right to remain unknown. Their personal information was kept confidentially. There were a number of findings obtained, however for the purpose of this study only those findings which show the views of the participants are presented. Screen shots of the current system have been included to show how the current platform looks like.

4. Findings

We have presented the findings based on the methods that were used. Results have shown that VI students are not very pleased with the current WiseUp interface. This is supported by the following findings below.

4.1 Questionnaire results

An online questionnaire was distributed to VI students at Walter Sisulu University College Street Campus Site, 33 students responded to the questionnaire. The responses obtained from the online questionnaire are indicated in the following section. The first section discusses the personal information of the participants and the second section discusses the access of information of the participants.

Table 1: Gender frequency of respondents

	Frequency	Percent	Cumulative Percent
Male	14	42.4%	42.4%
Female	19	57.6%	100%
Total	33	100%	

Another question required the participants to indicate the severity of the blindness using a likert scale ranging from 1 (Total blindness) to 5 (Near normal vision) .

Table 2: Visual severity of respondents

	Number of respondents	Percentage of respondents
Total Blindness	0	0
Near Total Blindness	7	21.2%
Profound Low Vision	11	33.3%
Moderate Low Vision	8	24.2%
Near Normal Vision	7	21.2%

Out of the 33 respondents as indicated in Table 1, none of them chose scale 1 (Total blindness), 21.2% of respondents selected the near total blindness option, 33.3% of respondents chose scale 3 which indicated they had profound low vision, 24.2% of the respondents chose scale 4 which indicated they had moderate low vision while the last 21.2% chose the last scale 5 which was near normal vision. Although seven of the respondents indicated slight visual impairment, when asked about, all respondents using the learning management system (WiseUp), agreed that they had difficulties in reading normal size fonts.

Another question asked required VI students to indicate how often they use WiseUp as a tool for accessing information. Students were required to indicate whether WiseUp was accessed and used every day, regularly, not often or has never been accessed.

Table 3: How often is WiseUp used to access information?

	Number of respondents	Percentage of respondents
Everyday	15	45.5%
Regularly	1	3%
Not Often	17	51.5%
Never	0	0%

As shown in Table 3, 45.5% of students said they access WiseUp every day, 3% mentioned that they accesses WiseUp often, interestingly 17 students (51.1%) mentioned that they hardly access WiseUp, when further asked why they made little use of the learning management system, students mentioned that they had some difficulties in navigating through the system, font sizes used were too small and the colors used were not friendly, and in most cases turned to fellow classmates for information and none of the students mentioned that they have never accessed WiseUp.

The other question requested that students indicate what they usually access WiseUp for, students were to indicate whether they accessed WiseUp for notifications, emails or online discussions.

Table 4: Activities done on WiseUp

	Number of respondents	Percentage of respondents
Notifications	17	52%
Announcements	11	33%
Online Discussions	3	0,09%
Video Links	12	36%
Lecture notes	16	48%
Online Assignments	9	27%

From Table 4, it can be concluded that majority students access WiseUp for notifications such as test weeks, due assignment and new module content. This shows the students minimize the interaction with the platform and only uses it to verify the communication.

Participants were asked to indicate their preference in the design of the LMS and whether they were comfortable with the current LMS design at the Walter Sisulu University.

Table 5: Respondents' opinions on WiseUp's design for visually impaired students

	% Number of respondents – saying Yes	Percentage of respondents – saying No
Do you like WiseUp Home page	0%	100%
Is the content clear and preferred font size	3%	97%
Is the content well-structured with easy to navigate	3%	97%
Are the colors used your preferred choice	0%	100%
Should WiseUp be redesigned	100%	0%

The results collected reveal that the engaged participants are not pleased with the current interface.

The engaged participants were also asked to indicate whether the adoption of assistive technology in the University would be of assistance.

Table 6: Respondents opinions on assistive technology introduction

	Number of respondents	Percentage of respondents
Yes	31	93.9%
No	0	0
Maybe	2	6.1%

As shown in Table 6, more than 90% of visually impaired students said, they would find it helpful if support of assistive technology was introduced, none of them disagreed and 2 students (6.1%) said maybe, when further asked to explain choice of answer, one said they had adapted and adjusted to the system and the other mentioned that he has been used to relying on other students for information

The last question requested the students to suggest how WiseUp as a learning management tool can be improved in order not to only suit a certain generic type of student but to accommodate all students at the university.

Suggestions thereof include:

- Install assistive and adaptive technology
- WiseUp needs constant update
- The use of bigger fonts size and brighter colors
- Customizing color contrast (e.g. lighter background color, darker text color)
- Redesign the system in order to accommodate all students
- WiseUp to be flexible in any kind of device

As mentioned above all students had something similar to say, which included making the use of assistive or adaptive technology, which was either audio and screen readers or having the font size increased and use different colors used.

The overall findings in the research concluded that the majority of the visually impaired students at the Walter Sisulu University College Street site conditions were severe and critical. Visually impaired students preference was of bigger fonts and bright colors that complemented one another. Colors that are neutral and similar were viewed as one and the same thing by the students. A follow up question was distributed to the participants in the form of an email which contained an example of a friendly look and feel design.

4.2 Participatory Design findings

Overview of current Wiseup interfaces

Based on current literature and also as pointed by the participants the preferred colors are as follows:

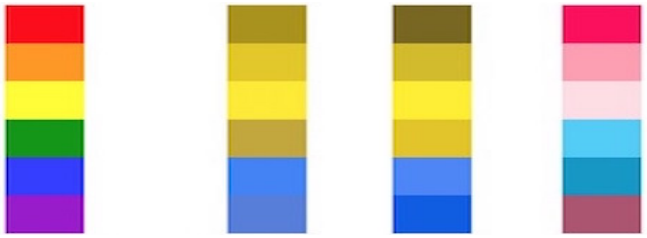


Figure 2 : Participant's color preferences

VI students prefer the combination and mixture of the colors above. The colors are also similar to the most recommended colors for the VI. Besides the colors, participants also mentioned the need of improvement on the current WiseUp design. For example, the current home page is as shown in Figure 3.

It can be noticed that the home page is too busy and has too many sections. The crowded sections make it difficult for the VI students to easily navigate and see clearly.

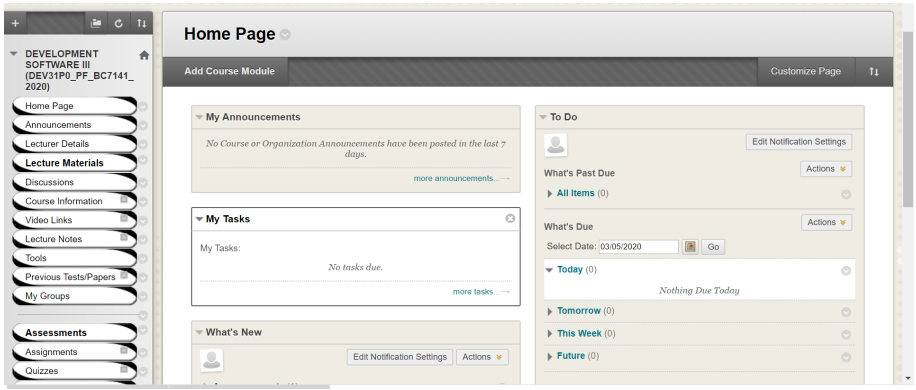


Figure 3 – Current WiseUp homepage

The preferred home page is as shown based on the views and input from all the participants.

Figure 4: Proposed LMS homepage by respondants

The participants prefer an interface where they select or press an option that they want without been disturbed by too many other unnecessary information on the home page. We understand that there were many suggestions and views from the participants, however we have presented the main points as per the diagrams.

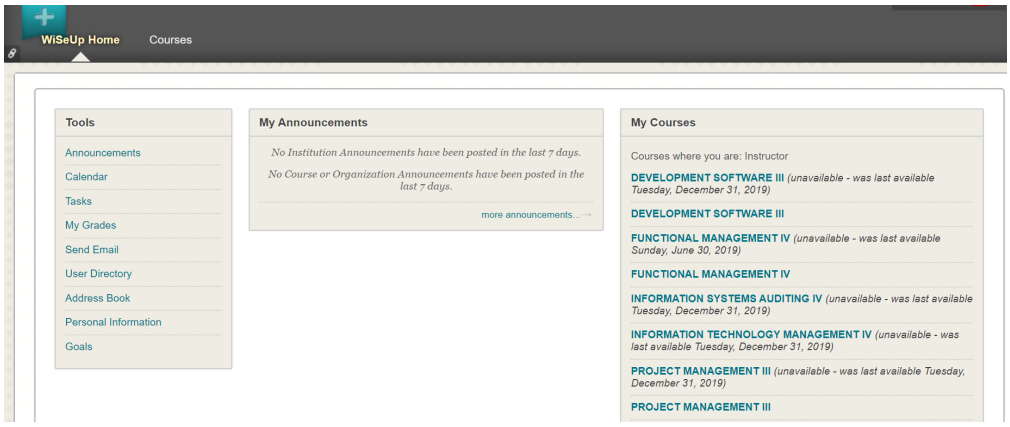


Figure 5: Current WiseUp menu with courses.

Participants mentioned that the courses are not well spaced out and becomes difficult to read. For students who are enrolled for many courses, this screen becomes over populated. The proposed design based on the different designs from the participants is as follows:

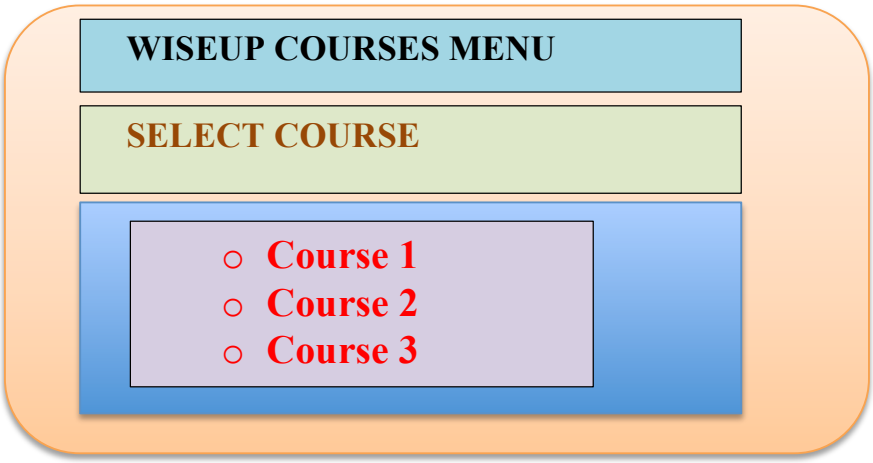


Figure 6: Preferred course page and colors by visually impaired

The most **common** is red/green **color** blindness, where sufferers mix up all **colors** which have red or green as part of the whole **color**. Those affected by Protan **color** blindness are less sensitive to red light, whilst sufferers of Deuteranopia have the same problem with green. Figure 7 is the design that was distributed among

the participant, 29 students (87.9%) of the visually impaired students responded and all agreed that the design was very user- friendly.

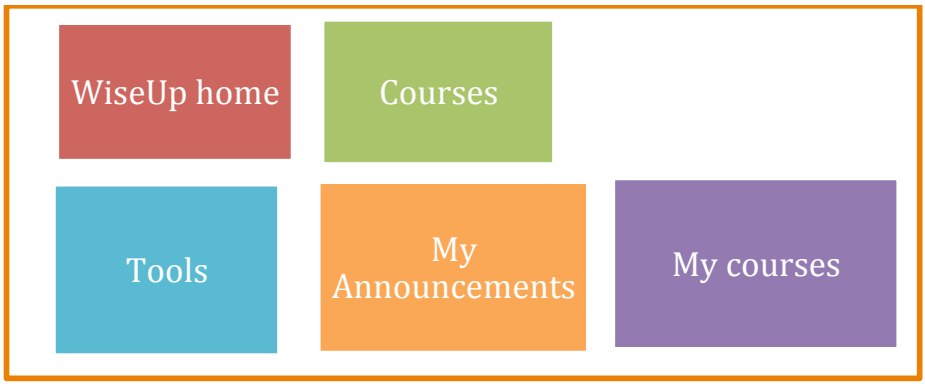


Figure 7: Distributed design

Figure 7 represented assistive or adaptive technology that could be introduced and installed to assist visually impaired students in information access. The design was in line with the barriers experienced when accessing information from the learning management system, they corresponded with the time constraints, the need of wanting to be independent and having equal access to the learning management system.

5. Interpretation of results

The evaluation of the students who are visually impaired at the Walter Sisulu University can be summarized as follows:

- All students with visual impairment need access to academic information
- Visually impaired students indicated difficulty in obtaining information
- WiseUp is used mostly to access notifications (such as module notes and assignments)
- Visually impaired students had a hard time navigating around WiseUp and need support
- Visually impaired students were not content with the current WiseUp design
- All visually impaired students agreed assistive technology on campus or a dedicated place for the visually impaired would be helpful towards accessing information
- Visually impaired students consulted other students for information.

In proposing the redesign, the following design considerations are proposed in order to have a new look of the current WiseUp interface. We argue that it is important for all the software engineers, developers and IT specialist to consider the following design guidelines. The cosiderations are important as could assist to enable LMS to benefit all the users [28].

Design Consideration

The design considerations are intended to allow a designer to design features that can be accessed by any person with or without disability and build the features according to the requirements. The design consideration is categorised into sub groups and presented as sub topics for ease of reference. We have considered the results from a related study by Kanyemba [29]. The considerations aim to provide design guidelines

and planning tools necessary for mobile application accessibility. In order to understand how the mobile information sharing application for visually impaired was designed, some visually impaired participants were asked to use a mobile prototype for preliminary testing purposes. The mobile testing was aimed at gaining participants personal insights on accessibility, though a focus was made on the mobile application prototype. After the testing process was complete, notes were compiled and feedback from the participants was analysed and the findings allowed improving the feature of a mobile information sharing application prototype. From the findings, the following issues need to be considered.

Design for Navigation

From the findings, the study concluded that the mobile application navigation design must link to the expected page, and the images used must not convey ambiguous instructions that will confuse the visually impaired users. The participants also emphasized the use of visual aids for navigation such as the use of screen text magnifier which they recommended other users to use and suggest big bolded font in order to allow those users that do not have screen text magnifiers as was proposed by Kanyemba [29]. Participants prefer a platform that is easy to navigate with right font size and colors.

Design for Usability

During the participatory design process participants demonstrated they would prefer an application that has the following features effectiveness, efficiency, and satisfaction objectives in a specified context of use. The same are raised in the sytudy by Kanyemba [29]. In order to improve ease-of-use of the application, the participants emphasized that the text font size must be large, recommended font size 18 and minimum font size 16; and the font type and style must be recognisable characters, either standard Roman or Sans Serif fonts but the prefered font type is Arial according to the participants. The participants recommended spacing between lines of text to be 1.5, rather than single space because when text are close to each other, visually impaired people face challenges in reading the text [29]. To ensure that the interface contains features that are user friendly and easy to read, the designer should avoid using italics or all capital letters because it will be hard for a visually impaired reader to identify characters.

The findings show also that, different colours used for writing headings and emphasizing the content is difficult to be seen by visually impaired people. The dark blues and greens are most effective colours. The findings are similar to the findings from Kanyemba [29]. The participants suggested that the colour theme used for the navigation links must be brighter colour theme for the text and soft background colour that will not destruct their vision. Furthermore, they added that contrast is the most important factor for improving visual operational features. Text should have the best possible contrast. The colours that were suggested by the participants include the dark or strong colours, black and white colours were chosen because they are visually friendly colours that can allow visual impaired people to read.

Design for adoption

The ultimate goal of innovation is user adoption. In this case, the authors conducted a participatory design and preliminary WiseUp paper prototype testing with an aim to understand the user's needs and expectations. The participants' feedback was used to

propose the features and functionalities of WiseUp. The participants are aware that the usage of WiseUp is very low.

6. Conclusion

The objective of this study was to investigate the perceptions of visually impaired students on WiseUp at WSU (College Street). We have presented the views of the VI students by sharing the current environment and the preferred interfaces. It was clear that VI students have to put in twice the effort and time than the sighted students in order to access information on WiseUp. There have been numerous initiatives to improve and consider VI people at the university, but more could be done. At the time of writing this paper, the findings have not yet been presented to the university. However, it is planned to engage more students including other WSU campuses and conduct further research on the same study. The results are going to be presented and shared to the university at large at appropriate research platforms. We are convinced that the proposed suggestions in this study shall assist LMS designers and developers. Emmerging technologies such as assistive technology should be incorporated to assist VI students to get the needed information. The visually impaired found systems that had fonts of bigger sizes and colors that were bright and complimented one another such as lighter background color, darker text color to be extremely user friendly. We have presented the findings in this study based on the engaged VI students from WSU. The results show the gaps that are available between modern technologies and those individuals with some disabilities. In conclusion, as technologies introduce and implement solutions, it is critical to consider all the users including the VI people. The study assisted in getting the views of the engaged participants. There is no doubt that the requirements of the VI students may be difficult to comply to as the LMS is generally a busy platform. However, the study recommends on the importance of engaging and co-designing LMS with the VI students. It is important where possible to consider the needs and requirements of such students as this will enable the sustainability and inclusivitiness of the VI students.

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Identifying Relevant Factors for an IT Career Choice Model

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Abstract

Research has indicated that scholars choosing careers in Information Technology (IT) are influenced by good career prospects, such as salaries, knowledge of IT career opportunities, the reputation of IT related fields in society and by parents, teachers and role models. Recent research indicates that exposure to new technologies and programming concepts at school level can influence a scholar's IT career choice. Theories relating to career choice have focused on the characteristics of individuals and their environment. Career choice models have identified factors that influenced a student's career choice. Presently, no IT career choice model has been proposed and evaluated in South Africa. Understanding first year students' academic IT career choices, behaviours and influencers would assist academic departments to improve methods and strategies to recruit first year Computer Science (CS) and Information Systems (IS) students.

The purpose of this exploratory study was to propose an IT career choice model, based on existing theories and conduct an exploratory study to determine the factors that influence first year IT students' career choices. A questionnaire was completed by first year CS and IS students. The results indicate that factors such as socialisers, specifically parents and teachers, learning experiences and career perceptions and awareness influenced a first-year student's IT career choice. This study forms the basis for future research to create an IT career choice model and identify the factors influencing a student's IT career choice at South African Higher Education Institutions.

Keywords: IT career choice, career advice, career choice model.

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1 Introduction

Computer Science (CS) and Information Systems (IS) graduates are experiencing a high employment demand from the Information Technology (IT) job market. Current predictions relating to the IT job market are that demand will increase by 12% through to 2024, according to the United States Bureau of Labour Statistics [13]. In South Africa, Kirlidog and Coetzee [19] concur that there is an acute shortage of skilled workers in the IT sector. Research shows the shortage of IT skills is not unique to SA, as many researchers have highlighted that the shortage of IT skills is a global problem [8].

In understanding the enrolment trends at Higher Education Institutions (HEIs) in IT, researchers in the field state that there are several factors that influence students' IT career choice decisions [3, 7, 25]. The factors identified in literature that influence students' decisions to choose IT careers are gender, culture, perceptions, computer experience, advisors, awareness of computer jobs, etc. [4, 11, 17, 25].

Exposure to new computer technologies at home and school creates IT career awareness [21]. Exposure to programming and programming concepts at school level [1] and the use of coding apps on mobile devices [21] creates IT career awareness amongst scholars. Scholars have increased access to mobile devices and social media platforms that can provide them with career information.

Theories relating to career choice have focused on the characteristics of individuals, their environment and more recently, have placed more emphasis on the stages and process of career development [22]. The Social Cognitive Career Theory (SCCT) has developed from Bandura's [6] general social cognitive theory. Alshahrani, Ross and Wood [2] indicated that the SCCT can be used as a framework for understanding how personal, cognitive and contextual factors influence career choices.

The SCCT is a theory that has become a fundamental model to study how young people develop interests and career choices [5]. In this study, an IT career choice model is proposed based on the SCCT theory and previous career decision models [15]. An exploratory study was undertaken to verify the selected factors identified from literature that influence students' first year IT career choice and decisions.

The layout of the paper is as follows. In Section 2, the research problem and research questions being investigated are introduced. Section 3 provides a literature review, which focuses on career decision theory, the IT career perceptions of students, their sources of information regarding careers and their IT career perceptions and awareness. The results of the pilot-study are discussed in Section 4. The paper is concluded in Section 5, where limitations and future research are also presented.

2 The Research Problem and Research Design

Organisations are increasingly recruiting CS, IS and IT university graduates and there is higher demand for IT graduates/professionals who can satisfy the demand [11, 19]. First year students have made a career choice to enter the IT profession and an understanding of the factors influencing IT, CS and IS students' career decisions are important. Therefore, five research questions were addressed in the first year IT career choice survey, namely:

1. *What theories exist to base a proposed IT career choice model on?*
2. *What factors influence first-year students' decisions in pursuing a career in IT?*
3. *What were the first-year students' perceptions of IT at school?*
4. *Who provided information about careers in IT?*
5. *What was the first-year students' initial IT career choice?*

A first-year questionnaire was compiled using a similar questionnaire used in previous studies [9]. In order to determine personal perceptions and honest information, it was decided to keep the survey anonymous. The first-year questionnaire consisted of the following sections:

- Biographical details;
- Socialisers - Sources of influence;
- Learning experiences;
- Career perceptions and expectations; and
- Career awareness.

The questionnaire was captured using an on-line survey tool, QuestionPro. The data were collected from first year students enrolled for either a BSc CS or BCom IS programme at a Comprehensive university in South Africa. The research study focused on these programmes as these students intend majoring in CS or IS and pursue an IT career. The data were statistically analysed using Statistica and the qualitative results were thematically analysed using AtlasTi. Ethics approval was obtained from the Nelson Mandela University Ethics Committee, #H2010BUSBS15.

3 Literature review

3.1 IT Career choice theory

Theories relating to career choice have focused on the characteristics of individuals and their environment [28]. Additionally, other theories have placed more emphasis on the stages and process of career development [22]. The Social Cognitive Career Theory (SCCT) has developed from Bandura's [6] general social cognitive theory and aims to understand the processes and outcomes whereby individuals develop interest and make decisions about their educational and occupational pursuits [20].

Alshahrani, Ross and Wood [2] state that the SCCT is a framework for understanding how personal, cognitive and contextual factors influence career choices. Additionally, Seymour and Serumola [29] indicate that SCCT is a theory that shows the influence of structural and individual factors. The SCCT postulates that the perceived social and cultural environment affects the development of career-related self-efficacy, which molds experiences related to vocational interests, goal choice and performances [8]. According to research, the SCCT is a theory that has become a fundamental model to study how people form interests, make choices and achieve different levels of success in both academic and career pursuits [5].

A computing and information technology (CIT) career decision model that included factors related to a student's plans to take CIT courses was developed by Downes and Looker [15]. The model included factors on home use and access, parental educa-

tion and school related variables. However, Dick and Rallis [14] developed an earlier career choice model to determine the factors that shaped the student's career goals. The factors included in the Downes and Looker [15] model were based on previous theoretical models. Fig. 1 depicts the factors included in previous models and specifically focuses on socialisers, as the central influence on a student's career decision. Socialisers can exert influence on the perceptions and interpretations of expectations [14]. Therefore, the career choice model focuses on the socialisers having a major influence on a students' decision to enrol for careers in Mathematics, Sciences and IT.

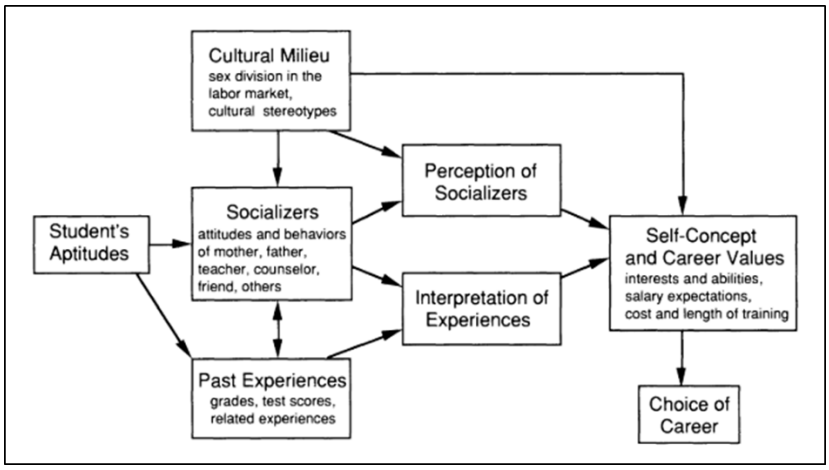


Fig. 1: Career choice model [14]

3.2 Socialisers

Cohen and Parsotam [12] state that the primary determinants of a student's career and study choice is the student's perceptions of IT at school. Additionally, they include stereotypes students have for the IT field/professionals and job availability. Hodges and Corley [18] further add that job availability does influence students' career choice. Students' IT career choice is further influenced by the reputation of IT-related fields in society [25].

Other factors that influence students' perceptions are opportunities for employment and salaries, access to technology at school and home and a students' perceptions of IT at school level [23]. Stone [26] indicated that at school level, students can form misperceptions regarding careers in IT. Factors such as gender, socioeconomic status, societal norms and access to information technologies all contribute to the misperceptions.

3.3 Sources of information

In South Africa, the factors affecting IT career choices have been extensively researched. Most of the studies indicate that IT graduates entering the IT industry were not familiar with IT careers, career descriptions and career opportunities [10, 12]. In a

number of countries there are many initiatives to promote careers in IT. In the U.S.A, scholars and tertiary level IT students are educated about IT careers and IT career opportunities.

The sources of information that scholars use to obtain information about IT careers were identified in a previous study [9]. These sources included career websites, university websites and Open days. The Open days allow scholars to visit universities and learn about different careers. Academic departments set up stalls to market careers and academic programmes during an Open day. Other sources of information include school visits, brochures and visits to academic departments.

Students receive advice from family, peers and teachers. This is referred to as social support, which students need in making career choices [2]. Additionally, interest, awareness and views from family and professionals have also been regarded as influencers to students' choice of pursuing a career in IT [4, 12]. Several studies have identified the support from family, friends, teachers and career advisors as key influencers for scholars' decisions in choosing a career [25, 26].

3.4 Learning experiences

Previous exposure to programming environments and programming experience are factors that can influence first year students' IT career choice [1]. In a study, examining the benefits of prior programming experience with the performance of students in CS1 courses, the findings indicated that female students with prior programming experience outperform male students [31]. Potter et al. [23] additionally found that exposure to technology at an early age creates an interest in pursuing an IT career.

Sugiyarlin [27] highlighted the importance of career maturity in adolescence and to obtain a career maturity profile as a reference to build career programs that create learning experiences that develop the career maturity of high school children. A career maturity programme can be arranged at school level based on the needs of scholars to develop skills in choosing a career. Introducing scholars to programming concepts assists scholars to develop programming skills and choosing an IT career [21].

3.5 Career perceptions and awareness

The National Association of Colleges and Employers (NACE) provide an extensive list of careers graduates can pursue. The NACE reports that there are fifty-five different IT job categories offered to IT graduates with degrees relating to Management Information Systems in 2006. Academic departments at universities generally do provide information about various careers to students. Additionally, HEIs have graduate placement services, which prove to be valuable sources of information. Hence, students are encouraged to investigate a range of possible career opportunities [25]. Creating awareness of careers in computing and the prospects of a better quality of life should be created amongst students [24].

IT students graduating from tertiary institutions are generally not aware of the possible IT career opportunities and career tracks available and are uninformed about IT job titles and IT job descriptions [10]. The study showed that there is a significant statistical difference between career knowledge students indicated they perceived they possessed and their actual career knowledge. In a further study by Esterhuyse et al.

[16] it was found that post-graduate CS and IS students were generally not familiar with IT job titles, job descriptions and career opportunities available in industry.

3.6 Proposed IT career choice conceptual model

The proposed IT career choice conceptual model (Fig. 2) indicates the factors identified from theories and career decision models that influence a student's career choice [14, 5]. The important factors included in the proposed IT career choice conceptual model are the socialisers, learning experiences, career perceptions and awareness. The socialisers specifically focused on the role parents and teachers played in their child's career decision. The self-attributes were not included due to time constraints and ethical approval.

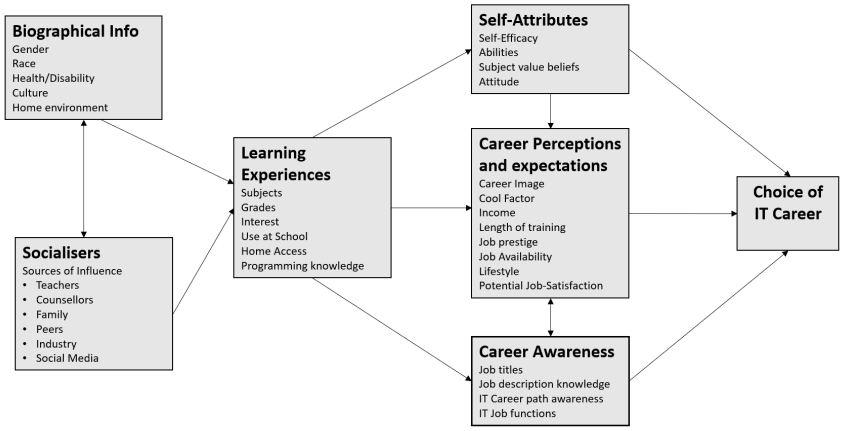


Fig. 2: Proposed IT Career choice conceptual model

4 Results

The qualitative and quantitative data analyses were conducted, and the research findings are discussed in the following sub-sections, namely:

- Biographical details;
- Socialisers - Sources of influence;
- Learning experiences;
- Career perceptions and expectations; and
- Career awareness.

4.1 Biographical Details.

The first-year survey was completed by 205 students who were registered for the BSc CS and the BCom IS programmes at the Nelson Mandela University. Table 1 shows that the sample consisted of 154 males and 51 females. The sample included 43% Black, 48% White, 7% Coloured and 2% Asian students. The citizenship of the

total group was mainly South African (86%, n=185). A small number of students were from Botswana, Malawi, Namibia, Zambia and Zimbabwe.

Table 1: Group and Sample Size

First year CS/IS programmes				
Gender	**Male**	**Female**	**Total**	
	154	51	205	
Race	**Asian**	**Black**	**Coloured**	**White**
	5	89	19	92
Nationality	**South Africans**	**Foreigners**		
	185	20		

This exploratory study focused on first year students who have chosen BSc CS and BCom IS programmes. The sample of 205 students were made up of 58% BSc CS (n=119) and 23% BCom IS (n=48) students (fig. 3). The 'Other' group (n=38, 19%) was made up of other degrees, for example students registered for a BA degree with music and IS. The results indicated that more students register for the BSc CS programme compared for the BCom IS programme.

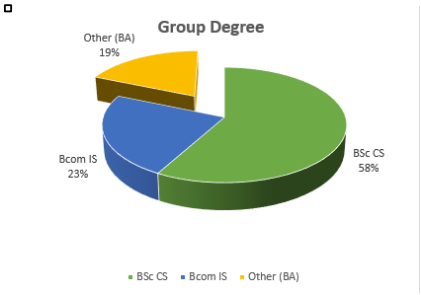
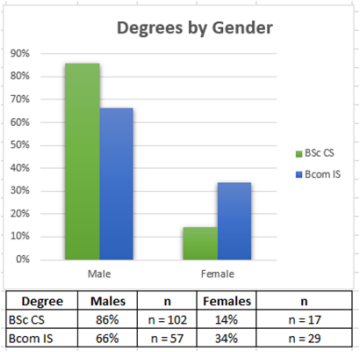


Fig. 3: Degree percentage from sample



Degree	Males	n	Females	n
BSc CS	86%	n = 102	14%	n = 17
Bcom IS	66%	n = 57	34%	n = 29

Fig. 4: Degrees by Gender percentage

Fig. 4 indicates a high percentage of males at 86% (n=102) and 66% (n=57) registered for respectively for BSc CS and BCom IS. However, there is a low percentage of females compared to males at 14% (n=17) and 34% (n=29) respectively for BSc CS and BCom IS. The BA students in this group was registered for the BCom IS modules. It is noteworthy, to see that more females register for BSc CS than BCom IS.

4.2 Socialisers - Sources of influence

The source of influence (fig. 5) for first year students' shows that more than 42% of students view the adverts in their school magazine as not useful. The NMU and

departmental website (84%), Open day (73%), brochures to Matrics (73%), social media (63%) and visits to schools by the department (63%) were regarded as useful by the respondents. Parents (75%), Teachers (7%), Friends (69%) and Career counselors (65%) were considered useful by the respondents.

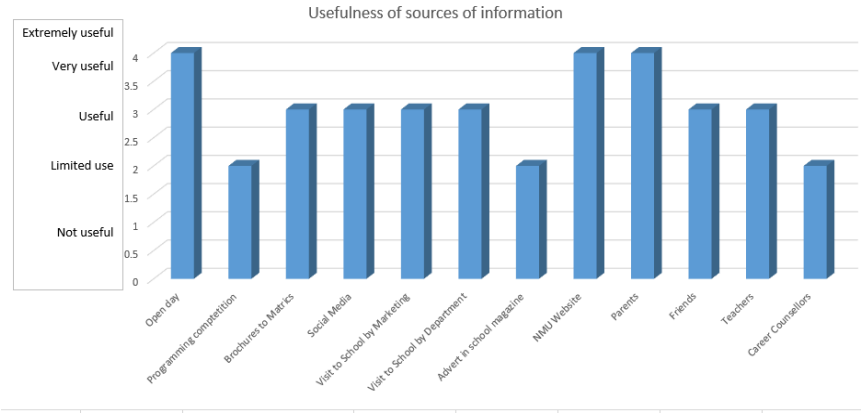


Fig. 5: Source of Information

The career advice had three sections that were open-ended questions:

1) Who provided you with career advice?
2) Career advice parents provided; and
3) Career advice teachers provided.

Who provided you with career advice?

The people who provided career advice to first year students are depicted in Fig. 6. Thirty students received advice from friends. Friends have not been significantly highlighted as a socialiser in previous studies, however role models have [15]. It is important that the item *friends* be included in the IT career choice model and further explored. Eighteen respondents did not receive any advice, eighteen from family, while eight did their own research. Lecturers were a source of advice as they provided advice to 10 respondents. The rest of advisors were career counsellors, people in industry, student counsellors, pastors and two teachers. These findings support related research findings that parents, family and friends are important sources of information for students [25, 23]. Stone's [26] research findings stressed the importance of teachers, career counsellors and parents. One respondent indicated that he received career advice from the "KFC counter girl".

Career advice parents provided

The data were analysed using thematic analysis to group the sentiments into categories and sub-categories (Fig. 7). There were four main categories for career advice provided by parents:

1) Advice focused on Feelings;

2) Advice focused on the Field of study;
3) Advice focused on the Benefits of a career; and
4) Other or no advice.

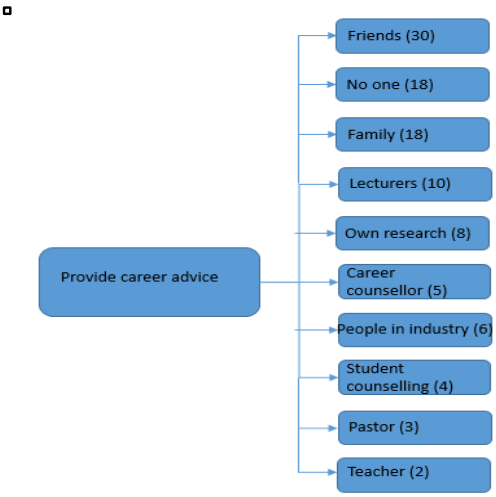


Fig. 6: Career Advice Provider

The parent's advice that focused on feelings encouraged the students doing what they like (n=32), what the students love (n=20) and students following their dreams. The field of study category had 26 responses, where mainly 13 parents encouraged pursuing an IT degree (Software Engineering, BSc CS, etc.), seven students were encouraged to pursue a medical field (medical doctor, pharmaceutical studies) and lastly parents encouraged the pursuit of any university degree or a dynamic degree. These results support similar research findings that family, peers and educators influence students' career decisions (Stone, 2018).

There were 10 responses categorised as benefits of a career, with five responses focused on the pursuit of a qualification, which will provide various opportunities for growth, five responses on a qualification that will bring money and lastly a career that will be stable and there must be a scarcity on the field had one response each. The last category focused on 15 students indicating that there was an absence of parental advice and two students who made their own choice.

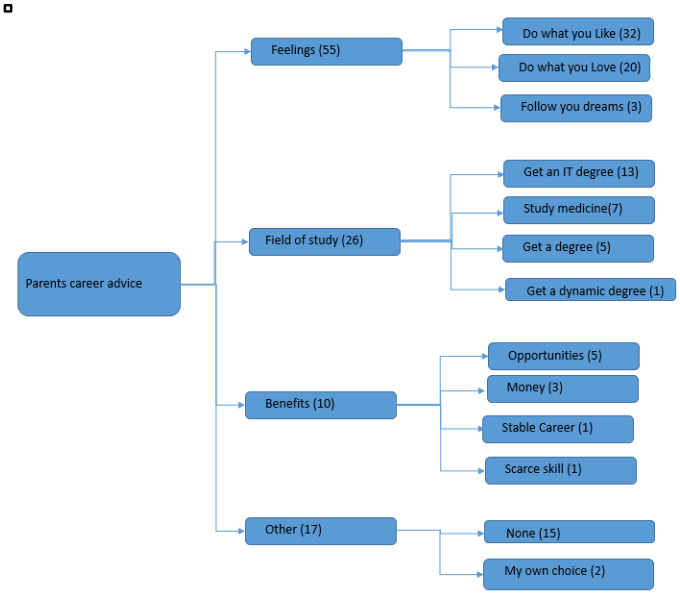


Fig. 7: Thematic rendering of Parents advice

Career advice teachers provided

This sub-section examined the advice given by teachers to the first-year students when they were at school. Fig. 8 shows advice provided by teachers. The students (n=29) indicated that they did not get any advice from teachers. Secondly, 18 teachers encouraged the students to do what they are good at and love. Studying at a university was encouraged by 16 teachers. Fifteen students were encouraged by teachers to choose their careers wisely. Regarding the field of study, 9 teachers directed students to pursue medical studies or engineering. Seven teachers gave direct advice to students to study IT degree related courses while the same number encouraged students to go into business.

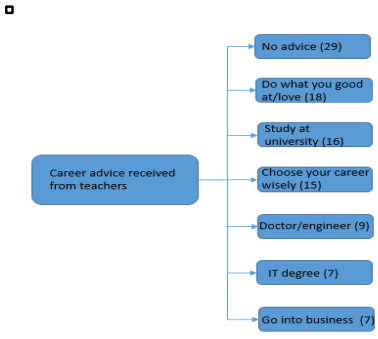


Fig. 8: Advice provided from Teachers

4.3 Learning experiences

The results from the open-ended questions indicated that 62% (n=128) had a computer lab at school. Thirty one percent (n=65) had IT as a subject at school and 38% (n=78) indicated they had CAT at school. The respondents further indicated that 86% (n=176) had access to a computer at home and 75% (n=153) had access to the Internet on their home computer.

4.4 Career perceptions and expectations

Stone [26] indicated that at school level, students can form misperceptions regarding IT careers. In this study, several statements were used to address the perceptions of students regarding IT at school. The perceptions of IT amongst the first-year students is shown in Table 2 using a 5-point Likert Scale. The data for Strongly disagree and Disagree as well as Agree and Strongly agree have been combined for discussion purposes. For the total group (n=205) 42% disagreed and 43% were neutral on the statement: *IT at school is difficult*. An overwhelming 94% disagreed that *only nerds take IT as a subject*. Only 28% disagreed that *CAT is an important subject at school* and 58% disagreed that *jobs were scarce in IT*. The majority (71%) agreed that *IT people receive good salaries* and 88% that *IT people can get work internationally.*

Table 2: Perceptions

Item	SD/Disagree	Neutral	Agree/SA
IT at school is difficult	87 (42%)	88 (43%)	30 (15%)
Only Nerds take IT as a subject	169 (82%)	24 (12%)	12 (6%)
CAT is an important subject at school	58 (28%)	62 (30%)	85 (42%)
Jobs are scarce in IT	119 (58%)	61 (30%)	25 (12%)
IT people receive good salaries	5 (2%)	55 (27%)	145 (71%)
IT people can get work internationally	4 (2%)	19 (9%)	182 (88%)

4.5 Career awareness

In this paper an extensive list of 33 IT professional careers, which are a combination of IS and CS job titles, were quantitatively evaluated by asking students to indicate their choice to the question *"What was your initial career choice?"*. Fig 8 shows some of the IT job titles that were indicated as initial career choices for the first-year group. Fifty two percent of students chose programming as their initial career choice, while 33% chose software engineering.

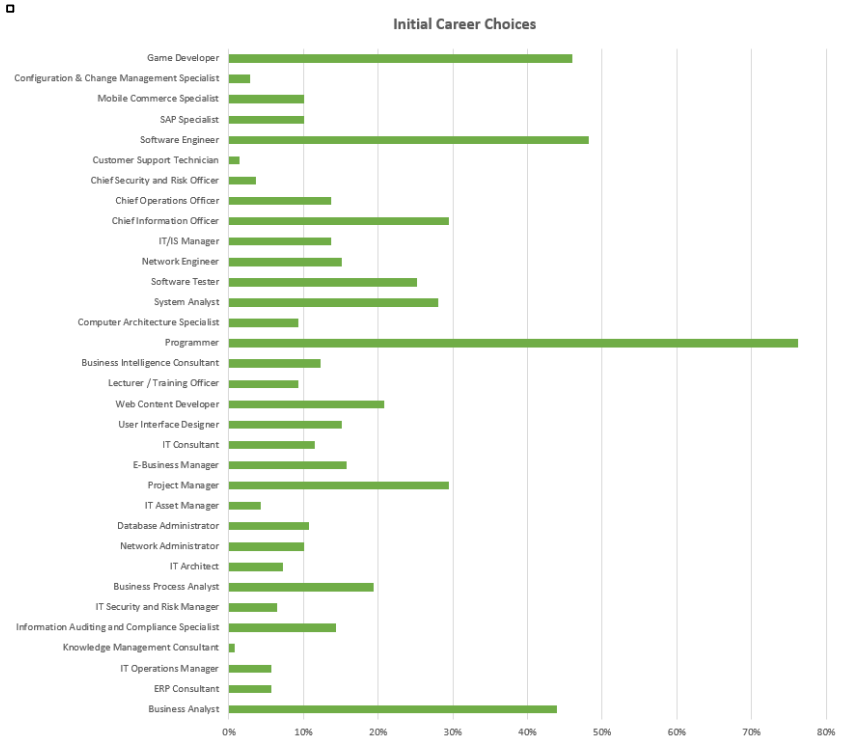


Fig. 9: Initial Career Choices

The results were further analysed and some differences between the two groups, BSc CS and BCom IS were found on their initial IT career choices. The BSc CS group chose mainly technical careers in IT, Game developer, programmer, mobile commerce specialist, SAP specialist and Configuration and Change management specialist. The BCom IS focused on ERP consultants, Business Process Analysts, User Interface Designer and managerial positions. The students were provided with a list of IT job titles, from which they had to choose IT career choices (Fig.9). The career awareness, however, needs to be further investigated as previous research indicated that CS and IS graduate and post-graduate students were unaware of industry career paths and job titles [10, 16].

5 Conclusions

The SCCT developed as a main theory used in models explaining student's career choices [20]. The proposed IT career choice conceptual model (Fig. 2) developed in this study, indicates the factors identified from theories and career decision models that influence a student's career choice [14, 5]. The important factors included in the proposed IT career choice conceptual model are the socialisers, learning experiences, career perceptions and awareness.

Research has indicated that socialisers, such as family, parents, teachers and friends are key influencers for scholars' decisions in choosing an IT career [25, 26]. Recent research indicates that exposure to new technologies and being taught programming concepts at school level using mobile technologies can influence a scholar's IT career choice [1, 23, 21].

The sources of information that the first-year students identified in this study as useful were the university website, career brochures, Open days and visits by and to academic departments. The qualitative analysis of the career advice offered to the first-year students indicated that advice offered by friends and family were highly regarded and that teachers, student counsellors and career counsellors provided limited advice. The advice offered by both parents and teachers included common themes, such as students were encouraged to do what they love or liked, to choose their career wisely and study at university. These findings support related research findings that parents, family and friends are important sources of information for students [25, 23].

The learning experiences' results indicate that 62% of the respondents had access to a computer lab at school. Thirty one percent had IT as a subject at school and 38% had CAT as a subject at school. The respondents further indicated that 86% had access to a computer at home and 75% had access to the Internet on their home computer.

The career perceptions of the first-year students at school regarding IT indicated that they did not perceive IT at school to be difficult. The majority (82%) did not see that only nerds take IT as a subject. They agreed that IT people receive good salaries and 88% indicated that they agree that IT people can get work internationally. Only 42% agreed that CAT is an important subject at school.

The students' career awareness indicated that their initial career choice in first year at university indicated that BSc CS students mainly focused on job titles such as computer programming, computer architecture and networking engineer. The BSc CS group seems to have mainly focused on a technical career initially. The BCom IS group focused on IT job titles such as ERP consultancy, IT Assets Management, systems and business analyst.

The research study has given insight into first year students' perceptions of the factors that influence their IT career choice before pursuing or enrolling for an IT qualification at university. The study has further given an in depth understanding of what sources were useful for first year students making a career choice. Finally, the study probed career advice received or given to students before university and students' initial career choices.

The limitations of this study were a relatively small sample size and the inclusion of respondents from one department. Additionally, these students have chosen a career in IT, which could bias the findings. Future research can address these issues and include respondents from different faculties. The next step in this research process is to conduct an extensive survey amongst first year students and to statistically examine the factors that influence a student's IT career choice and to validate the proposed IT career choice model. The statistical analysis will include Exploratory Factor Analysis and Principle Component Analysis. Finally, this exploratory study assisted in verify-

ing selected factors that influence a student's IT career choice. The research will contribute to the IT career choice theory, which is based on SCCT.

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Short Papers

Guidelines for IT Industry Advisory Boards at Higher Education Institutions in Southern Africa

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Abstract

The use of Industry Advisory Boards (IABs) can ensure programme quality and the compliance with international curriculum standards, such as the ACM curricula recommendations. An IAB can provide a platform to discuss topics such as Information Technology (IT) trends, graduate education standards and industry requirements. Academic literature provides general guidelines on the role and responsibilities, membership and functioning of IABs. Accreditation bodies provide guidelines for the implementation and functioning of IABs at Higher Education Institutions (HEIs). Presently, there is insufficient recent literature on the accreditation board requirements for IABs at HEIs in Southern Africa, specifically relating to departments teaching IT. Limited studies on best practices and guidelines for the use of IABs at HEIs in Southern Africa exist.

The aim of the study is to propose a set of guidelines for Computer Science, Information Systems, Information Technology and other related schools and departments at HEIs in Southern Africa, for managing their IABs. An IAB questionnaire was compiled and sent to the Heads of Departments (HODs) of 32 universities in Southern Africa. A total of 35 HODs or representatives at 21 HEIs completed the survey. The data were statistically analysed and the results of the study can be used to develop guidelines and best practices for departments seeking accreditation with the South African Computing Accreditation Board (SACAB). The data analysis included responses from South African traditional research universities, comprehensive universities and universities of technology. Additionally, S.A. universities' results are compared to other Southern African universities, including Botswana, Mauritius, Namibia and Zambia. A set of guidelines are proposed for the implementation and functioning of IABs. This research study will assist academic departments to maintain IAB best-practices, as required by accreditation body requirements and standards.

Keywords: Industry Advisory Boards, guidelines, accreditation bodies.

Proceedings of the 49th Annual Conference of the Southern African Computer Lectures' Association (SACLA 2020)

1. Introduction

Academic departments in Computer Science (CS), Information Systems (IS) and Information Technology (IT) at Higher Education Institutions (HEIs) in South Africa offer degree programmes that comply with the international organisation ACM curricula recommendations [2]. Academic departments maintain and update these curriculum programmes by implementing ACM guidelines, such as CS (CS2016), IS (IS2010) and IT (IT2017); and by following industry IT trends. Industry, employing graduates from these departments, require graduates to obtain relevant knowledge and skills to become productive members in organisations. There is, however, a gap between the classroom and real-world practice [19]. There seems to be a mismatch between the skill sets expected by employers and students' formal learning experiences [11].

Successful industry-university collaboration benefits all parties. The industry partners may acquire a more skilled workforce and universities can benefit by developing awareness of business requirements [21]. An industry advisory board is one form of industry-university collaboration (others are, for example, training programmes, internships and mentoring). Advisory boards provide opportunity for engagement with external stakeholders and enable response to external policy drivers. They can be used to support industry and / or community engagement [22].

Industry Advisory Boards (IABs) perform an important function at HEIs and provide a crucial link between academia and industry. IAB industry members provide important feedback on academic programme relevance and have become an important activity at CS, IS and IT departments at HEIs [9]. IABs provide an important perspective and are a valuable source of advice on academic matters, student employment and guidance for academic department members and for students [18].

Academic departments use IABs to provide diverse viewpoints [18], provide advice to customise or strengthen academic programmes [18, 16], programme quality and provide advice on course content [6]. IABs further monitor the effectiveness of curriculum programmes and the performance of graduates. They provide guidance on the latest industry and technology trends and the needs and graduate requirements of industry [16]. In cases where academic programmes are accredited by international accreditation bodies, they assist academic departments to meet the requirements for accreditation [16].

Academic schools or departments must ensure the careful planning and management of an IAB, as a number of challenges must be overcome to maintain an efficient IAB [20]. Facilitating an effective IAB is advantageous for HEIs and academic departments. However, there are not sufficient guidelines available to provide CS, IS and IT departments at HEIs in Southern Africa, on how to use an IAB in the most effective way. Departments that do not have an IAB can gain from a set of guidelines for the establishment and use of IABs. Departments that do have an IAB can use these standard best-practices to ensure that they use the IAB in the most effective and efficient manner. Advisory boards can have positive outcomes for faculty, students and board members.

IABs are an under-researched contributor to education and it has become essential to conduct research regarding the functioning of IABs, as there is limited academic literature on their functioning [23], specifically in the Southern African context [20]. This paper provides the current practices by CS/IS/IT departments in Southern Africa, including Botswana, Mauritius, Namibia and Zambia. The research problem, the main research question and the IAB survey are discussed in Section 2. Literature on IAB composition, meetings, roles and responsibilities are discussed in Section 3. The IAB survey results are presented in Section 4. IAB guidelines for South African universities are provided in Section 5. Conclusions and future work are discussed in Section 6.

2. The Research Problem and Research Design

The lack of scholarly interest in advisory boards may limit the understanding of the advantages and complications of IABs [17]. Further research on IABs would help departments better understand the role and attributes of advisory boards, as well as how to best realise their potential [23]. Presently there is a lack of studies on best practices and perspectives relating to the effective use of IABs, specifically in South Africa [20]. Sources differ on factors of effective and efficient IABs, such as membership composition, size, meetings and management [7].

The research problem investigated in this study is based on the realisation that there are insufficient guidelines on the use and functioning of IABs by HEIs in Southern Africa. Only a limited number of CS and IS programmes are accredited in South Africa and the HEIs presenting these programmes have to comply with the international accreditation body's IAB requirements. The South African Computing Accreditation Board [15] needs to provide IAB guidelines as an accreditation body in South Africa and this study lays the foundation for specifying these IAB guidelines.

The research question addressed in this study is: *What IAB guidelines can assist CS/IS/IT departments at HEIs in Southern Africa to effectively manage an IAB?* The aim of the study is to provide guidelines on the functioning and best practices for CS/IS/IT schools and departments at HEIs in Southern Africa. An IAB questionnaire was compiled from similar studies discussed in literature [20, 6]. The survey was completed by HODs or representatives from South African and Southern African universities, including, Botswana, Mauritius, Namibia and Zambia. The IAB questionnaire consisted of the following sections:

- Biographical details;
- Twelve open-ended questions relating to the use of an IAB by the specific department/school; and
- Likert scale questions relating to IAB membership, IAB meetings and documentation, roles and responsibilities and functioning.

The questionnaire was captured using the Nelson Mandela University on-line survey tool, QuestionPro. The next step in the research process was contacting the Head of Departments (HODs) from the 32 universities in Southern Africa. The first call for participation was distributed via e-mail to

the HODs listed on the SACLA HOD list and later followed by personal requests to HODs. A total of 26 HODs or representatives completed the survey over a six-week period. The data were statistically analysed using Statistica and the qualitative results were thematically analysed using AtlasTi.

3. Industry Advisory Boards

There are many definitions of Advisory Boards, which all share a common theme, that an advisory board's main role is to serve the university and provide it with feedback on what is important for companies/organisations outside the university that will hire their graduates [6]. The use of advisory boards to help and advise educational programmes is common across most university departments, regardless of their field of study [7]. Advisory boards in education institutions are voluntary and are composed primarily of industry practitioners who provide advice on education programmes and their relevance. An Advisory board does not have any formal legal responsibilities. Rather, an advisory board is convened by the organisation to give advice and support [12]. Advisory boards are an important resource that can enrich academic departments and should consist of practitioners dedicated to improving the education provided to students through suggestions on curriculum and course topics [19].

The main role of an advisory board is to introduce an industry perspective on the current desired efficacies and skills that the academic department has to deliver [3]. Aligning with the needs of the workplace ensures that the content covered in the programmes is relevant. Nehls and Nagia's [13] study found that advisory board volunteers can be a very valuable constituency for institutions of higher education. The benefits are both internal and external. Internally, guidance and advice were received. Whereas the external benefits are the positive messaging the board members relay in public settings as well as their association with the institution.

Departments must ask why an IAB is being established and what do they want to achieve from it? Determining an advisory board's purpose will ensure that it will be structured to maximise its contribution to an organisation's success [14]. Mission and objective statements are important for setting the direction and structuring conversations for the board. This can include educational goals (curriculum design), research goals, funding and reputational activities, e.g. bringing in high profile speakers [10].

The roles and responsibilities of an IAB need to be clarified. There are advisory boards that inform research, where others give advice with curriculum content and job placement. The board meetings should be used as a platform for academics to share current research to indicate the creation and advancement of knowledge [19]. One aspect of the advisory board's contribution could be the introduction of a mentoring programme so that the Advisory Board can give input to students as well as faculty [19]. Creating opportunities for board members to interact socially benefits group dynamics and allows board members to network [13].

It is important that advisory boards make the best use of the valuable time industry and faculty members spend on meetings, etc. Board members must understand exactly what is expected from them [17]. Mandviwalla et al. [10] recommend that the board should meet often as regular meetings maintain continuity. Dates need to be established a year in advance. Efficient planning of the agenda of meetings is very important. This also shows respect for members' time. Meetings should focus on specific issues, decided on in advance and supplemented with occasional e-mails and reports [17].

The functioning of an IAB is affected significantly by how effectively the board's activities are organised and directed. The number of members on an advisory board is important [14] and running an effective IAB meeting is essential. An effective chair must be chosen and that chair must be committed to running effective meetings. A well-run meeting requires that an agenda be established and that adherence to the agenda be enforced. Time management is important. Care in the selection of companies from which members are taken is important, as the business relevance to the programme objectives must be considered [5]. Craig [5] also advises that members who understand higher education should be chosen. A healthy balance of members from a diverse representation of the relevant profession is ideal [17]. It is also important to have members in different stages of their careers.

Members early in their careers can provide suggestions for the knowledge, skills and competencies required when beginning a career. Members in higher-level positions are able to identify the skills that are increasing or decreasing at all levels of the organisation. Members who are more senior also provide valuable advice with respect to strategic initiatives and long-term planning [19]. The authors indicate that considerable thought needs to go into various aspects of a board, specifically the members of the board. Members should mainly represent industry but high school teachers, who provide a link to future

students should be considered as well as academics from other departments who provide collegial input [8].

The Technology Accreditation Commission (TAC) of the US Accreditation Board for Engineering and Technology [1] stipulates that each accredited programme must have an industrial advisory committee composed of industrial representatives. The British Computer Society (BCS) stipulates that their accreditation of degree programmes provides an indicator of quality to students and employers and provides independent recognition for the institutions that offer them [4]. When considering accreditation, the BCS seeks evidence of (amongst other requirements) the involvement of external experts and students.

The South African Computing Accreditation Board (SACAB) is made up of senior academic and industry representatives in S.A. and is currently implementing accreditation guidelines for degree and IT diploma programmes. The SACAB will evaluate and endorse CS/IS/IT degree programmes at HEIs in S.A. These programmes must comply with international standards, supporting international portability of degree programmes and provides graduates with career paths and skills required by the IT industry [15]. From the above it is clear that Accreditation Boards worldwide require departments to have an Industry Advisory Board in place.

4. Advisory Board Survey Results

The *IAB* survey was completed by representatives from universities in South Africa (n=19), Namibia (n=2), Zambia (n=1), Botswana (n=1) and Mauritius (n=1) (Table 1). The distribution is presented in fig. 1. A total of 33 universities were listed in the survey and 27 HOD's and 9 HOD representatives from 35 departments at 21 universities in Southern Africa completed the survey (fig. 2). The respondents included departments / schools of Computer Science (n=9), Information Systems / Informatics (n=11), CS&IS (n=4), Schools of ICT (n=4) and 7 other related departments. Responses were received from traditional Research universities (62%, n=11), Comprehensive universities (27%, n=5) and from Universities of Technology (12%, n=5).

Fig. 1. Response distribution

Country	Universities
Botswana	1 (5%)
Mauritius	1 (5%)
Namibia	1 (5%)
South Africa	17 (80%)
Zambia	1 (5%)
Total	**21 (100%)**

Table 1: Responses received from countries

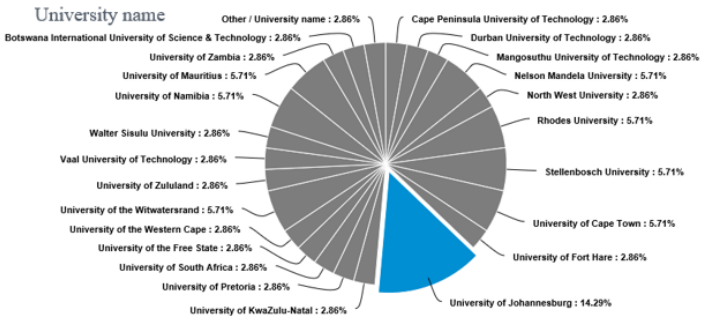

Fig. 2. Southern African universities that participated in the study

Sixty-six percent (n=23) of the respondents from 35 departments indicated that they had an IAB. Fourteen of the 23 departments that indicated they had an IAB provided detail feedback on the survey. The respondents (34%, n=12) that did not have an IAB indicated that:

- They were in the process of establishing an IAB (n=6);
- They have an informal IAB (n=3);
- The IAB does not serve their needs (n=2); and

• Informal arrangements with companies in industry (n=1).

The membership size of the IABs on average were 22 members, with a minimum of 9 and a maximum of 50 (Table 2). Four departments indicated they included academics from other Higher Education Institutions on their IAB. The number of years the departments have had an IAB ranged from 4 years to 20 years, with an average of 10 years. The frequency of meetings ranged from 1 to 4 times a year. The average was 1 to 2 meetings per year (Table 2). The duration of the meetings ranged from 1 hour to 6 hours. The average duration of IAB meetings were 3 hours.

IAB membership size	Count (%)	Frequency of meetings	Count (%)	Duration of meetings	Count (%)
9	1 (7%)	1	9 (64%)	1	2 (14%)
10	4 (30%)	2	4 (29%)	2.5	1 (7%)
14	1 (7%)	4	1 (7%)	3	6 (44%)
20	2 (14%)			3.5	1 (7%)
22	1 (7%)			4	2 (14%)
25	1 (7%)			5	1 (7%)
30	2 (14%)			6	1 (7%)
40	1 (7%)				
50	1 (7%)				
Total	14 (100%)	Total	14 (100%)	Total	14 (100%)

Table 2: IAB size, frequency and duration of meetings

The number of department members that serve on the IAB on average is 10 and the maximum are 30 as indicated by 2 institutions (Table 3). One institution indicated that they have no academics on the IAB "The Division only has a single representative on the Faculty of Science's IAB; this makes it difficult to get a variety of views." Seven departments indicated they have no students serving on the IAB. The seven departments that indicated they have students serving on the IAB, the average number of students was 3, with a minimum of 1 and a maximum of 5 (Table 3). Five departments indicated they have no Alumni serving on their IAB. The remaining 9 departments indicated that they have Alumni serving on their IAB, the average number of Alumni were 7, with a minimum of 1 and a maximum of 19 (Table 3). The departments that indicated they had two or more students serving on the IAB, specified that the student representation included both under-graduate and post-graduate students.

No of Dept. members	Count (%)	No of students	Count (%)	No of Alumni members	Count (%)
0	1 (7%)	0	7 (50%)	0	5 (37%)
4	1 (7%)	1	1 (7%)	1	1 (7%)
5	1 (7%)	2	1 (7%)	2	1 (7%)
6	1 (7%)	3	3 (22%)	3	0 (0%)
7	2 (15%)	4	1 (7%)	4	2 (14%)
8	1 (7%)	5	1 (7%)	5	2 (14%)
9	1 (7%)			10	2 (14%)
10	1 (7%)			19	1 (7%)
15	3 (21%)				
30	2 (15%)				
	14 (100%)	Total	14 (100%)	Total	14 (100%)

Table 3: Number of departmental members, students and Alumni serving on IAB

The analysis of the criteria used to select IAB members included the following criteria:

- Willingness to serve and time availability;
- Relevant skills, IT education and industry experience;
- Knowledge of IT field and new developments and technologies;
- Interest in IT education and experience in education would be an advantage;
- Senior member of an organisation and decision maker in IT industry, including member(s) of the local IT industry if possible;
- Should include students and Alumni;
- Involvement in department and willingness to assist department; and
- Employer of graduates.

The businesses represented on the respondents IAB included:

• National IT industry; • Local IT industry; • Financial services industry; • Manufacturing industry;	• IT Consulting organisations; • Government entities; and • IT software development organisations.

None of the 14 respondents that had IAB compensated IAB members for serving on the IAB. Two departments indicated that they contributed towards travelling expenses by car and all provided meals and beverages on the day of the meetings. The topics discussed at meetings included:

• Curriculum and curriculum development (Stated by all 14 respondents); • Departmental activities and achievements; • Departmental strategies; • Research projects, specifically at post-graduate level; • Quality control;	• Employability and work placement of graduates; • Industry requirements and trends in industry (for example 4IR); • Solicit guest lectures; • Changing education landscape; and • Internships.

The respondents indicated the following advantages of having an IAB:

• Quality control; • Guidance with re-curriculation to meet the industry demands and to keep curriculum relevant; • Feedback from and linkage to industry; • Placement and employability of graduates;	• New industry trends and developments; • Departmental strategy and alignment; • Employability and work placement; and • Sponsorship for prizes for top students and events.

The challenges faced by departments maintaining and organising IAB meetings:

• Meeting attendance; • No funding for IAB activities; • Identifying and recruiting members; • Distance to meetings, including flights and car hire; • Being forced to have an IAB because of accreditation requirements; • Members not being compensated;	• Competition between university and IAB for students. University wants students for postgraduate studies while industry contact these students and offer them jobs; • Frequent changes of individuals in corporates cause difficulties in keeping connections; and • Challenging to make sure members feel it is worth their time to attend the meeting.

The respondents indicated that the main purpose of the IAB was to:

• Aligning academic activities and industry demands; • Making academic programmes relevant and graduates more employable; • Informing, assisting and guiding the Department on their programmes (but not to prescribe what must be done, as often industry needs require short-term turnarounds that are not possible in structured or research degrees;	• Advice on curriculum issues; • Maintaining quality; • Ensure what department is doing is still leading edge; • Providing information about trends in industry, and requirements that industry has on our graduates; and • "To have ambassadors for your department in industry."

The respondents were asked: What advice would you give other institutions wanting to implement an IAB? The following advice was provided:

• "Study the needs of industry so that they increase the employability of graduates"; • "Think carefully who you want to have on your IAB, how these people can benefit your department; ensure their commitment; start small, with a few members, they will recommend other relevant people to include"; • Members must be executives that can make decisions;	• An IAB requires clear expectations, planning and commitment; • Ensure the right people are on the IAB; • "Choose members with correct qualifications; choose senior managers; choose alumni in senior positions"; • "Identify key business and government entities that are influential or innovative in your local context and approach them to join your advisory board."; and • Most importantly, "Implement an IAB".

Responses were received from research universities, comprehensive universities and Universities of Technology in South Africa. Comparing the responses received from South African universities to Southern African Universities, i.e. universities outside South Africa, the responses to the survey questions were very similar. The importance of establishing and maintaining IABs and their requirements, as specified by international accreditation bodies, were emphasised by the non-South African universities.

5. General IAB guidelines for universities

The following guidelines are provided from literature and the results from the survey, presented above.

General IAB guidelines

- ✓ All CS/IS/IT departments or schools must have an IAB.
- ✓ The mission and vision statements of departments are important for setting the direction and structuring conversations for the board.
- ✓ The strategic direction and objectives of the department must be communicated to the IAB.
- ✓ The department must supplement annual or regular meetings with occasional e-mails and reports.
- ✓ Roles and responsibilities must be clear.
- ✓ IAB activities must be included in the budget.

Membership guidelines

- ✓ Include national and local industry representatives.
- ✓ Departmental members.
- ✓ Student members; include under-graduate and post-graduate members on the IAB.
- ✓ Alumni members.
- ✓ If required, an academic or academics from other universities.

Guidelines concerning membership of the IAB

- ✓ Identify and select members with the willingness to serve and ensure time availability of members.
- ✓ Include members with the relevant skills, experience and interest in IT education.
- ✓ Start with a small board and expand as necessary. The IAB membership size should be at least 10 representatives. The average size of the IABs in Southern Africa is 20 members.
- ✓ Industry members should be senior managers / executives who are in a position to make decisions and who have enough time available to serve on the board.
- ✓ Care should be exercised in the selection of companies from which members are taken. The business relevance to the programme objectives must be considered.
- ✓ Members should be from companies that understand higher education or have an interest in higher education.
- ✓ Members should be from a diverse representation of the relevant profession.
- ✓ Consider including members early in their careers as well as members in high level positions.

Guidelines concerning meetings

- ✓ Meetings should be held at least once or twice a year. Regular meetings are necessary to maintain continuity.
- ✓ Dates for meetings should be established a year in advance.
- ✓ Establish policies on attendance by conference calls, number of missed meetings, and substitutes.
- ✓ Proper planning must be done to make the best use of everyone's time during meetings.
- ✓ Meeting objectives must be clear.
- ✓ Choose an effective chairperson with meeting management skills.
- ✓ Keep to the agenda and to meeting times.
- ✓ Distribute the minutes soon after the meeting.
- ✓ Duration of meetings should be 3-4 hours.
- ✓ Number of meetings: minimum of one meeting a year.
- ✓ Provide opportunities to socialise.

- ✓ Engage students as interaction with students is an incentive for active participation in an advisory board.

Guidelines for agendas, discussion items

- ✓ Departments must include educational goals (curriculum design), research goals, funding and finances, including reputational activities, such as in high profile speakers on meeting agendas.
- ✓ The agenda should include a discussion of departmental achievements, as well as and an opportunity to give feedback on action items from previous meetings.
- ✓ The agenda should include items on current and new curriculum developments, new IT trends as well as strategies, graduate employability and contingency planning.

Guidelines for requirements of members

- ✓ Make sure that members understand exactly what is expected of them.
- ✓ Members should be familiar with programmes offered in the department.
- ✓ Members should be informed of departmental staffing situations and requirements.
- ✓ Members should be aware of the departmental strategy, mission and vision.

Guidelines on planning, attendance and documentation of meetings

- ✓ Plan IAB meeting dates annually and provide reminders.
- ✓ Distribute meeting agendas timeously and ask for items to be included on the agenda from all board members.
- ✓ Give feedback on action items from previous meetings.

Guidelines for IAB minutes publication and website

- ✓ Maintain an IAB distribution list.
- ✓ Include IAB membership on departmental web site.
- ✓ Distributer the minutes soon after meetings.
- ✓ Provide central storage of IAB minutes.

6. Conclusions

IABs perform an important role for academic departments in maintaining academic standards and links to industry. There are differences of opinions on issues surrounding IABs, such as the objectives, membership, benefits, size, leadership, meetings and guidelines. Academics departments are required by accreditation bodies to have IABs. In this study, only 12 out of the 26 participating departments indicated that they did not have an IAB and the reasons mentioned were that they were establishing a board; had informal arrangements with companies or that the IAB was not serving departmental needs.

The analysis of the responses indicates that the average size of an IAB is 20 members. This usually includes school/departmental members, alumni and other industry members and one under-graduate and one post-graduate student representative. The IAB includes senior management members in the IT industry (e.g. managers, consultants and specialists). Meetings are held 1-2 times a year and the duration of the average meeting is 3 hours. Topics discussed include the curriculum, activities, strategies, industry trends, graduate employability and contingency planning. Several advantages of an IAB were mentioned. IABs assist departments in keeping up to date with industry requirements and IT trends, secure employment of graduates, give advice on curriculum and do quality control. Challenges mentioned were attendance (e.g. conflicting dates on members' calendars and the distance to the venue), recruitment of members and making sure that it is worthwhile for members to attend.

A list of guidelines for the use of IABs at HEIs in Southern Africa has been proposed. This first study on the use of IAB's in Southern Africa, has provided the foundation for continuous IAB functioning and stakeholder management and engagement. Valuable opinions and information regarding IAB operations, procedures and composition were obtained from various CS/IS/IT schools and departments in Southern Africa. Future research will evaluate the proposed guidelines with respondents and after consultation the updated guidelines will be included in the SACAB IAB guidelines. The data obtained in this study will be used to propose a theory pertaining to IABs in academia. A model for IAB effectiveness is presently being developed.

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Answering Student Programming Questions using Domain-Specific Search

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Abstract. Discussion forums are commonly used in online learning environments for teaching programming, to create a platform for students to discuss course content. This platform of interaction is not without its challenges, as students regularly repeat questions that others have asked, both within and across offerings of a particular course. If past answers can be reliably provided to students, it eliminates the need for repetition and provides students with immediate assistance. This study investigates an approach to enable this through the addition of a search feature that indexes and queries discussion forum messages from a previous year to answer student questions. In particular, the paper presents a comparison of different ranking approaches based on the exploitation of domain-specific features of a social discussion forum on a learning management system, in particular, the authority of respondents. Results show that information retrieval can yield relevant answers to students in a programming course within the first 3-5 results, with some improvement in the outcomes when the social notion of authority in exploited.

Keywords: discussion forum, information retrieval, search, social discussion

1 Introduction

Discussion forums are a common tool for students and teachers to use in online learning environments such as learning management systems. They offer a new platform for communication that improves the learning process for the students who participate in the forum [5] and adds a new dimension to the course in conjunction with traditional teaching methods of lectures and tutorials. The first year computer science courses at University X make use of a basic threaded social discussion forum that students in the course can use to post questions they have about the course content or any other matter relating to the course as a whole. Social discussion forums go beyond discussion forums by incorporating elements commonly found in social networks; in the system that is the focus of this study, there are identities and groups, notifications and likes [15].

The threaded nature of the forum allows lecturers, tutors and other students to answer questions and then have focused discussions [12] while other questions can be asked and then responded to in their own threads. This forum is used by the students for topics ranging from questions about course content to general course administration questions to other common questions many first year students have. The discussion forum functions well as a platform for communication amongst students as it is always available and the asynchronous nature of such a discussion forum also allows lecturers and tutors to provide feedback and other forms of assistance to students when they are able to do so. While the students in the courses change every year, the lecturing staff change less frequently. This leads to questions from students in the discussion forum being repeated from year to year and sometimes even within the same year. This can be frustrating for the lecturing staff who have to repeatedly answer the same questions. More critically, if the answer is already available in a previous offering of the course, there is need to answer the same question again. Further, this answer can be provided to students immediately.

This paper argues that a search feature would allow students to look for previous answers before posting new questions, but also that a domain-specific search system, using variable boosted queries by authority of posters, would make better use of the nature of social discussion data to provide more relevant answers to users.

2 Information Retrieval

Information Retrieval [8] is the area of Computer Science concerned with the development of search engines and related technologies. A search engine is fundamentally comprised of an indexing system that processes a collection of data and creates an index; and a querying system that submits queries and returns a list of ranked results to the user.

Ranked retrieval [9] is what makes such systems fundamentally different from traditional database systems. In a traditional database, an item of data either matches or does not match a query. In a traditional information retrieval system, every item of data matches a query to a certain degree, and this degree can be used to sort results in order of probable relevance. Common formulations for this matching function include a combination of the number of occurrences of a term in a document and the rarity of the term.

Domain-specific search goes beyond general information retrieval algorithms to incorporate and exploit aspects of the data specific to an application areas. For example, patent search [11] will incorporate structural information into the matching function so some aspects of the patents are deemed to be more important than others.

Information retrieval algorithms are evaluated by comparing algorithms using a set of well-established metrics calculated on whether or not a user deems a result to be relevant to a query (for every query and every result) [10] [8]:

– Recall, which indicates how many of the relevant results have been found

– Precision, which indicates how many of the results that have been found are relevant
– Mean Average Precision, which takes the average precision of the set {first 1 result, first 2 results, ... first n results}
– Normalized Discounted Cumulative Gain, which takes a weighted average that favours results at the top of the list

3 Related work

The use of information retrieval techniques for many Web search tasks is well understood [13], however, online discussion forums represent a different challenge in that they tend to follow conversational style of group interactions that differs significantly from the Web 1.0 [14] approach of a single static piece of content. This conversational aspect often leads to the question a person is asking being mixed in with other sentences describing the context the person is in, which can be further complicated by single posts potentially containing multiple interlinked questions. The context of a question is generally important to the people who answer the questions, but the conversational nature of online forums tends to produces many answers to a single question. The answer posts are also not straight forward to interpret as they too contain context to frame the answer. The answer posts may still only contain partial answers or only answers to a few of the questions posed in the original question post, while other answer posts may go into unnecessary detailed answers for the information need of the question. The combination of these factors is what makes this a difficult problem in information retrieval, however, there are attempts to solve the problem of effective search through online discussion forums.

An approach used by Cong et al. [1] to analyse forum data is to link questions and answers from threads to improve search performance. They used a two part approach consisting of a pattern based classification method to detect questions in forum threads, along with a graph propagation approach to finding answers in the thread.

This work was continued by Hong et al. [2] who looked at other methods to identify question-answer pairs. Their methods differ from the work by Cong et al. through trying to detect answers without analysing the potential answer post's content. They were able to improve on the methods used by Cong et al. for a question detection method by performing analysis on the question posts rather than by using a pure classification approach. Hong et al. also found that using information about the users who made the posts improved relevance-based retrieval performance. Their ranking scheme that combines authorship, which considers the quality of other posts made by the user, and the position of the answer post, significantly out-performed the other ranking methods they examined.

Another related work is that of Elsas et al.[3] who looked at several algorithms for searching threaded message structures. They found that recognising the message thread structure and that evaluating messages in a thread individually performs better than methods that treat the entire thread as a single

document. This result is validated by the work by Seo et al. [4] who also found that considering the thread structure of discussion forums improves search performance. While their paper focuses on their approach to thread structure identification and annotation, their findings also support the idea that the use of the thread structure improves search performance.

While most prior work was aimed at question answering in general-purpose online forums, this study is specifically about students who are learning programming.

4 Methodology

4.1 Overview

In order to answer the research questions, a proof of concept system was first developed. This was to confirm how users would interact with a real system and demonstrate the core functionality. The results of the different algorithmic approaches were then compared in terms of standard information retrieval metrics.

Experimental Design

As the aim of this research is to compare the different methods to rank results, any information retrieval toolkit would suffice for indexing and querying purposes. Apache Solr[1] was used as it supports query time result boosting.

The 2013 first year discussion forum data was used as the test collection to be searched. The first step was to create a new document collection within Solr, into which the data could be indexed. To this collection a list of stopwords (common words that can be ignored, such as 'the') was added, along with a few other configuration settings that were based on the example simple configuration settings in the Solr documentation [6]. The data was converted from an SQL database dump (obtained from the learning management system) into an XML formatted file that conformed to the Solr XML specification for adding documents to a collection. This XML file was then added to the Solr collection and indexed through the POST tool provided with Solr.

To answer the research questions, 2 different methods for ranking results were compared. The domain-specific method used Solr's query time boosting to change the order of the results; this is a mechanism to multiply the effect of one or more fields when calculating a score for each result, thereby boosting the results (moving them higher up the result list) if they contain higher values in those fields.

The first ranking method (NORM) was to take the results as Solr returned them. The second method (AUTH) was to boost results that were made by authoritative figures; in this context these would be lecturers and tutors.

In Solr the process of performing query time boosting is done through user specified query parameters. This includes which query parser to use, which fields

[1] http://lucene.apache.org/solr/

to boost and which fields to search. For this experiment the dismax query parser was used as it is designed for working with simple queries and supports field boosting [7]. The query boosting was achieved through the boost query parameter, which boosts all results based on the searchable fields listed in the parameter. For the AUTH system the boost query parameter was set to the lecturer and tutor fields; these are boolean fields indicating whether or not a lecturer or tutor posted a particular message.

Test Query selection

To compare the ranking methods, a set of queries is required. This set of queries was randomly drawn from the 2014 discussion forum data. This was done to provide a more realistic set of queries as, in practice, the system would be exposed to student questions that are expressing an information need, in the form of a discussion forum post.

The process for randomly selecting queries was as follows. All the top level comments in the 2014 data were randomly sorted and then the first 32 questions were selected. The questions were selected at the researchers discretion as to which top level comments constituted a post containing a question. This selection process was used as not all top level posts are questions or, more specifically, the criteria for selection was that the post expressed an information need.

User Study

Once the list of queries was established, each query was submitted to Solr, through the Solr query endpoint Web service. Each query was submitted twice, once for each ranking method. The number of results for a single query on each method was restricted to only the top 30 results. This cut-off was also chosen as the final system will only display a very small number, much fewer than 30, of results to the students. The distinct results for each query, across the 2 ranking methods, were then combined to form a superset of unique results for each query. This superset is what was given to participants to assign relevance scores to each result.

The process of how the participants provided feedback was as follows. Each participant was randomly assigned 8 queries (of the 32) and each query was assigned to 5 people at random, thus making a total of 20 participants. Then, for each result to each of the 8 queries the participant was assigned, they rated how relevant that result was to the given query on a scale from 1 to 5. This scale was used to allow for a variable amount of relevance for each result as some results are more useful than others; in addition to this the scale allows for an average relevance for a given result to be calculated.

This study was conducted through an instance of the limesurvey tool hosted by the research group.

Data Analysis

After all the results had been given a relevance rating, the information was moved out of limesurvey and split up into the results for the 2 ranking methods. To calculate the precision, recall and mean average precision (MAP), a binary classification of relevance is required. In binary relevance, a result is either relevant or not. To do this a cut-off of 3 was chosen; this means that any result with an average relevance of 3 or more was deemed to be relevant. As the relevance of every document in the collection was not known, the whole-set approach for recall and precision could not be used; rather these metrics were calculated at various ranks within the results, e.g., recall for the top 5 results. The significance of using recall and precision at 3 and 5 is that those are typical of the number of results shown to users in a popup search interface.

Recall and precision were first calculated for each of the 30 result subsets, averaged over the users who repeated the assessment for each query. The MAP was then calculated using the precision values. The final measure that was calculated was the normalized discounted cumulative gain (NDCG); this is the only measure that does not require results to be given a binary relevance class and as such was calculated with the average relevance assigned by the participants. All these metrics were implemented in their standard formulations, as outlined earlier.

5 Results

The results are given in Figure 1 and Table 1.

Table 1 shows the precision, recall, MAP and NDCG of the different methods at various result ranks. Figure 1 shows the interpolated precision-recall curve for the systems.

	NORM	AUTH
P@3	0.3021	0.3021
R@3	0.4732	0.4911
P@5	0.3	0.3
R@5	0.5427	0.5617
MAP	0.3793	0.3882
NDCG@3	0.5955	0.6034
NDCG@5	0.6139	0.6211
NDCG@30	0.8292	0.834

Table 1. Table of the precision, recall, MAP and NDCG at various ranks. P@3 denotes the precision at the third result. R@5 denotes the recall at the fifth result. NDCG@3 denotes the NDCG at the third result.

Both ranking methods achieve a recall of nearly half at rank three along with a precision of a third. This means that within the first three results for

the ranking methods, one out of the first three results is relevant and about half the relevant documents for the query are in the first three results. This does not change significantly by the fifth result.

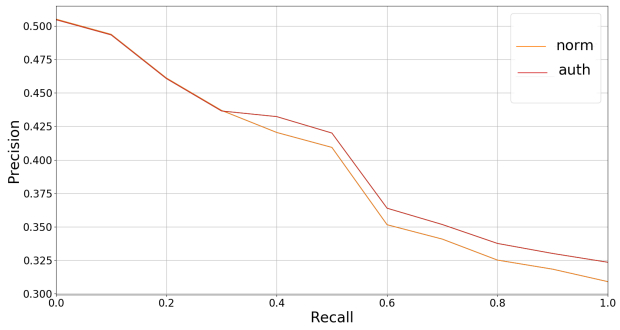

Fig. 1. Figure showing the precision-recall curve for the different ranking methods.

Both ranking methods are very similar in terms of overall performance, with the AUTH ranking methods having higher recall for lower ranked results. While the difference is not substantial over the complete result set, the AUTH ranking method produces the highest quality results.

The MAP of the systems is very similar, with the AUTH ranking method performing better than the NORM method. This is a continued trend as seen in all the other metrics. From the above results it is clear that boosting results that are made by authoritative figures yields improvements over a standard information retrieval system.

6 Conclusion

This research aimed to determine if information retrieval methods can be applied to give students answers based on previous years' interactions, and if domain-specific features can be exploited for this. Results indicate that indeed it is possible to find relevant answers using information retrieval algorithms, and that the relevance of answers can be improved by exploiting authority as a domain-specific feature. Future work can investigate other domain-specific features in this domain to improve on answerability of questions without human intervention.

7 Acknowledgments

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A Framework for Teaching Secure Coding Practices*

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Abstract. Cybersecurity attacks existing in web applications remain rampant as these application's usage rises. These attacks may cause loss of integrity in an organisation's information, in some cases leading to financial loss or even damage to their reputation. The vulnerabilities which lead to these attacks often result from developer's lack of secure coding knowledge or non-adherence to secure coding practices. This paper presents a framework for teaching secure coding practices to software development students to help ensure an increase in knowledge and an improved adherence to secure coding practices. The proposed framework is based on experiences and lessons learnt at a South African university.

Keywords: Secure Coding Practices · Cybersecurity · Security Education.

1 Introduction

Due to the increasing consumer demand for web applications, software development companies have increased the frequency in which newer versions of their web applications are released [30]. In addition, the rise in web application features has raised the number of attacks, and caused more attacks to evolve in web applications targeting organisations [28].
Attacks posed on vulnerabilities existing in web applications may result from software developer's lack of secure coding knowledge or non-adherence to secure coding practices. This lack of knowledge or adherence can be addressed by educating software development students and monitoring their adherence relating to secure coding practices. This paper therefore seeks to address this problem by providing a framework for teaching secure coding practices to software development students through a blended learning approach. The context of the

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framework is in web applications' data access layer, developed in the .NET environment.
The next section presents the related literature relating to secure coding practices, blended learning, brain-compatible principles and behavioural compliance monitoring which provides the theoretical grounding of the proposed framework. This is followed by a discussion of the research methodology in Section 3 and the research context in Section 4. The over-arching research approach is addressed in Section 5. Section 6 highlights the key elements of the proposed framework and Section 7 presents the proposed framework. Section 8 concludes the paper and Section 9 highlights the ethical considerations of this study.

2 Related Literature

The increase in cyber security risks has led to application security becoming an absolute necessity [33]. These risks have raised attention from both academia and industry on how to equip software developers with the necessary skills and knowledge for developing secure software [19]. Research shows that one way to equip developers with the skill set for developing secure software is to incorporate secure coding practices into programming classes at university level [3, 10, 11, 20].

2.1 Secure Coding Practices

In order for developers to build a secure web application, they need to understand the threats posed to such applications [31]. Therefore, they need to be made aware of the threats of the specific development environments they use since developers may be more familiar with threats posed to the web applications they develop. This is the case, as there is not a definitive list of security vulnerabilities within web applications. Application software at most organisations have their own set of unique security issues [29]. However, the high-risks and weaknesses are mostly described by various organisations such as the Open Web Application Security Project (OWASP), SysAdmin, Audit, Network and Security / Common Weakness Enumeration (SANS/CWE), and Microsoft Developer Network (MSDN). These organisations provide secure coding knowledge to organisations wanting to improve their developer's security knowledge. They also provide vulnerability lists for different software applications (Mobile, Web, and Desktop), across various development environments (C#, Java, C++ etc). Each vulnerability in these vulnerability lists can be addressed by one or more secure coding practices. Secure coding practices are security guidelines which developers employ when developing software, resulting in software that is less likely to be vulnerable to known vulnerabilities. In order to enhance software developer's knowledge relating to secure coding practices, they should be educated with the relevant secure coding practices [19]. In order for these secure coding practices to be delivered effectively, they should be designed and presented according to sound blended learning principles [23].

2.2 Blended Learning

In South Africa, the increased demand for higher education has led to an increase in class sizes. This compels university lecturers to figure out how they can reach out to all students as they did with small class sizes. Research shows that smaller class numbers have positive academic outcomes compared to large class numbers, since lecturers have less time to personalise the discussions in classes with large numbers [2, 24].

One way that is commonly used to cater for large classroom sizes in higher education institutions is to augment traditional classroom lectures with one or more educational materials, which includes online experiences and laboratory practices [13]. Integrating online learning material with the traditional classroom is referred to as blended learning [24]. In a blended learning environment, students often participate in laboratory practicals where they can apply their learnt knowledge [14].

In a blended learning environment, the lecturers have the decision of selecting from a variety of educational materials to include, depending on the learning context, and to determine the target skills that students should have at the end of the course [25]. It represents an approach and mix of classroom and online activities consistent with the goals of specific courses or programmes.

Also, blended learning does not only cater for large classes, it depends on the needs in a particular learning environment. Many disciplines make use of the blended learning approach to facilitate teaching and learning in their curricular where lecturers and students curriculum may already be overloaded with the core course content [10]. This helps students to personalise their learning, and work when it best suites them. In South Africa, a noticeable increase in the adoption of blended learning occurred during the 2016 #FeesMustFall movement where students protested for the demand of free education. During this period, most higher education institutions were compelled to reach out to students through the use of online educational platforms.

Online educational platforms distribute their course content and activities on various Learning Management Systems, including Moodle, Blackboard and Canvas. These Learning Management Systems are used by educators to create effective blended learning material for students in various higher educational institutions. They have been adopted by many institutions for their cost effectiveness, ability to expand with increased student populations, as well as meeting the needs of institutions, students and educators [12]. Any blended learning course should adhere to sound pedagogical principles [24], such as brain-compatible principles.

2.3 Brain-compatible Principles

Many higher education institutions have responded to the increase in student intake and improved academic performance with blended learning courses. This adds a further challenge on how best to deliver this content and to facilitate learning for students [7]. Student learning is mostly impacted by how their brains

accept and process the information delivered. Therefore, brain-compatible educational principles should be adhered to in the design of online material. Brain-compatible educational principles promote a student centred approach, which is used to assure that the learning process is more effective and lasting [32]. Sound brain-compatible principles can provide a framework for learning and teaching that can assist in moving away from the traditional classroom approach [5]. These principles provide a general understanding of the theoretical foundation for brain-compatible education [4]. There is currently no single comprehensive list of brain-compatible principles. The researcher has combined various brain-compatible principles which are provided by some researchers as listed in Table 1 [4, 16, 24]. The brain-compatible principles that have been used in this study

1. There is no long term retention without rehearsal.
2. Short, focused learning activities are best.
3. Learning is enhanced by challenge and inhibited by threat.
4. Emotions affect learning.
5. Learning involves both focused attention and peripheral perception.
6. The brain has a spatial memory and a set of systems for rote learning.
7. The brain simultaneously perceives parts and wholes.
8. Learning engages the entire physiology.
9. The brain is a parallel processor.
10. Learning is embedded in natural and social settings.
11. Each brain is unique.
12. The search for meaning is innate.
13. The search for meaning occurs through patterning.
14. Learning always involves both conscious and unconscious processes.
15. Learning with specific content is best.
16. Learning is a process of forming novel neutral networks or patterns.
17. Learners need to recognise and connect patterns by themselves.
18. Novel patterns can only form as extensions of existing patterns.
19. Learning should be given choices to accommodate different learning styles.
20. Learning must apply to real life experiences of learning.
21. Immediate feedback amplifies learning.
22. Learning is collaborative and influenced by interactions with others.

Table 1: Comprehensive Brain-Compatible Educational Principles.

were selected from the list in Table 1. Although brain-compatible principles as described by the researchers [4, 16, 24] are effective for students' learning, some of these principles can be difficult for a lecturer to control in a blended learning or a classroom environment. For example, principles like *Learning engages the entire physiology* and *The brain is a parallel processor* can be difficult to control, but it can be beneficial for students to understand in order to improve their learning. However, the principles in Table 2 could guide the lecturer when delivering the content, and guides the student to work through the content.

1. The search for meaning occurs through patterning.
2. Learning involves both focused attention and peripheral perception.
3. We understand best when facts and skills are embedded in natural, spatial memory.
4. Immediate feedback amplifies learning.
5. Learners should be given choices to accommodate different learning styles.
6. Learning with specific content is best.

Table 2: Brain-Compatible Principles Relevant to this Study

Example, identified Principle 1: **The search for meaning occurs through patterning**, this principle requires the lecturer to find out what knowledge students already have at the beginning of the course, and to adjust the lessons accordingly. In this context, these students were being taught programming in the .NET environment. Therefore, the content for the course was based on .NET, with a specific focus on web applications in the data access layer.
In a blended-learning environment where students would mostly be working on their own, providing them with feedback could be challenging for the lecturers. Therefore, developing reflections or self-assessment tools, which identify the desirable criteria or standards to which students should adhere when performing a task, would assist both students and lecturers [22]. Since students would have been taught the theoretical aspects of the tasks, the feedback criteria would have to be simple for them to understand and would act as a memory aid for them.

2.4 Behavioural Compliance Monitoring

Blended learning replaces some aspects of the traditional classroom with appropriate online experiences (including laboratories, tutorials, and assessments) through which students should be able to assess their own behaviour. These online experiences often do not always come with immediate lecturer feedback. That is why students should be able to assess their own behaviour. As it is known that secure coding knowledge alone is not enough, it is important to address the behavioural aspects relating to secure coding [21]. This allows them to check whether they have followed the correct steps when performing activities, since they would typically be working on their own, at their own pace and at a time convenient to them. For example, during a practical session in a laboratory where students apply knowledge that has been learnt, they could use self-assessment tools such as rubrics, scripts or checklists, which they can use to plan, monitor and self-assess, to evaluate their progress and adherence to requirements [27]. In the common self-assessments tools listed by Panadero [27], checklists are deemed as a simple and effective form of self-assessment, as researchers recommend them for students' self-assessment [1, 9, 15]. Checklists have been considered to be one of the most common and simple forms of inspection for students used in software development [17, 18]. Checklists can be given to students before they start their tasks, as it is important to establish a set of guidelines before engaging in a project or an activity [17]. These guidelines help to determine the set of requirements that students should satisfy and the means

by which to check behavioural compliance with such requirements.

3 Methodology

This research is presented as a case study since it describes an inquiry that investigates a contemporary phenomenon in depth and within its real-life context' [35]. Creswell [8] describes a case study as a 'bounded system' in the sense that the researcher should make the focus of the research, and the extent of the research, very clear in the research objectives. There is no single fixed structure for the presentation of case study research [8].
In this paper the theoretical underpinnings and literature that informed the study is presented in Section 2 while the real-life context of the research is presented in Sections 4, 5 and 6. The focus of the research is presented in the form of five specific objectives, namely:

- **Objective 1:** To determine what secure coding practices a web application developer should adhere to in the .NET environment.
- **Objective 2:** To determine the adherence of third year software development capstone projects to the identified secure coding practices.
- **Objective 3:** To determine whether third year software development students have the requisite knowledge relating to secure coding practices.
- **Objective 4:** To design and implement an educational intervention to support software development students in the development of secure web applications.
- **Objective 5:** To determine the effect of the educational intervention on both student adherence and their requisite knowledge regarding secure coding practices.

These research objectives informed the research approach followed by this research study.

4 Research Context

This research was conducted at a South African University, and the sample was drawn from students registered for their National Diploma: Software Development, engaged in their capstone projects. This diploma is a vocational qualification focusing on providing prospective students with the requisite skills for professional work. Figure 1 presents the subjects students registered in this diploma must take. At first, the students learn introductory programming, general end-user skills and an introduction to relational databases. Students in their second year, learn business applications programming, using .NET Windows forms and ASP.NET web forms to develop applications using the 3-tier architecture which includes the Data Access Layer (DAL), Business Logic Layer (BLL), and the Presentation Layer (PL). All the work learned at first and second year supports

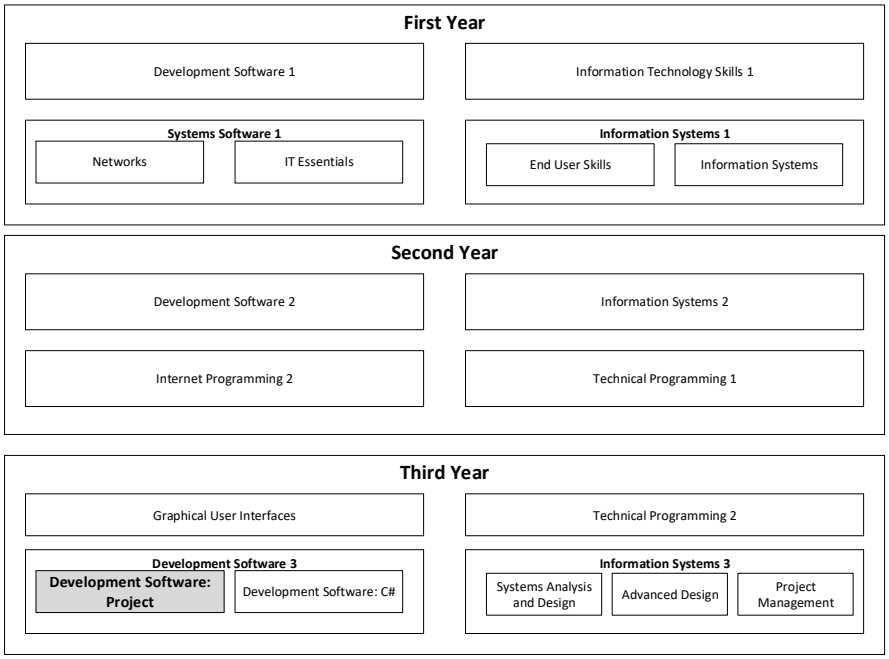

Fig. 1: Subjects for the Diploma: Software Development

the students to be able to work on their capstone projects, which integrates the work learned in previous years. Students engaged in their software development capstone projects identify real-world problems and solve these problems by developing a software application. Students typically develop web, mobile, desktop or gaming applications. The focus of this research, was on web application projects developed in the .NET environment with a specific focus on the data access layer. The secure coding practices used for this research were selected from OWASP. These secure coding practices are for addressing vulnerabilities in the data access layer, for web applications developed in the .NET environment as shown in Table 3. The secure coding practices presented in Table 3 are basic secure coding practices for countering vulnerabilities in the data access layer of web applications in the .NET environment, and were taught to third year software development students. Most of these secure coding practices are addressed in some .NET frameworks, such as the entity framework. However, the students that this educational framework was implemented with, were working on basic asp.net web forms, where they would not be enabled to have access to the entity framework. Also, the security considerations in the entity framework are similar to the secure coding practices presented in Table 3 [34], hence these secure coding practices were identified as being important when teaching software development students.

Table 3: Secure Coding Practices. Adapted from [26].

SP	**Secure Coding Practices**
SP1	Use Parameterised SQL commands for all data access, without exception.
SP2	Do not use SQL command with a string made up of a concatenated SQL strings.
SP3	Properly validate input fields.
SP4	Apply the Principle of Least Privilege when setting up the database of your choice.
SP5	When using SQL Server, prefer integrated authentication over SQL authentication.
SP6	Using stored procedures is the most effective way to counter the SQL injection vulnerability.
SP7	Encrypt sensitive data in the database including connection strings.
SP8	Connection strings should be based in a configuration file.
SP9	Never write your own encryption.

Some researchers recommend that teaching secure coding practices would be more effective if done in introductory programming [6, 3]. It may be challenging to introduce secure coding practices at advanced programming classes, since students may be used to their old programming habits learnt in previous programming classes.
Students' adherence to these secure coding practices was assessed after completing a blended learning course on the secure coding practices listed in Table 3. The online learning platform that was used to distribute the lessons was the *Moodle Learning Management System* that runs on the university's learning management site. A course was created on Moodle, which was called the *Web Application Security* course, and the content was distributed. This course was divided into 9 lessons which addressed each of the identified secure coding practices. After a student worked through a single lesson, they were provided with a quiz question to test whether they understood the content learnt in that lesson. In order for the student to move to the next lesson, they were required to get a correct answer to the quiz question of the previous lesson.

5 Research Approach

This research study followed a phased approach with four main phases. Figure 2 illustrates the four main phases which includes behavioural analysis, knowledge assessment, educational intervention, and verification.
All these phases were based on the identified secure coding practices as shown in Table 3. The identification of these secure coding practices addressed **Objective 1** of this research study, while Phases 1 and 2 seeked to determine the adherence to the identified secure coding practices and the requisite secure coding knowledge of students. Phase 1 relates to **Objective 2**, and Phase 2 relates to **Objective 3** of this research. The results indicated that these students lacked

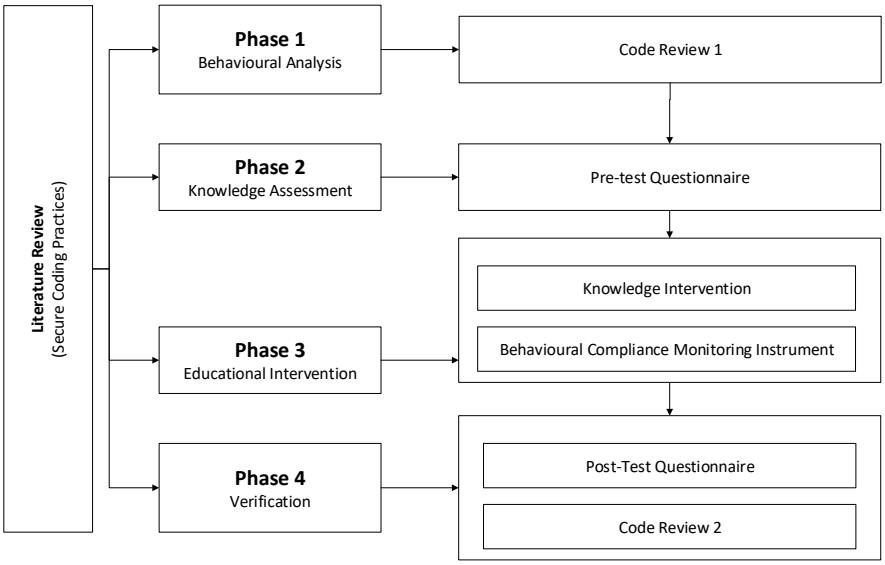

Fig. 2: Phased Research Approach

both behavioral adherence and knowledge relating to secure coding practices. The work presented in these phases together with the results indicating poor knowledge and adherence was published and presented in the 2017 Human Aspects on Information Security Assurance (HAISA) conference [19].
Phases 3 and 4 presented the educational intervention and the verification for this research which indicated improved secure coding knowledge and adherence to secure coding practices. These were published and presented at the 12th World Conference on Information Security Education (WISE 12) in 2019 [20]. These phases relate to **Objectives 4 and 5** of this research respectively.

6 Key Elements of the Proposed Framework

The framework presented is the output of a research study where the key elements of the framework were aligned with the objectives of the study as seen in Section 3. Figure 3 illustrates the key elements and how they relate to each other. The key elements were identified through the experiences and lessons learnt in teaching secure coding practices at the South African university previously described in Section 4.

– **Defining the Context (Objective 1)**: In order to know what secure coding practices should be taught, the researcher defined the context that the secure coding practices had to address. This research focused specifically on

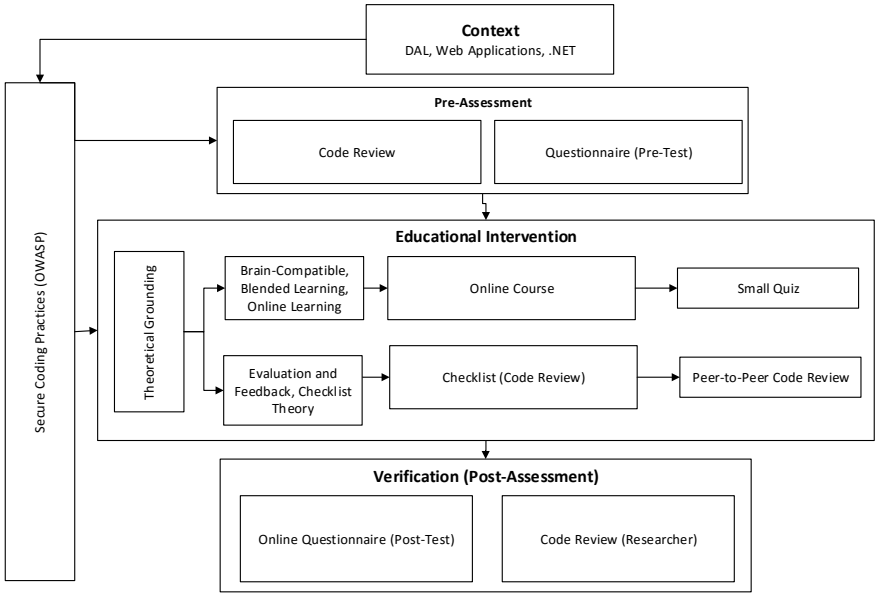

Fig. 3: Key Elements of the Proposed Framework

the data access layer of web applications developed in the .NET environment . The secure coding practices used throughout this research were identified from OWASP as indicated in Table 3.

– **Pre-Assessment - Code Review (Objective 2)**: A code review was conducted to determine the adherence of previous capstone projects to the identified secure coding practices. Conducting a code review on previously completed capstone projects was deemed valid since the students who developed those capstone projects were integrating learnt knowledge from all modules from first and second year of their course. These results can also be compared to the results of a different year, since these students would have done the same modules in order for them to engage in the capstone project. This code review was conducted using a checklist based on these secure coding practices. To formulate the checklist, all the identified secure coding practices were converted to close ended questions which required a (Yes/No/Not Applicable) answer. This checklist was used by the researcher to conduct a manual code review on all capstone projects meeting the selection criteria, which is web applications developed in the .NET environment. The aim of the code review was to determine the adherence of students to the identified secure coding practices when developing their .NET web applications. After the code review, the results were analysed, showing low levels of adherence and inconsistencies when developing their web applications [19].

- **Pre-Assessment - Questionnaire (Objective 3)**: The next step in the research was to assess the students' knowledge relating to these secure coding practices. This was achieved by using a questionnaire which served as a pre-test. The results from the knowledge assessment showed that most students lacked the requisite knowledge relating to the identified secure coding practices [19].
- **Educational Intervention (Objective 4)**: After the knowledge and behavioural adherence results were analysed, there was a need to address the lack of knowledge and low levels of adherence through an educational intervention. The knowledge aspect was addressed through online lessons and the behavioural aspect was addressed by using a checklist provided to the students to monitor their own compliance with the identified secure coding practices.
  This research included a theoretical grounding, which informed the design of the educational intervention. The theoretical grounding for the knowledge aspect included theory on brain-compatible principles and blended learning. For the behavioural aspect, the theory included evaluation and feedback, and theory on behavioural compliance monitoring through self-assessment tools such as checklists.
  For each lesson in the knowledge aspect, students were required to complete a simple quiz to ensure that students had worked through the lesson. For the behavioural aspect, students were required to review fellow group members' work to measure their compliance to secure coding practices [20].
- **Post-Assessment - Verification (Objective 5)**: In order to determine the effectiveness of the educational intervention, verification of both the knowledge and behavioural aspects was required. The knowledge verification approach was an online quiz that was distributed to the students through the Moodle site, and this served as an post-test assessment for the knowledge aspect. For the behavioural verification, the researcher conducted a code review on students' capstone projects to measure their adherence to the identified secure coding practices, using the same checklist used throughout the code review in Phases 1 and part 2 of the educational intervention.

The results from both the knowledge and behaviour verification showed an improvement in knowledge and a higher level of adherence to secure coding practices [20]. These key elements were therefore deemed effective in teaching secure coding practices through a blended learning approach, and therefore, informed the development of the proposed framework, as discussed in the next section.

7 A Generic Framework for Teaching Secure Coding Practices

Figure 4 illustrates a graphical representation of the proposed generic framework resulting from this research. This generic framework is based on the key elements identified within the specific context. However, these elements are flexible and can be adapted to various contexts, thus providing a generic framework.

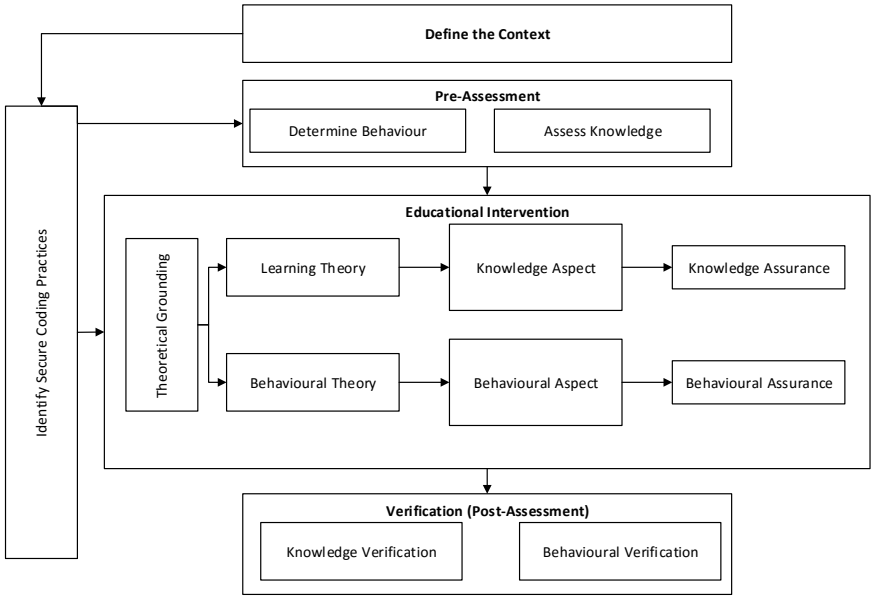

Fig. 4: A Generic Framework for Teaching Secure Coding Practices

- **Define the Context:** When teaching secure coding practices, the context in which the secure coding practices will be taught needs to be defined which may differ depending on the development environment (Java, C#, PHP etc) and development platforms (Mobile, Desktop, Web).
- **Identify Secure Coding Practices:** The defined context would influence the selection of the secure coding practices to be used for the particular context.
- **Assess Knowledge and Determine Behaviour:** The identified secure coding practices should be used to determine the students' adherence and to assess their knowledge relating to the identified secure coding practices. After the analysis of the results of both the knowledge and behavioural aspects, these aspects should be addressed through an educational intervention.
- **Educational Intervention:** The educational intervention should address the knowledge and behavioural aspects within the given context. The knowledge aspect should provide the students with the knowledge relating to the relevant secure coding as defined by the context. The traditional classroom education can be augmented with any form of educational approach that will be effective in improving students knowledge relating to secure coding practices.

  The necessary theory required to design the educational approach would need to be gathered so that the content for the knowledge and behavioural aspects is delivered in an effective manner. The developer of the educational

intervention would have to employ some educational techniques, such as blended learning techniques, or instructional design to ensure that the students work through and apply the learnt knowledge when developing their applications.
- **Verification - Post Assessment:** After the students have worked through the educational intervention, it is necessary to determine the effectiveness of the educational intervention. In doing so, the verification will depend on the nature of the entire educational intervention. The verification should also be based on the identified secure coding practices, which will depend on the context of the study. This verification should assess improvement on both the secure coding knowledge and behavioural adherence of students to secure coding practices.

It is acknowledged that the implementation of this framework may come with varying challenges. These challenges may be determined by the specific context it is implemented in.
In addition, the successful implementation of such a framework would require the commitment of lecturers teaching programming. These lecturers would need to ensure that they have the necessary secure coding skills and knowledge to ensure that effective teaching and learning takes place.

8 Conclusion

This paper presents a framework for teaching secure coding practices to software development students engaged in their capstone projects. This framework has been effective in teaching secure coding practices and has improved students' knowledge and behaviour relating to the taught secure coding practices.
The limitations of this research is that it only focused on the data access layer of web applications developed in the .NET environment. The students selected for participation were students engaged in their third year capstone projects. However, this framework can be used to teach secure coding practices to students working in different programming environments. Different educational and behavioural monitoring approaches for students can be employed when implementing this framework. It can also be used in formal education and should address both the knowledge and behavioural aspects of software development students.

9 Ethical Considerations

This research project adhered to all ethical requirements of the Nelson Mandela University and obtained ethics approval from the university research committee (REF H15-ENG-ITE-009).

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The Role of Continuous Assessment in Improving Learning of Research Methodology: Case of Information Technology

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Abstract. Apart from the fact that most university students' empirical research foundations are generally weak, the high levels of unpreparedness (for university education) of students joining South Africa's Universities of technology makes teaching of research methodology challenging. Research methodology is one of the modules offered in the 4th year of the Information Technology course in all these universities. Despite elaborate efforts in teaching this course, quantitative and qualitative data indicate that dismal research skills are being impacted onto the students. The problem is two-fold: first, information technology is different from other domains and therefore the traditional research methods alone are not adequate; two, despite the obvious need for constructivist approaches to teaching this subject, traditional lecture-based methods are still being practiced. Using eleven-year data from the Central University of Technology, Free State (CUT), results indicating positive effect of applying constructivism (within continuous assessment approaches) on students' ability to carry out research is presented in this paper. The results are packaged in form of an empirical and practice-supported generic guideline for teaching research methodology to students enrolled for an Information Technology (IT) qualification at institutions of higher learning.

Keywords: Continuous Assessment, Constructivism, Student Engagement, Research Methodology, Information Technology, Central University of Technology, Free State (CUT).

1 Research Background

1.1 Related Literature

South Africa is one of the countries where elaborate Continuous Assessment (CA) policy has been enacted through national programmes(Glover and Thomas, 1999; Foxman, 2002; Pryor and Lubisi, 2002). In (De Lisle, 2016), the three main components of CA are presented as: (1) continuous summative assessment; (2) formative assessment; (3) authentic assessment; and (4) multiple measures. Citing the work of Nitko (Nitko, 1995), De Lisle (De Lisle, 2016) presents the theoretical impetus of CA policy that allows combination of CA with public examinations and further asserts that CA has to be curriculum-based, criterion referenced and seamlessly aligned with all the aspects of a curriculum. At implementation level, CA policy should enable diagnostic and remedial actions as well as facilitation of bi-directional feedback and corrective actions by the teachers/lectures/facilitators and the students. There are many reasons for choosing to adopt CA; three of these that are relevant to this paper are that it: (1) serves multiple assessment purposes; (2) allows for integration of both formative and summative assessments; and (3) promotes quality teaching and learning. Using Theory Action, De Lisle (De Lisle, 2016) (citing the work of Bennet (Bennett, 2010)), presents a cause-effect relationship among the various aspects, components of CA, their inputs, activities and intended outcomes. This Theory Action framework is adopted in this paper. However, it is worth noting that the nature and success/failure of the implementation of CA highly depends on appropriate use by the teachers/lectures/facilitators.

Continuous Assessment as a driver for Student engagement and learning

Student engagement is a measure of the amount of physical and psychological energy that the student puts into his/her learning experience (Trowler, 2010; Holmes, 2015). It is also associated with student satisfaction (Cole and Spence, 2012). The positive correlation between student engagement and high-quality teaching and learning has been presented in literature. Moreover, CA that is implemented in form summative assessment, has been linked to increased student engagement (Holmes, 2015). For example, in (Esposto and Weaver, 2011), CA that was implemented in form of series of tests and a major project led to an improvement of student engagement and active learning in economics subject. A comparative study across seven universities in Ireland that implemented CA showed similar correlation, hence confirming this assertion (Hernández, 2012). In (Cole and Spence, 2012), CA is presented as an ideal tool for increasing student engagement in large classes.

Teaching Research Methodology

Literature is awash with studies that indicate that teaching/learning research methodology is generally challenging for both students and lecturers (Edwards and Thatcher, 2006). In (Groessler, 2017) for instance, the author argues that the attempt to alter teaching of research methodology subject from lecture-based to active and authentic learning strategies compounds this challenge. Other challenges stem from the students' feeling of being disconnected from both the complex research process and culture. A comprehensive list of most common challenges of teaching/learning research methodology are found in (Groessler, 2017). Researchers have proposed different ways of motivating students to embrace research methodology e.g., in (Altinay and Paraskevas, 2007), the use of a computer-supported collaborative learning (CSCL) approach, implemented through different computer mediated discourse, was found to be effective. In (Chilton *et al.*, 2019), the use of virtual environment was adopted in teaching research methodology to nursing students while in (Ball and Pelco, 2006), active cooperative learning approach is pursued in teaching of psychology students. Many authors have used student engagement as means of encouraging learning of research methodology. In (Edwards and Thatcher, 2006), a student-centred tutor-led approach is proposed while the effectiveness of student-centred teaching methods is analysed in (J Barraket, 2005).

Teaching Research methodology to IT Students

Differentiation between qualifications in computer science (CS) and those in Information Technology (IT) has been a subject of discussion for many years and in many forums. Put simply, computer scientists are 'scientists' with the knowledge on why computers work the way they do while IT graduates can be said to understand how computers work. In between these two qualifications, is the (Management) Information Systems (IS) qualification. A top-down differentiation of the three can be found in (Reichgelt *et al.*, 2004). Of importance to this paper is the definition of IT:

> "*Information Technology focuses on meeting the needs of users in an organizational and societal context through the selection, creation, application, integration and administration of computing technologies.*" (Reichgelt *et al.*, 2004)

From the defintion of IT qualificaitons/profession above, it emerges that skills in carrying out research enables IT professionals to accelerate the process of understanding uncertain circumstances relating to their duties (Altinay and Paraskevas, 2007). However, similar to other fields (Altinay and Paraskevas, 2007), student pursuing IT qualifications find the research methodology subject abstract and irrelevant to their careers. This is worsened by the fact that most research methodology books and literature targets physical, economic, and social sciences(Edwards and Thatcher, 2006). When it comes to the IT (as well as CS and IS) fields, a few authors (Antill, 1985; Palvia *et al.*, 2003; Heidelberger and Uecker, 2009; Olivier, 2009) have attempted to provide an exhaustive list of applicable research methodologies. Such a differentiation is supported through the thesis that such an approach supports professional academic identity which in turns promotes scholarly advancement of the IT discipline (Daniel, 2018).

The definition of IT given above further implies that carrying out research in IT requires tapping into research methods from several disciplines such as systems theory, computer science, design science, engineering, cybernetics, and information systems. Furthermore, IT professionals are also trained to take up IT management roles. This means that in addition to the list of the research methodologies they need to learn, those from the behavioural sciences are also necessary (Edwards and Thatcher, 2006). At undergraduate level however, the overall outcome of research methodology course should be two-fold; to develop the student's critical thinking and research skills. By achieving this, other secondary outcomes such as identification of students with the potential for graduate studies, could emerge (Olsson *et al.*, 2003).

Researchers have identified fundamental uniqueness of research in IT and gone further to propose different approaches to it (Steenkamp, A.L., McCord, 2003; Olivier, 2009). Most IT research is empirical; focuses on application of the theory to real-life situations. In most cases, the traditional research methods applied in most natural or social sciences are only used as supplementary methods in IT research. The methods most commonly used in IT are: literature surveys, models, prototypes, mathematical proofs, experiments, surveys and case studies(Olivier, 2009). Further, unlike in other domains, conducting research in IT is marred by unique challenges; two of these are: one, the domain is very broad and two, the involvement of too diverse 'researchers' (academics, it vendors, market researchers etc.). Within universities, the domain is clouded, and most research projects tend to be multi-disciplinary; technology management, business, education technology, engineering, agriculture – literally everything goes.

1.2 Research Methodology Course at universities of Technology (UoTs)

In the context of a university module (subject), the following definition of assessment is adopted.

> *"... is a process whereby evidence of performance is gathered and evaluated against agreed-upon criteria, in order to make a judgement as to whether the learning required for the achievement of a specific outcome is taking place or has taken place. It determines what a student understands, what he/she knows, and what he/she is able to do."*(Phelps, 2014)

At South Africa's universities of Technology (UoTs) (formerly known as technikons), an introductory research methodology course is offered to the fourth year IT students. It is aimed at equipping students with skills and knowledge on how to plan, conduct and document IT research. However, the extent to which this noble goal is achieved is disputable; at least given the meagre number and unpreparedness of students progressing to masters. This is partly traced to the way this research methodology module is taught. In the case of the Central University of Technology, Free State (CUT), the module was previously (until 2013) delivered through a traditional lecture-based method.

Research methodology courses have been branded 'problematic' for many university students (Schulze, 2009). Researcher postulates that the best way to dissect this problem is by adopting student-based teaching approaches (Jo Barraket, 2005; Ball and Pelco, 2006; Aguado, 2009). This could be by providing constructivist learning environment that allows the students to generate the knowledge themselves (Hein, 1991). Some of the shifts required in achieving student-centred approaches include (Seaman and Nunan, 1990; Alfassi, 2004): (1) shifting the balance of classroom power from teacher to student; (2) designing content as a means to building knowledge rather than a 'knowledge end' in itself; (3) positioning the lecturers as facilitator and contributor, rather than director and source of knowledge; (4) shifting responsibility for learning from teacher to learner; and (5) promoting learning through effective assessment.

Jonassen and Rohrer-Murphy (Jonassen and Rohrer-Murphy, 1999) (cited in (Schulze, 2009)) provides the following five interdependent components of an effective constructivist learning environment: problem-project space, related cases, information resources, cognitive tools, and conversation and collaboration tools. Research methodology is a very practical subject; for practical domains such as IT, practitioner-oriented method would aid in taking the students through the entire research process. For this reason, constructivism (within continuous assessment approaches) was deemed the best and therefore applied in both CUT's research methodology subject.

2 Research Design

Case study research design was applied on the research methodology subject offered at CUT. Data pertaining students' scores, research proposals and subject syllabuses, for 11 years (2009 to 2019) was collected and analysed.

2.1 About Research Methodology at CUT

Research Methodology (subject Code: NMT11AB) is a subject taught to the B. Tech, IT students at the Central University of Technology, Free State (CUT). The course is offered by the Department of Information Technology (DIT) which falls under the Faculty of Engineering Built Environment and Information Technology. The B. Tech course is structured such that students are supposed to take at least 4 compulsory and 6 elective subjects. Research methodology is one of the electives. Given the students' tendency to select subjects based on the chances (how easy it is) of passing it, the number of students enrolled for NMT11AB fluctuates year after year based on different factors. Between 2009 and 2013; the subject was delivered via the examination model. However, during the 2013-2015 DIT's research strategy development, it emerged that this teaching approach was negatively impacting on students' research culture and outputs. A decision to change this was reached and implemented in 2014.

2.2 NMT11AB Design: Creating a constructivist learning environment

In designing the NMT11AB course, the Theory of Action framework described in (De Lisle, 2016) and shown in figure 2, was adopted and used to design the syllabus, the content (and associated delivery methods) and a series of elaborate continuous assessments. The elements were then infused together in a way that ensured constructivism as described in (Hein, 1991). The details of how the various components of the syllabus, the actual content delivery and assessments build up to the overall goal of the improved student learning is captured in the

high-level learning outcomes, the syllabus and the detailed content of the course shown in tables 1 and 2 below.

Table 1. Research methodology syllabus.

High level learning outcomes	You will be assessed on the learning outcome in task/s:	Completing these tasks successfully will contribute to students becoming:
To demonstrate and apply research communication skills	Class exercises, response to papers and oral presentation, Research proposal, final oral, presentation	Empowered
Demonstrate and apply knowledge of research methodologies and methods, and apply knowledge gained to prepare a research proposal	Response to papers and oral presentation, research proposal	Knowledgeable and empowered
Analyse, generate and transmit solutions to complex problems	Final presentation, SPSS exercise and Mendeley exercise	Creative and critical thinkers; engaged
Demonstrate and apply ethical research practice	Research proposal and group assignment	Ethical
Be ready for graduate studies	Research proposal	Knowledgeable, skilled and empowered

Table 2. Research methodology detailed content

Teaching Week / Module	What key concepts/content will I learn?	Delivery Method	
		Directed Study	Independent Study
Introduction	The What, the How, Why, where and When research methodology in/for IT	Lecture	Read a selected paper on research methodology in/for IT
Using Research Repositories	Guidelines on how to effectively make use searches of scientific publications databases	Tutorial	Search for papers related to the students' selected topic
Automated Referencing	Learn how to use referencing tools (endnote, Ms Word, RefWorks Mendeley etc.) to manage your references	Tutorial	Auto-generate references for the summary prepared from the 5 papers students have read
Elements of a research proposal Part I, II and III	The stages and elements of the research project	Lecture Research Seminar by an invited speaker	Student to prepare the first 2-page draft of their proposal
Proposal Writing	The elements of a successful research proposal	Lecture	
Research Ethics Part I	Legislation and approaches to managing ethics in a research context. Research ethics applied at CUT are taught	Lecture	Students to identify and apply aspects of research ethics in their research proposal
Research Ethics Part II	Ethical and professional expectations on scientists	Lecture	
Data management	Managing your research data	Lecture	Analyse sample data for your proposal
Introduction to Data Analysis Tools	The basics of set-up, data entry and generating summary analyses using SAS/SPSS	Tutorial	
Qualitative data analysis	The value and application of qualitative data analysis	Lecture	Student to prepare their final report
Research communication skills	Communicating your research effectively	Lecture	Student to prepare the presentation and present their final proposal
Publishing Research	The what, where, when and why of publishing	Lecture	

2.3 Constructivist Subject Delivery Assessment

Measuring Students Motivation for doing research methodology

During the first lecture of the NMT11AB at CUT, the students' interest, preparation, anticipations/expectations and the reasons for enrolling for the subject is assessed. Students are requested to anonymously scribble this on sticky notes which are handed back to the lecturer. Examples of these are shown in the figure below:

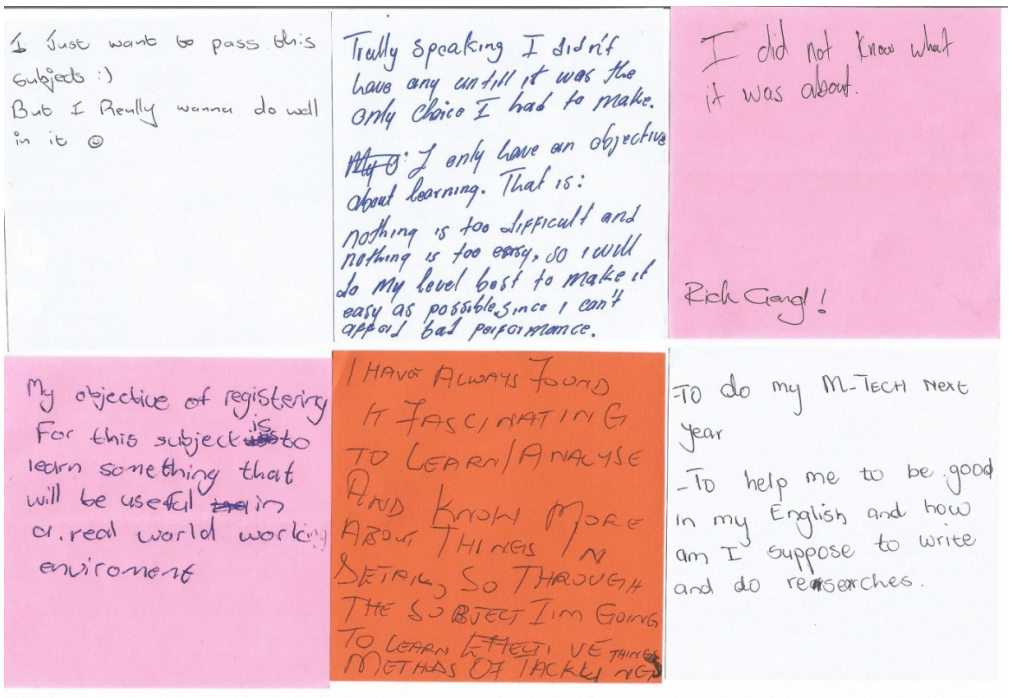

Fig. 1. Students' subject preparedness input sample

Hand in hand with the qualitative information above, a quantitative survey is also administered. The results of such a survey, administered in 2018, is shown in table 3 below.

Table 3. Sample results from subject preparedness survey

Survey Question	Multiple Choices	Percent Responses (N=46)
What would you consider to be the MAIN reason for choosing to enrol for the B.Tech Programme?	B.Tech is the next step in my career, it was just the obvious path after my National Diploma	45%
	Pursuing further studies is my vision and B.Tech is my bridge to this vision. I could even consider putting off a job offer until I complete my B.Tech	53%
	I could not find a job in good time, if I get a job offer, I would consider dropping out of the course	2%
What would you consider to be the MAIN reason for choosing to register for the Research Methodology subject	I am VERY interested in learning about how to do research	19%
	I am interested in pursuing a masters degree and hence I needed to start preparing myself	51%
	I am actually not sure; I just chose the subject and am here to explore what it is all about	11%
	There was no other subject I could select so I chose research methodology as a last result	17%
	Others	2%

Results in figure 1 and table 3 above indicate that majority of the students have informed reasons for enrolling for the research methodology. There are several them (over 19% in the case of the 2018 class) whose reason for being in the class can be termed misplaced. For most students, more effort towards ensuring their engagement is required. This is because only 19% of them chose the option "*I am VERY interested in learning about how to do research*".

Implementation of theory of action for continuous assessment

In implementing the CA for this course, all the components of the generalized theory of action for continuous assessment (see figure 2 below) are incorporated to ensure constructivism.

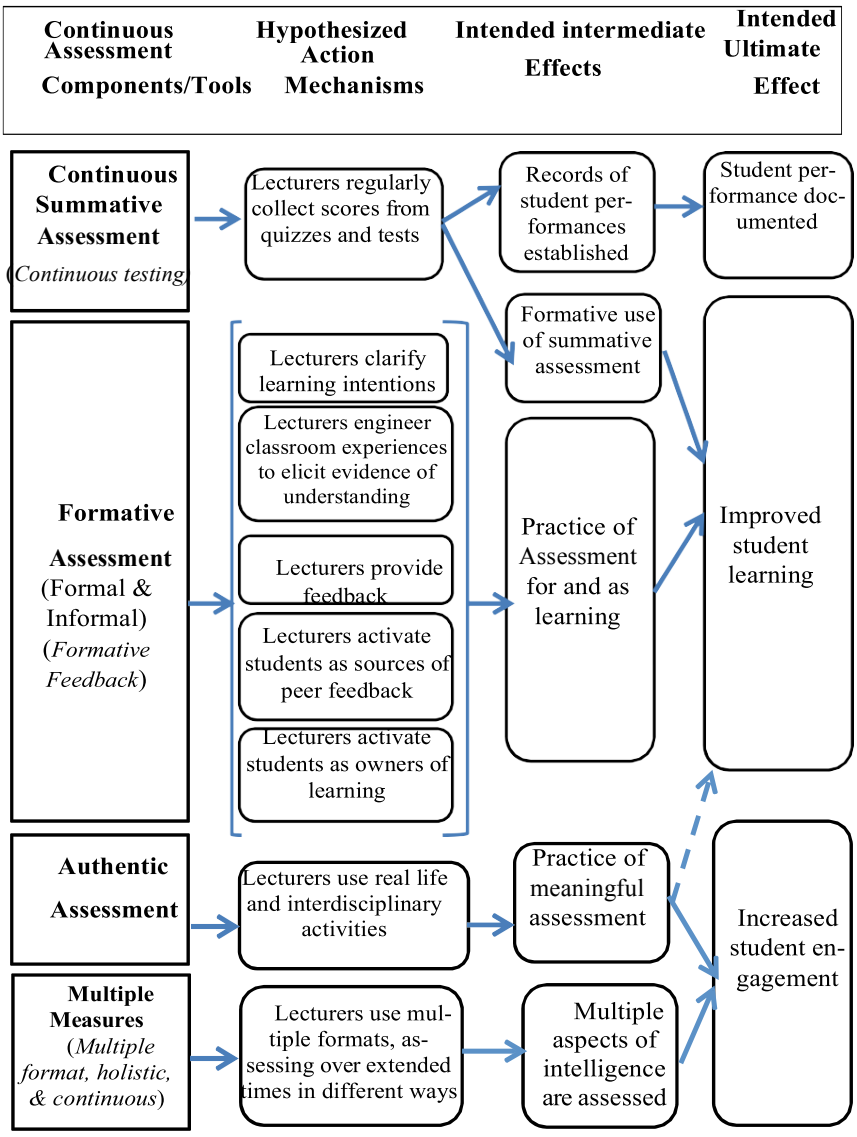

Fig. 2. Generalized theory of action for continuous assessment (adapted from: (De Lisle, 2016))

a) Component 1: Continuous Summative Assessment

In order to ensure that the students continuously generated the knowledge, regular and class exercises are issued throughout the semester. Below the description of these exercise:

Assessment Task 1: Class Exercises

Goal:	**Demonstrate the understanding of the research methodology concepts, terminologies and theories to enforce and motivate class attendance**
Product:	Responses (via the Learning Management System) to a class exercise
Format:	A series of varied write-ups and/or mini-oral presentations
Criteria	This assessment carries a weight of **10%** and it will be assessed on the quality and content of the presentation as well as the write-up
Generic skill assessed	**Skill assessment level**
Understanding of the concepts	B. Tech
Activeness in class	B. Tech

One examples here are impromptu written exercises in-between a lecture. A major component here however is the identification and oral presentation/defence of the students' selected topic. Below is an extract of such an exercise.

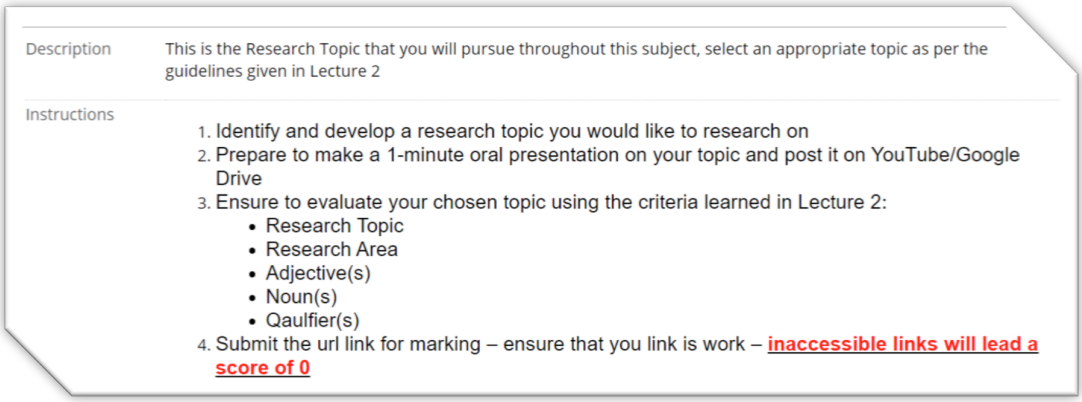

Fig. 3. Sample class exercise

b) Component 2: Formative Assessment

Formative assessment is achieved through assignments such as the one described below.

Assessment Task 2: Response to research papers

Goal:	**demonstrate the ability to read, analyse and summarise critical issues presented in selected research papers Demonstrate an understanding of the elements of effective spoken communication**
Product:	Spoken presentation outlining key issues from the papers read
Format:	10-minute, individual spoken presentation presented to the class and one-page write-up per paper
Criteria	This assessment carries a weight of **10%** and it will be assessed on the quality and content of the presentation as well as the write-up
Generic skill assessed	**Skill assessment level**
Problem solving	B.Tech
Analytical skills	B.Tech
Organisation	B. Tech

c) Component 3: Authentic Assessment

This is assessed through two deliverables: a mini-research proposal and the final research proposal. The final research proposal assessment is described below.

Final Research Proposal

Goal:	**Apply knowledge and skills to formulate a research question and prepare a proposal to undertake the research required to answer the question**
Product:	A research proposal based on the individual students' selected research topic, including a short literature review and project justification, aims, methodology and methods, outcomes and output, timeline, and budget.
Format:	3,000-word written document written to the Faculty of Engineering Built Environment and IT Research and Innovation Committee (FRIC).
Criteria	This assessment task carries a weight of **50%** and will be evaluated against the following criteria: • demonstrated understanding of the breadth of research already undertaken in the research area and identification of gaps in that research, • clear objectives and justification of the proposed research, • clearly defined and appropriate research methods, • realistic and achievable timeline and budget which are clearly aligned to the objectives of the study, and • appropriate presentation and formatting including correct format, use of appropriate vocabulary and grammar, and correct referencing

Generic skill assessed	**Skill assessment level**
Problem solving	B.Tech
Organisation	B.Tech
Communication	B.Tech

d) Component 4: Multiple Measures

Each academic year, different approaches of are applied in ensuring multiple measures' assessment. This is mostly implemented through a group work assignment. For instance, for a few years, the use of BlackBoard Learning Management's discussion forums was adopted to assess individual students' contribution to the literature review of a given research area – e.g. Robotics in mining

Assessment Task 3: Research projects reviews (Group work)

Goal:	**demonstrate the ability to read, analyse and summarise critical issues presented in selected a research project** **Demonstrate an understanding of the elements of effective spoken communication and ability to work in groups**
Product:	Spoken presentation outlining key issues from the research project studied
Format:	20 minutes, group presentation presented to the class and three-page write-up per paper
Criteria	This assessment carries a weight of **30%** and it will be assessed on the quality and content of the presentation as well as the write-up

Generic skill assessed	**Skill assessment level**
Problem solving	B.Tech
Analytical skills	B.Tech
Organisation	B.Tech
Communication	B.Tech

3 Results and Discussion

3.1 The dataset

Quantitative data in form of students' numbers and their scores was collected from the lecturers who delivered the subject. On the other hand, qualitative data regarding the quality of research proposals was collected through interviews (of the students' supervisors) and by reading the proposals submitted. The various statistic measure of final scores of the students is show in table 4 below.

Table 4. Statistic measure of final scores of final scores

	2009	2010	2011	2012	2013	2015	2016	2017	2018	2019
Valid	45	32	56	53	67	39	57	66	63	77
Mean	74.62	70.03	69.82	71.81	62.96	56.51	63.95	66.70	62.62	63.01
Median	73.00	68.00	71.00	73.00	63.00	55.00	66.00	67.00	61.00	62.00
Std. Deviation	10.329	9.516	9.456	9.692	12.105	13.835	11.757	9.698	11.686	9.633
Variance	106.69	90.54	89.422	93.92	146.52	191.41	138.22	94.06	136.56	92.80
Range	44	35	43	41	58	60	52	51	49	45
Minimum	53	54	46	51	30	30	34	41	37	44
Maximum	97	89	89	92	88	90	86	92	86	89

3.2 Quantitative Data analysis

Performance Distribution

From the analysis of the students' performance curves, stabilisation of the normal distribution over time was observed. This is (among other things) evidence of improved students' learning. Further, given that traditional lecture-examination based model was in use between 2009 and 2013; the results indicated that students scored higher for examination-based model and lower for the continuous-based model. The performance post introduction of CA on the other hand shows consistent normal distribution in performance in all the assessment.

3.3 Qualitative Data analysis

From 2012 to 2019, the author has overseen recruiting postgraduate students at CUT. The author has observed the steady improvement (post introduction of continuous assessment model) in the quality of the research skills awareness and culture of the students. The following examples explain this.

Progress Report

BCBTIP	B TECH: INFORMATION TECHNOLOGY	
2012 ADS42AB	ADVANCED DEVELOPMENT SOFTWARE IV	80 PD
BSL42AB	OPERATING SYSTEMS IV	93 PD
CRA42AB	COMPUTER ARCHITECTURE IV	78 PD
CSY41AB	COMPUTER SECURITY IV	91 PD
DBS41AB	DATA BASE SYSTEMS IV	91 PD
ITM41AB	INFORMATION AND TECHNOLOGY MANAGEMENT IV	77 PD
NMT11AB	RESEARCH METHODOLOGY	82 PD
OPG41AB	DEVELOPMENT SOFTWARE IV	62 P
PIO42AB	SOFTWARE ENGINEERING AND DESIGN IV	94 PD
USR42AB	USER INTERFACES IV	76 PD

Progress Report

BCBTIP	B TECH: INFORMATION TECHNOLOGY	
2010 ADS42AB	ADVANCED DEVELOPMENT SOFTWARE IV	84 PD
BSL42AB	OPERATING SYSTEMS IV	86 PD
CRA42AB	COMPUTER ARCHITECTURE IV	78 PD
CSY41AB	COMPUTER SECURITY IV	82 PD
DBS41AB	DATA BASE SYSTEMS IV	62 P
ITM41AB	INFORMATION AND TECHNOLOGY MANAGEMENT IV	80 PD
NMT11AB	RESEARCH METHODOLOGY	89 PD
OPG41AB	DEVELOPMENT SOFTWARE IV	75 PD
PIO42AB	SOFTWARE ENGINEERING AND DESIGN IV	83 PD
USR42AB	USER INTERFACES IV	62 P

Fig. 4. Sample Academic records - Pre-Adoption of Continuous Assessment Model

Two top-performing students (academic records shown in the figure above) joined the M. Tech programme (one in mid-2013 and the second in February 2015) under the supervision of the author. Despite having scored over 80 for in research methodology, the students did not have a clue on where to start in terms of writing a research proposal. They did not know how a research question, or a research objective looked like; it took over six months to teach them these skills and eventually develop and present the M. Tech proposals. In the contrast, students joining the masters program post-adoption of the continuous assessment model had way more developed research skills. For instance, the students whose academic records are shown below had their proposals developed and approved by the Faculty Research Committee within three months.

Progress Report				
BCBTIP	B TECH: INFORMATION TECHNOLOGY: WEB & AP			
2015	APE42AB	ADVANCED INTERNET PROGRAMMING AND ECOMMERCEIV	99	PD
	CRA42AB	COMPUTER ARCHITECTURE IV	81	PD
	CSY41AB	COMPUTER SECURITY IV	93	PD
	IPE41AB	INTERNET PROGRAMMING AND ECOMMERCE IV	100	PD
	ITM41AB	INFORMATION AND TECHNOLOGY MANAGEMENT IV	97	PD
	NMT11AB	RESEARCH METHODOLOGY	90	PD
	PIO42AB	SOFTWARE ENGINEERING AND DESIGN IV	95	PD
	PRJ40AB	PROJECT IV	75	PD
	USR42AB	USER INTERFACES IV	77	PD

Progress Report				
BCBTIP	B TECH: INFORMATION TECHNOLOGY: WEB & AP			
2018	APE42AB	ADVANCED INTERNET PROGRAMMING AND ECOMMERCEIV	79	PD
	BSL42AB	OPERATING SYSTEMS IV	69	P
	CRA42AB	COMPUTER ARCHITECTURE IV	61	P
	CSY41AB	COMPUTER SECURITY IV	80	PD
	DBS41AB	DATA BASE SYSTEMS IV	58	P
	IPE41AB	INTERNET PROGRAMMING AND ECOMMERCE IV	72	P
	ITM41AB	INFORMATION AND TECHNOLOGY MANAGEMENT IV	97	PD
	NMT11AB	RESEARCH METHODOLOGY	77	PD
	PIO42AB	SOFTWARE ENGINEERING AND DESIGN IV	77	PD

Fig. 5. Sample academic records - post-adoption of continuous assessment model

Example 2

Ever since the introduction of continuous assessment for research methodology, the number of M. Tech enquires from the CUT's IT Department's B. Tech cohort has more than doubled. Report from the Department Research Committee indicate that, unlike before, the students interested in pursuing M. Tech have very clear ideas on what research they are interested in. The Committee has also reported a sharp increase in quality of research proposals being presented at the Department's Research and Innovation Committee. Furthermore, the enrolment and graduation figures confirm this increase in quality. For instance, between 2009 and 2013, only 7 students attained masters qualification. Conversely, double (14) number attained masters and 2 attained doctoral qualifications between 2015 and 2019.

4 Discussion and Conclusion

Two main assessment methods are currently in use in South Africa's universities of technology: an official examination model that is conducted at the end of the module or continuous assessment model where there is no official examination. Research methodology is one of the modules offered in the now phased out (replaced with Advanced Diploma) B.Tech, Information Technology course in all of these universities of technology. Based on the author's (of this paper) first-hand experience in teaching the research methodology subject at the Central University of Technology, Free State (CUT), the results presented in this paper indicate that the adoption of student-centred, activity-based teaching approaches positively influences the quality of students' research skills. Constructivist learning is based on an understanding that learners construct knowledge for themselves (Hein, 1991; Baumgartner *et al.*, 2003). Riding on this, the curriculum for the research methodology was modified to include activities such as case studies, paper reviews, group work, role plays and simulations.

Eleven-year data from CUT was analysed using qualitative and quantitative methods. The assessment model was changed from examination to continuous in 2014; this is the point where constructivist was introduced. Quantitative (pass/failure rates, class averages and marks distributions) and qualitative (quality of research proposal and preparedness for masters studies) data analysis indicate more normal distribution of students' scores and an increase in quality of students' research proposals. The overall findings indicate that continuous assessment model that is designed within constructivist approaches increases the chance of equipping students with the necessary research skills.

The above results are presented with the acknowledgement that the success of impacting research skills to Information Technology students is far more complex. For this reason, the design (of the syllabus) of the course, its delivery and the assessment therefore of, are not the only factors to this success. Other factors such as recruitment of staff with research degrees (e.g. PhD) could also have contributed to this success. This however does not take away the main contribution of this paper – an empirical and practice-supported generic guideline for teaching research methodology to IT students. Other lectures can adopt and adapt these guidelines and apply them in improving the teaching the research methodology course at their institutions of higher learning.

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General Papers

A Systematic Literature review of data governance frameworks for Big Data implementations

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Abstract. As the fourth industrial revolution unfolds, emerging data sources, such as data from sensors, from social media and the Internet of Things (IoT), are coming into play that have traditionally not existed. Organizations are now collecting, analyzing, and storing more data than ever before, leading to the phenomenon referred to as Big Data. Big Data provides organizations with new insights and offers opportunities for enhanced strategic decision making. However, the usage of Big Data also brings its' own challenges. For the organizations to have trust in their Big Data and for it to prove useful to them, they require assurance that the data being collected and used is prepared on time and that the data is consistent and of superior quality. Big Data requires careful management and defined governance procedures and policies to ensure the reliability of its source and the meaningfulness of its' results. Although there are currently Big Data governance frameworks in existence, there are limitations associated with them, and there has not been a consensus between researchers and practitioners on a single Big Data governance framework to be used. By means of a systematic literature review, five (5) existing Big Data governance frameworks were identified and analyzed. Based on this analysis, a conceptual structure is proposed that incorporates the critical components that should be adopted when managing Big Data. These components should be included in any data governance framework organizations wish to adopt.

Keywords: data governance, framework, big data

1 Introduction

In a single day, 2.5 billion gigabytes of data is produced [1], and by 2020; it is expected that over 40 trillion gigabytes of data will be created, replicated, and consumed [2]. The growth in data volumes can be attributed to several factors, including recent technological trends, such as the Internet of Things (IoT), the rapidly increasing use of Cloud Computing as well as the spread of internet-enabled devices [3].

Due to the ever-evolving nature of technology, the generation of data by organizations has increased significantly [4]. Big Data differs from traditional data as it is of a high-volume, high-velocity, and high-variety. Big Data is an information asset that demands cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation [5]. Organizations should be focused not only on the storage and access of Big Data, but also on the process of extracting and analyzing Big Data to aid in more informed decision-making [6]. The

process of extracting and analyzing Big Data is commonly referred to as Big Data Analytics [6].

Big Data has the potential to fundamentally change the way organizations compete and operate [7]. Although Big Data provides organizations with numerous opportunities, there are significant challenges associated with the use of Big Data. These challenges include information privacy, data curation, data capture, and analysis, as well as the sharing, storage, and transfer of data [8]. According to EYGM Limited [7], organizations need to implement a comprehensive strategy to enable them to fully take advantage of the benefits associated with Big Data while mitigating the risks at the same time.

Due to the diverse nature of Big Data, Big Data governance should be a vital data management consideration for any organization [9]. Data governance is defined as "the specification of decision rights and an accountability framework to encourage desirable behavior in the valuation, creation, storage, use, archiving, and deletion of information. It includes the processes, roles, standards, and metrics that ensure the effective and efficient use of information in enabling an organization to achieve its goals" [10]. A Data governance framework should form the foundation of information management [4].

The objective of this paper, and subsequent research question, is to identify the data governance frameworks, with sub components it constitutes, that should be adopted during Big Data implementations. As a result, these components, rather than the overall data governance framework, can be considered during Big Data adoptions.

The paper starts with a brief literature background to clarify related terminology such as Big Data, data governance, data governance frameworks. The importance of the adoption of a Big Data governance framework is also considered. The research method is described followed by a discussion and analysis of the findings. Based on the findings, a conceptual data governance framework is presented depicting the components of a good data governance framework.

2 Literature Background

In order to answer the main research question - *what data governance frameworks exist for Big Data adoption?* - it is imperative to clarify terminology prior to the literature review. This section clarifies three main concepts namely; Big Data, data governance and data governance frameworks. Furthermore, the importance of the adoption of big data governance is highlighted.

2.1 Big Data

Gartner [10] defines Big Data as "high-volume, high-velocity, and high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation". Definitions from other researchers and practitioners alike encompass the core components of Gartner's definition; high-volume, high-variety, and high-velocity.

Initially, Big Data was characterized by the 3Vs of Big Data, namely, volume, variety, and velocity. However, in more recent articles, an additional two (2) V's, veracity, and value were added, giving readers an upgraded definition of Big Data [11]. These characteristics are briefly described as follows;

Data Volume refers to the massive amounts of structured, unstructured or semi-structured data generated from a variety of sources [11]. In 2013, the International Data Corporation estimated that 4,4 Zettabytes of digital data were created, consumed, and replicated [3]. *Variety* refers to the varying formats, structure, and size of Big Data generated. As the number of sources data is generated and collected from increases, the complexity of handling it increases too. *Velocity* refers to the exponentially increasing speed of the creation, replication, and consumption of data [12]. The continually growing velocity of data collected by an organization is a result of an increase in the sources of information available [9]. *Veracity* refers to the quality and usefulness of the data generated and captured [11], [12]. Due to the high volume, velocity, and variety of Big Data, there is an increased possibility that the data will not be 100% accurate [12]. Dirty data negatively affects the potential value and usability of data [11]. *Value* refers to the extraction of valuable information from the large volume of data generated [6]. Value is seen as the most vital characteristic of any Big Data application as it allows for the generation of useful business information that can aid in strategic decision making [6], [12]. In a more recent study, Seddon and Currie [13] introduced an additional two (2) characteristics to the definition of Big Data: variability and visualization. *Variability* refers to the understanding and interpreting of data, whose meaning is constantly changing, in the right context [13]. *Visualization* refers to the method of representing data in meaningful ways (such as artificial intelligence methods) to aid management in their decision making [13].

2.2 Data governance and data governance frameworks

Several definitions for data governance exists both in the researchers' community as well as in the practitioners' community [14]. In the researchers' community, data governance is defined as a structural framework for decision-making rights and responsibilities regarding the use of data [15].

In the practitioners' community, IBM [16] defines data governance as the overall management of data availability, relevancy, usability, integrity, and security in an enterprise. Gartner [10] extends on this definition and defines data governance as "the specification of decision rights and an accountability framework to encourage desirable behavior in the valuation, creation, storage, use, archiving and deletion of information."

Although no single, universal definition of data governance exists, both researchers and practitioners agree that data governance refers to assigning rights and responsibilities regarding the management of data assets to ensure accountability, and the adoption of data governance should be on organizational task [17].

Data governance is essential in ensuring that data is managed appropriately by organizations. The data governance framework adopted and implemented by an organization outline processes and policies to be adhered to throughout the data's lifecycle

and create accountabilities for the data by allocating responsibilities [18].The data governance framework should cater for the protection of data, the proper use of the data, and the management of data as a business asset to aid in strategic decision making [19]. One of the critical success factors for the successful adoption of Big Data projects lies in the implementation of a Big Data governance framework [4].

2.3 The importance adopting Big Data governance

The massive size and diverse nature of Big Data requires governance to play a vital role in its management [9]. Existing data governance concepts are suitable for data that is structured in nature, while Big Data governance needs to take into consideration both structured and unstructured data [4].

In order to adequately prepare for the transition to Big Data, organizations must establish a data governance framework to ensure that data captured and stored is accurate, useful and that privacy laws and regulations are adhered to [20]. A data governance framework can is defined as "a set of processes that ensures that important data assets are formally managed throughout the enterprise" [21]. Although the notion of Big Data creating value for organizations is not a new one [7], it is evident, through existing literature, that many organizations are failing to govern Big Data [42] effectively.

In today's Big Data world, governance is the glue that drives value and mitigates risk [22]. The design and implementation of a Data governance strategy is a practical approach to increase data quality levels, improve the usefulness of data, and ensuring that the maximum value of data is achieved [1]. Soares [23] defines Big Data governance as "part of a broader information governance program that formulates policy relating to the optimization, privacy, and monetization of Big Data by aligning the objectives of multiple functions." An organization's Data governance policy should stipulate who keeps the decision making rights regarding data processes, as well as establishing a framework under which these processes are executed all while being coherent with the mission and strategy of the organization [24]

Big Data governance plays a role in the broader information governance framework, and organizations should extend the scope of their current information governance programme to include Big Data [23]. To successfully manage Big Data, organizations may require additional skill sets and technology; there may also be a change in the business process needed [25]. Although data governance is seen as only one component of the overall Information Management needed for Big Data [4], Loshin [26] argues that it is the most crucial component in the overall information management and that, if implemented early on, organizations can reduce the risks associated with working with Big Data. Chamberlain [27] further explains that organizations must develop well-formed data governance frameworks to assist in reducing risks, safeguarding information, and realizing data as an asset. In order to increase the trust in Big Data, there needs to be standardization in governance structures [7].

3 Research Method

The research method of this study is a Systematic Literature Review (SLR) based on the guidelines proposed by Kitchenham [28]. A Systematic Literature Review is a secondary study that composes of extracting data from existing work (primary studies) and synthesis the findings; this is done by identifying, evaluating, and interpreting available research relevant to a specific research topic [28]. The steps taken in this study are detailed below.

Firstly, search terms were identified. These included: Big Data governance, Big Data governance Framework, Big Data, Data governance, Data governance Framework.

All these search strings were combined by using the Boolean "OR" and "AND" operator as follows: ((Big Data governance) OR (Big Data)) AND ((data governance) OR (data governance framework) OR (Big Data governance framework)).

In conjunction with the selection of search terms, inclusion and exclusion criteria were defined and applied to all search results obtained. This step assisted in ensuring that the validity of the Systematic Literature Review is guaranteed. The inclusion criteria are as follows; Papers that were published between 2006 and 2019, Journal Papers, Conference Proceedings, Reports, and Book Chapters were included, Peer-reviewed papers, and Papers that are written in English. The exclusion criteria are as follows; Papers that are irrelevant to the research question, Short papers such as introductions, posters, and mini-tracks, and papers that were inaccessible.

The source selection process consisted of three (3) main steps, which are described below. All search results returned were documented in a data extraction table containing the title of publication, author, and the year of publication.

In step one (1), a literature search was conducted to source all papers relevant to the study. Four (4) academic online databases were searched, namely; ScienceDirect, Worldcat.org, DOAJ, and JSTOR. The primary search term was "Big Data governance," additional but related terms, such as "data governance," "Big Data governance framework," and "Big Data" were also searched. All search results returned were imported into the data extraction table. For step two (2), an initial screening was done whereby each paper title was checked to determine whether it is relevant to the research topic and the inclusion and exclusion criteria, was applied. All records that did not contain keywords or concepts relevant to the research topic or did not meet the inclusion criteria were immediately excluded. Step three (3) consisted of a full-text analysis. There were several cases where the full texts were not available. Alternative searches were done, and the author of the paper was contacted. In the case where no response was received, or the paper was not available on another online database, the paper was excluded. For each paper excluded during the full-text analysis, motivation was given.

The search strategy, as outlined above, as well as the PRISMA flowchart in Fig. 1, depict the selection process of the articles reviewed for this study. The outline of the PRISMA flowchart is adopted from the PRISMA groups' suggested structure [29]. A heuristic search using the defined search terms was done on Google Scholar and re-

turned 17,800 results after the custom date ranges were entered. The same search was done on the four (4) academic online databases used for this study, namely; ScienceDirect, Worldcat.org, DOAJ, and JSTOR. 209 results were returned. Once duplicates were removed, a total of 197 records remained. After the initial screening was completed, 68 records were excluded leaving 129 full-text articles to be assessed. Of these 129 articles, 89 were excluded, with the most common reason being that the articles were inaccessible. 40 articles remain for data extraction and synthesis.

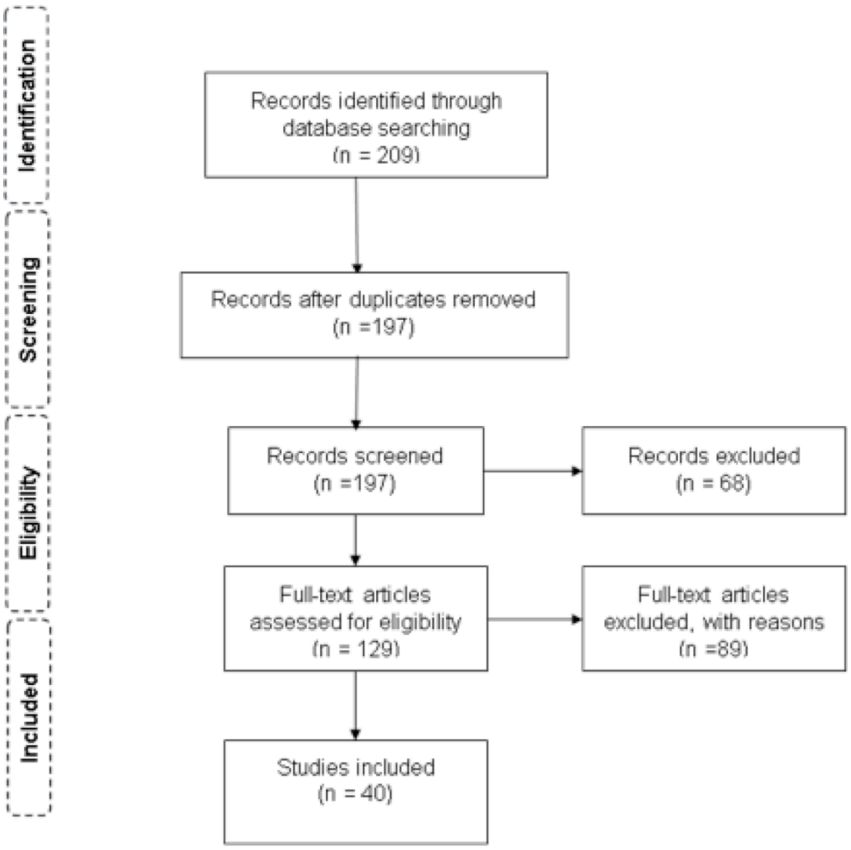

Fig. 1. PRISMA Flowchart adopted from [29]

4 Analysis of Findings

The final literature pool evaluated identified five (5) main conceptual data governance frameworks. These were labelled as **BDGF-1** [30], **BDGF-2** [31]**, BDGF-3** [27]**, BDGF-4** [23] and **BDGF-5 [4].**

BDGF-1 [30]. The framework proposed by Kim and Cho [30] places importance on Big Data services creating value that aligns with organizations' overall objective. Big Data provides an organization with the opportunity to create a new analysis that will, in turn, produce more value for the organization. Organizations should clarify the values the Big Data services will reveal through the formalization of their purpose and declaration [30]. Kim and Cho [30] propose a Big Data governance framework whereby organizations formulate their strategy to manage challenges and create new analysis and value based on their defined objective. The three winning strategies identified to enable Big Data services to create a new analysis that results in more value are: a) protecting personal information by defining data protection levels and developing protection devices, b) preserving the level of data quality and c) defining data responsibilities for its ownership and management [30].

Organizations can realize these strategies through the use of components required to execute Data governance [30]. The components identified in the Big Data governance Framework proposed by Kim and Cho [30]*,* are an extension of the already existing data governance framework, as described by Panian [32]. The components include:

Organization (the design of the organizational structure and defining the data ownership roles and responsibilities); standard and guidelines (defining and formulating guidelines for data formats, storage, and processing); and policies and procedures (used to govern and supervise the creation, flow and management of data).

The fourth and final pillar of the Big Data governance framework is IT infrastructure [30]. Organizations need to ensure that sophisticated infrastructure is implemented to ensure data security and scalability [1]. The Big Data infrastructure will require new solutions and computing resources in order to enable the useful collection, processing, and analysis, and visualization of data [30].

BDGF-2 [31]. Krishnan [31] adopts and modifies seven (7) key Data governance concepts to govern the implementation of any Big Data initiative. The selected information concepts adopted were stewardship, information governance, data definition and usage standards, master data management, metadata management, data lifecycle management and risk and containment. Data stewards assist in creating clear data definitions, enforce data governance policies and procedures and have a clear understanding of data usage [9], [33]. Information governance refer to creation of policies focusing on the acquisition, processing, storage, and security of Big Data [31]. Data definition and usage standards refer to well-defined rules and standards on how the data is consumed, formatted, and processed for each business unit that shares the data. Master data management (MDM) emphasize the consolidation, matching, and standardization of data across systems to improve data quality [33]. Metadata management refers to the maintenance of information relating to enterprise data and define the context for metadata processing [9], [33]. Data lifecycle management refers to the

management of data throughout its complete lifecycle - from the inception of data until it has been archived [33]. Risk and containment refers to the need to understand and prepare for the risks and potential hidden costs that are associated with any Big Data initiative [9].

BDGF-3 [27]**.** Chamberlain [27] uses an established data governance Framework as a base and extends on each of the five (5) domains that can be used to govern any Big Data initiative. The five (5) domains are data principles, data quality, metadata management, data access and data lifecycle. The application of data principles (domain 1) refers to the need to realize business value from data and treating it as an asset for which policies, control standards, and control procedures need to be set [27]. It is crucial to define and set data principles that will govern the design of new data services and changes to existing data services [34]. Data quality (domain 2) refers to the need of data to be accurate, complete, reliable and relevant [35]. To achieve high-quality data, organizations need to establish standards to ensure that data collected and stored is complete, credible, and up-to-date [27]. Poor data quality can harm the value of the organizations' data [35]. Metadata (domain 3) is defined as the information that is used to describe data within the organization – it is a summary of what the data is [36]. Metadata provides a means for organizations to search and analyze their data [25] effectively. When designing metadata management policies, organizations need to have a futuristic view and understand that there will be inevitable business operation and objectives changes, which will cause a shift in the way metadata is designed and managed [27]. Data access (domain 4) refers to the realization of organizations to effectively mitigate risk and manage compliance through the development and enforcement of strict data access controls [27]. These controls need to be established to ensure that users are only able to access the Big Data sets for which they are authorized and to prevent the misuse of data. Organizations need to establish a Big Data governance framework to safeguard the various channels of data collection and storage mechanisms [27]. The data lifecycle (domain 5), as presented by Chamberlain [27] caters for the complete data lifecycle, from inception to archival of data. The data lifecycle provides organizations with an understanding of how their data is sourced, the progression of the data, and, finally, the archival or deletion of data [27]. By focusing on the data lifecycle within a governance program, organizations are able to identify all business processes that use the data and possibly identify any overlaps in data storage [37].

BDGF-4 [23]**.** Soares [23] provides a framework for Big Data governance that consists of three (3) dimensions; Big Data types, information disciplines, and industries and functions. The framework provided allows organizations to tailor their Big Data governance framework based on the data types used, the information disciplines that are relevant to the organization as well as to what industry the organization forms part of [23]. Big data types, as identified by Soares [23], was into five (5) distinct types, namely social media and web data, machine-to-machine data (M2M) (readings from devices such as sensors and meters [38]), big transaction data (such as utility billing records [23]), biometric data (data identifying persons based on anatomical detail such as fingerprints [23]), and human generated data (for example voice recordings) [38]).

Information Disciplines identified by Soares [23], referred to eight key data governance concepts that apply to Big Data, namely the organization, metadata, privacy, data quality, business process integration, master data integration, information lifecycle management, and industries and functions. The organization should be proactive in their Big Data approach and seek to employ Big Data experts as members of the information governance council and by identifying and appointing data stewards [23]. A metadata repository should cater for Big Data items and subsequently maintained [23], [39]. Privacy is important to ensure that limited access to confidential data is allowed through the application of restriction policies and user access rights [39]. The quality of data should not be compromised due to the high volume and variety of Big Data. Organizations need to keep sight of and ensure that all quality dimensions are met[9]. The quality dimensions include; completeness, validity, integrity, consistency, timeliness, and accuracy [9]. Both core business processes and new Big Data processes should be integrated to run parallel and managed effectively [23], [39]. Policies need to be established to govern Big Data integration with the master data management environment [23]. Big data, similar to organizational transactional data, should be manage according to the information lifecyle. As result, the business requirements should identify which data to retain, which data to archive, and which data to delete [23]. Finally, in his proposed Big Data governance framework, Soares [23] explains that a Big Data framework will look different depending on the industry the organization functions in.

BDGF-5 [4]. Al-Badi, Tarhini, and Khan [4] conducted a review of twelve (12) existing Big Data governance frameworks. For each of the frameworks, Al-Badi, Tarhini, and Khan [4] identified the components and discussed their limitations. Based on their findings, Al-Badi, Tarhini and Khan, [4] proposed a new conceptual framework that consists of the following eight (8) components: 1) identify organizational structure, 2) identify relevant stakeholders, 3) identify the scope of Big Data, 4) set the policies and standards, 5) optimize and compute, 6) measure and monitor quality, 7) store the data and 8) communicate, and manage the data. The proposed framework incorporates the seven (7) core principles of information governance and applies it to Big Data governance [4].

Table 1 shows a comparison between the components or characteristics of each of the five (5) frameworks. The components of each framework are listed in each row of the table. To cater for instances where components have the same meaning but are named differently, a generalized label was given to that component. An "X" is used to mark each Big Data governance framework that possesses the component. The comparison aims to highlight the similarities between each framework and identify the key components that should be incorporated into the conceptual Big Data governance framework.

From the above comparison, it is found that in four of the five frameworks, an emphasis is placed on enforcing data quality when working with Big Data. The emphasis on data quality can be attributed to the fact that Big Data is often unstructured and requires an extra focus to ensure that the data is in a format that renders it useful. In addition, the lifecycle of the data is also a common component and needs to be care-

Table 1. Comparison of existing Big Data governance frameworks

Component	BDGF-1 [30]	BDGF-2 [31]	BDGF-3 [27]	BDGF-4 [23]	BDGF-5 [4]
Data Quality	X		X	X	X
Master Data Integration/Management		X			
Metadata Management		X	X		
Organizational Understanding	X			X	X
Stewardship/ Data Ownership	X	X			X
Data Lifecycle Management	X	X	X	X	
Data Privacy and Security	X		X		
Data Storage and Retention	X				X
Information Governance/Policy Formulation		X	X		X
Risk and Containment		X			
Business Process Integration				X	
Big Data Scope Determination					X
Optimization					X
Communication and Data Management					X

fully managed. Adequate retention, archival, and deletion policies need to be put in place to ensure cost-effective storage

The guiding principle for the adoption of a conceptual Big Data governance framework should be to understand the context of the organization subsequent objectives. Organizations need to define the objective/s they wish to achieve through the collection, usage, and analysis of their Big Data. It is also essential to get an understanding of the context of the organization and its structure to determine the formality and focus of the Big Data governance to be implemented. Contextual factors that will influence the organizations choice when deciding on which Big Data governance framework to implement include, but are not limited to; the industry of the organization, the size of the organization, and the corporate culture of the organization [37]. A one-size-fits-all approach to data governance is unlikely to succeed [40], forcing organizations to consider contextual factors when design and adopting a Big Data governance framework [37].

Subsequently six (6) main pillars, or components of a conceptual Big Data governance framework was identified namely data quality, data ownership, data security and privacy, metadata management, master data management and data lifecycle management. These pillars should be supported by a strong foundation of people, processes, and technology.

Big Data is an emerging phenomenon with a limited number of people who have had hands-on experience with using and managing it. Organizations need to ensure that the right people, with the right skills, are placed in roles and given responsibilities that will improve the usage of Big Data. The capabilities offered by Big Data will redefine and reshape current data processes [9]. The organization will need to develop the right procedures for the collection, processing, and optimization of Big Data. The high volume nature of Big Data requires that specific technologies are implemented to handle the additional storage, management, and retrieval features required [27]. To maximize the value of its Big Data assets, organizations need to have a holistic approach to data governance and strike a balance between people, processes, and technologies to achieve organizational efficiency [27].

5 Conclusion

An ever-increasing number of organizations are relying on Big Data to provide insights to enhance strategic decision making. Data is considered as a critical organizational asset and requires the implementation of adequate management and governance procedures in order to safeguard it as an asset and to ensure that the most value is derived from it. Big Data differs from traditional data as it is of high volume, high variety, and high velocity. In addition, Big Data is often unstructured in nature. These differences make it crucial for organizations to develop new or adapt existing data governance structures to cater to Big Data and to ensure that the Big Data collected integrates with the organizations' traditional data. Although Big Data is a growing phenomenon, there are few studies on how to correctly govern it. In order to provide an answer to the research question, What data governance structures exist for Big Data adoption, the challenges faced by organizations when using Big Data were detailed, five (5) existing frameworks were analyzed, and a conceptual framework was derived. The components of each of the five (5) existing Big Data governance frameworks were detailed, and the similarities highlighted. A conceptual framework was developed incorporating components and structures from existing Big Data and data governance. The guiding principle of the conceptual Big Data governance structure is understanding the organization and defining the objective of the Big Data implementation. Organizations should formalize a Big Data governance framework that aligns with their objective and understanding. Where, depending on the context and objective of the organization, more emphasis will be placed on one or more of the pillars. The proposed framework consists of six (6) pillars; Data Quality, Data Ownership, Security and Privacy, Metadata management, master data management and data lifecycle management. These pillars are supported by a foundation of people, processes, and technology. Organizations need to view their governance framework as an ever-evolving structure that requires continuous improvement and adaptation.

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Exploring the Impact of ICT Use Patterns on Postgraduate Student Academic Achievement in a Developing Country

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Abstract.
A common motivation for the use of ICT in teaching and learning is the central belief that it has the potential to exert a positive effect on student academic achievement. Evidence to support this assertion, however, is contradictory. The current study attempts to address known research gaps by examining the impact of ICT use patterns on postgraduate student academic achievement in a developing country. Specifically, potential student bias in reporting educational achievement was removed by using instructor-assessed class marks as the dependent variable. Data collected from 302 students were analysed to test several hypotheses constructed after a literature review of previous studies in the field. Statistical evidence showed constructs of teaching and learning with the aid of ICT, student ICT literacy, and behavioural engagement to correlate strongly with student performance, with challenges of ICT use not influential. The current research findings affirmed the belief that technology-supported education in a developing country can play a significant role in student academic achievement, especially in postgraduate settings.

Keywords: Course Activities using ICT; Student Engagement with ICT; Student ICT Literacy; Challenges of ICT Use; Student Academic Achievement, Developing Country, Postgraduate Students

1 Introduction

Over the last few decades, technology investment and usage in education has increased more than a hundredfold [1]. The primary reason for this spending is the general belief that information and communication technology (ICT) can increase the effectiveness of teaching, thereby improving student learning and performance. Not surprisingly, the provision of ICT in education has become a major focus of many governments, especially in developing countries. However, research data to support this belief is equivocal. For example, whereas there is research evidence of a positive impact [2-5], other studies have reported little or no impact [6-9]. One possible reason for the disparity is

that the real impact of ICT on learning is not easily understood, and for various reasons [6]. For example, "Are we referring to ICT infrastructures or their actual use? Is the intensity of use an important factor? Are we referring to specific skills, competences and domains, or more holistic concepts of learning?" (p. 28). A further question asks, how do we define and capture the relationship between ICT use and learning?

Fifteen years ago, Trucano [10] created a series of knowledge maps on behalf of The World Bank regarding what is and what is not known about key areas of ICT use in education in both Organisation for Economic Co-operation and Development (OECD) and developing countries. From these maps, several pressing research questions were formulated. A decade later, the author noted that many of these research questions are still relevant, confirming that we still do not have answers to many of the basic questions asked in 2005. Despite such uncertainties, substantial investments in ICT in education continue, and to convince educators that the use of ICT is indeed a worthwhile pursuit, there remains a pressing need for ongoing research.

The broad focus of this study is on three statements as extracted from the knowledge base: (a) it is still unknown if some subjects are better suited to ICT integration than others, (b) many studies that find positive effects of ICT on student learning often rely (to an unacceptable degree) on self-reporting, which may be open to a variety of positive biases, and (c) the impact and nature of ICT use on student engagement has not been well documented. Furthermore, we limit our focus to a developing country, because what lessons were learned, and best practices developed, have not been packaged well [10].

The 1st objective of this study is to review and use the available literature on ICT use in education to identify a suitable research setting, relevant concepts, and research questions and hypotheses that may assist us in the construction of an appropriate research instrument. The 2nd objective is to employ the instrument and to use instructor-assessed class marks in place of student self-reporting as the dependent variable in further statistical procedures. In reporting the results, the overall purpose of this paper is to contribute to the gaps that have been identified.

2 Literature review

2.1 Identification of research setting

Of the recent literature we reviewed and referenced in this study, and where we could source relevant factors, a total of 19 studies reported an ICT impact on student achievement, while 9 did not. Most studies were conducted in developed countries, while subject areas studied ranged from the traditionally "more challenging" (e.g. medicine and mathematics) to the arguably "less demanding" (e.g. languages and education). What stood out from our review, however, was the level of education, which ranged from primary (5) and secondary (30) to undergraduate (14). Just one study focused on postgraduate students (at MBA level, in a developed country [12]). On face value, a study of postgraduate students offers a well-defined group, whose members share some common characteristics: (1) Being older, but still part of the Millennial Generation, they are expected to have had more exposure to ICT, thereby removing potential ICT experience

bias; (2) postgraduate studies are research-oriented by nature, which necessitates the use of ICT outside the classroom, such as searching for and exploring online research resources; and (3) by demonstrating a capacity and dedication for further independent learning, the use of a wide range of learning strategies, including the use of ICT, is likely. The latter two notions are in line with research which observed that whereas undergraduate students use scaffolded learning activities more frequently, postgraduate students use research-based e-learning activities [13] and are more likely to use ICT for academic purposes [14]. For these reasons, a post-graduate and research-oriented course became a focus of our study.

2.2 Formulation of research questions and hypotheses from the literature

Having identified an appropriate research setting, this section identifies relevant ICT use concepts from the literature that will guide us in constructing suitable research questions and hypotheses. At the most rudimentary level, successful use of ICT in education is reliant on several key constructs, which, in our view and experience, can broadly be categorised as the extent to which available ICT is employed in course activities by the instructor; the level of student engagement with such ICT inside and outside the classroom; students' ICT knowledge and skills; and ICT challenges encountered. Where possible, we limit our review to research that focused on the relationship between ICT use and student achievement.

Course activities using ICT constructs of interest include teaching with the aid of ICT, presentation and discussion of classwork with ICT, and suitability of classwork for ICT integration. Whereas positive teaching-with-ICT influences were reported by many authors [4, 15, 16], students have been found to perform worse when personal computing technology was available [8]. As for presentation and discussion of classwork, ICT is seen to support more dialogic and synergistic approaches in both group and individual activities [17], although its value appears dependent on the context and situation [18]. We formulate the following broad research question and hypothesis: **RQ 1:** To what extent do course activities using ICT have an impact on academic achievement*? H1: Course activities using ICT have a positive impact on academic achievement.*

Significant relationships between student engagement and academic achievement have been reported, with the former defined as the emotional, cognitive, behavioural and psychological reactions to the learning process [19]. However, no significant difference in the level of student engagement between a group of students where ICT was used to teach the subject, and another group, where ICT was not used, has been reported [20], although relationships between cognitive and behavioural engagement and student achievement were found. In both studies, behavioural engagement was a key consideration; hence we focus on three conventional dimensions of student engagement, namely individual attitude, attentiveness, and preferences and interest. Since student diligence has also been related to academic achievement [21], it is included as a fourth construct. We therefore define and use the term "engagement" to imply a symbiotic

relationship between student engagement with ICT, general engagement (i.e. attentiveness and diligence) and academic performance. **RQ 2**: To what extent does student engagement (with ICT) have an impact on academic achievement? *H2: Student engagement (with ICT) has a positive impact on academic achievement.*

In terms of students' ICT use, knowledge and skills, quality, rather than quantity of technology use, have an impact on academic achievement [22]. While some authors have reported a direct and significant relationship between ICT literacy [12, 20, 23, 24] and familiarity with ICT [28] and academic success, others found no impact on educational achievement [25-27]. The constructs we focus on are student use of ICT, ICT competence and skills, exposure to ICT, and the enhancement of personal skills such as critical thinking, motivation, self-confidence, and creativity when using ICT [29]. **RQ 3**: To what extent does student ICT literacy impact on academic achievement? *H3: Student ICT literacy has a positive impact on academic achievement.*

Challenges associated with ICT use are numerous. The effects of anxiety on student academic achievement has been well documented [30 – 32]. Some students may experience an almost irrational fear and stress brought on either by a lack of experience or a deep-rooted and adverse reaction to the threat that ICT poses to the user [34]. Effective education is thought to impossible when there is no provision for ICT facilities [33], while there is general concern about the impact of undesirable content and internet overuse on the youth, including internet crime, copyright infringement, and security and privacy concerns [35]. Barriers to ICT use in developing countries has been reported extensively [e.g. 36 – 38]. Constructs of interest are therefore anxiety over the use of ICT, privacy, safety and security issues, and barriers to the use of ICT. **RQ4:** To what extent do challenges of ICT use have an impact on academic achievement? *H4: Challenges of ICT use have a negative impact on academic achievement.*

Having formulated suitable research questions and hypotheses, we now present our research design.

3 Research design (statement, strategy, methods and setting)

The main purpose of the current study is to investigate the impact of ICT usage patterns on postgraduate student academic achievement in a developing country. The philosophical base adopted is a positivist perspective, the aim to explain and predict objectively. Given this perspective, the study adopted a quantitative research paradigm [39] that lends itself to statistical analysis and a deductive approach. Inductive reasoning [40] was employed to develop the hypotheses previously presented.

Clearance for the study was requested and received from the relevant ethical committees. Purposive sampling [41] was employed, in terms of which the researchers used the literature to identify an appropriate subject pool given the objectives of the study.

The master's class is a largely taught postgraduate three-semester (eighteen months) program. Research Methodology (RM) is one of the courses offered for all master's students from nine departments at a private university in Nigeria. Several instructors present different aspects of the course to all RM students as a group. Whereas each

instructor presents an aspect of the course using his/her choice of ICT, all students are exposed to the same set of ICTs. In preparation for a final and individual research mini dissertation to be delivered in the 3rd semester, the 1st and 2nd semesters focus on course work. The end of 2nd semester, which incorporated formal class time, was used to collect data. The classmark consisted of four instructor-assessed components: a class test mark, an assignment mark, a research project mark, and a presentation mark.

As research instrument, we selected the survey method. Some survey questions were sourced from previous studies on ICT use in education. To ensure relevance, we modified a few questions. Based on our own experiences with, and theoretical research sensitivity about, the use of ICT in education, we constructed a few questions of our own. The final survey instrument consisted of 77 questions subdivided into five constructs, each containing several sub-constructs.

Construct A**:** Personal information, contains eight demographic questions.

Construct B**:** Course activities using ICT, has three sub-constructs: *B1: Teaching with the aid of ICT* (7 items); *B2: Presentation and discussion of classwork with ICT* (5 items); *B3: Suitability of classwork for ICT integration* (7 items, 2 adapted [42, 43]).

Construct C**:** Student engagement, has four sub-constructs: *C1: Individual attitude* (6 items, 1 adapted [20]); *C2: Attentiveness* (7 items, 6 adapted [20]); *C3: Diligence* (5 items adapted [20]); *C4: Preferences and interest* (7 items, 3 adapted [44]).

Construct D**:** Student ICT literacy, contains four sub-constructs: *D1: Exposure to ICT* (4 items, 3 adapted [45]); *D2: Student use of ICT* (5 items); D3: *ICT competence* (6 items adapted [25]); *D4: Personal skills* (4 items);

Construct E: Challenges of ICT use, has three sub-constructs: *E1: Anxiety over the use of ICT* (5 items, 4 adapted [46-48]); *E2: Privacy, safety and security issues* (4 items); *E3: Barriers to ICT use* (4 items adapted [47]).

For each item, a five-point Likert scale was employed, where 1 = strongly disagree, 2 = disagree, 3 = indifferent, 4 = agree and 5 = strongly agree.

A unique questionnaire number was made available on both the cover and first page of each questionnaire. After the administration of the questionnaire, and on the first page, the course instructor recorded the student's classmark next to the questionnaire number. Before returning the completed questionnaires to the researchers, the instructor removed student information, thereby ensuring the anonymity of data. To explore possible relationships between the construct items and class marks achieved, multiple linear regression analysis was conducted using the Statistical Analysis System (SAS) JMP v.12.

4 Data analysis and results

From a total of 320 questionnaires distributed to students, 302 were returned for a response rate of 94%. Exploratory factor analysis was carried out to validate the main constructs. In Construct B: Course activities using ICT, the initial three sub-constructs were reduced to a single main construct with the same label. In Construct C: Student engagement, the four sub-constructs were reduced to three (C1: *Individual attitude; C2: Diligence; C3: Preferences and interests*). In Construct D: Student ICT literacy, the

four sub-constructs were merged into the main construct, as was the initial three sub-constructs in Construct E: Challenges of ICT use.

To establish internal consistency, the reliability of the new constructs was measured using Cronbach's alpha. The following coefficients were reported: Construct B: Course activities using ICT (0.969); Construct C: Student engagement (0.934); Construct D: Student ICT literacy (0.967); and Construct E: Challenges of ICT use (0.963). All the values are greater than 0.8, which is indicative of excellent results.

Demographics. Fifty-seven percent (57%) of respondents were male and 43% female. Gender had no significant impact on the mean class mark (male = 61.1%; female = 60.1%). Further analysis revealed other interesting patterns. In the demographic section of the questionnaire, two questions provided us with a general overview of the extent to which ICT is used inside and outside the classroom. Here, a significant gender difference in the mean class mark in favour of males was reported when ICT is used outside the classroom for purposes of class work (Table 1). For both genders, the mean class mark improved significantly the more ICT was used outside the classroom, with the difference between *rarely used* and *mostly used* 10% for males and 8.6% for females. This result is not only in line with research reporting ICT to increase student engagement and the amount of time that students spend working outside the classroom [49], but reinforces a long line of research that points to the existence of a gender gap in favour of males [42]. Of the 33 students that rarely used ICT outside the classroom for course work, 52% were male and 48% were female. Of the 79 students that occasionally used ICT, the split is also more or less equal, with 49% being male and 51% being female. However, of the nearly 70% of students that use ICT most of the time outside the classroom, only 38% were female. Whereas the gender difference in the mean class mark was small, the mark increased for both genders the more ICT was used outside the classroom.

Table 1. Gender difference: To what extent do you use ICT outside the classroom for purposes of classwork?

Variables	Total	Male		Male mean	Female		Female
	n	*n*	%	class mark	*n*	%	mean class mark
Rarely	33	17	52%	57.2	16	48%	53.6
Occasionally	79	39	49%	54.8	40	51%	59.0
Most of the time	190	117	62%	63.8	73	38%	62.2

* Significant difference ($p < 0.05$) in mean class marks

As postgraduates, most students fell into the age groups of 21-26 and 27-32. Table 2, with one exception, shows a marginal increase in the mean class mark across age groups in favour of the older students. The table also reflects a higher combined mean class mark (63.3 as opposed to 55.6 and 59.2) when instructors made use of ICT *most of the time* in teaching the course. This pattern mirrors student use of ICT outside the classroom (Table 1), where the mean class mark increased the more ICT was used by all students for purposes of classwork.

Most students, both male and female, had between 1- and 7-years' experience in using tablets (78%) or PCs/laptops (57%), with 54% and 98% respectively having up to and over 10 years' experience. Overall, more males had more experience (4 years and more) in the use of tablets and PCs/laptops. Gender differences were not as marked for the rest of the ICT used, although males and females with no hardware and software experience returned a lower mean class mark.

Table 2. Other demographics

Construct	Variables	Total n	% of students	Mean classmark
Age	21-26	136	45.03%	60.2%
	27-32	110	36.42%	60.6%
	33-38	38	12.58%	62.5%
	39-44	10	3.31%	60.7%
	45-50	4	1.32%	62.5%
	51+	4	1.32%	64.0%
My lecturer uses ICT in presenting the class work*	Not at all/rarely	55	18.21%	55.6%
	Occasionally	87	28.81%	59.2%
	Most of the time	160	52.98%	63.3%

* Significant difference ($p < 0.05$) in mean class marks

Students with more than 10 years' experience returned the highest mean class mark. These outliers, however, consisted of only five students each, with class marks for the rest of the students being relatively constant (59–61%).

Using decision tree analysis and a calculated median of 62% for class marks, two patterns were readily evident. Eighty-seven percent (87%) of students (n = 110) who used ICT *most of the time* outside of the classroom received a mark higher than the median, while only 13% of students who *did not make use of ICT*, or made use of ICT *only occasionally*, received a mark higher than the median. Similarly, when ICT was used *most of the time* in teaching inside the classroom, 97% of students (n = 81) received a mark higher than the median, while 90% received a mark lower than the median when ICT *was not used*, or was used *only occasionally*, in teaching and learning activities.

ICT usage patterns.

Table 3 presents the correlations reported between the various constructs and class marks.

Table 3. Construct correlation coefficients

Constructs	B	*C1*	*C2*	*C3*	D	E	Classmark
B: Course activities using ICT	1						
C: Student engagement							
C1 Individual attitude	.730*	1					
C2 Diligence	.694*	.630*	1				
C3 Prefs & interests	.584*	.599*	.599*	1			
D: Student ICT literacy	.698*	.679*	.633*	.635*	1		
E: Challenges of ICT use	-.323*	-.256*	-.222*	-.280*	-.317*	1	
Class mark	.827*	.698*	.678*	.632*	.817*	-.251*	1

* Significant at $p < 0.05$ (Spearman's correlation coefficients)

Except for Construct E: Challenges of ICT use, all constructs returned significant and positive correlations. Construct B: Course activities using ICT (0.827) returned the strongest correlation with class marks, which is consistent with the interpretation that ICT is more effective when it is integrated into a classroom's teaching programme [4]. The next strongest correlations were Construct D: Student ICT literacy (0.817), followed by student engagement sub-constructs C1: *Individual attitude* (0.698) and C2: *Diligence* (0.678). The lowest positive correlation was reported for sub-construct C3: *Preferences and interest*s (0.632). Construct E: Challenges of ICT use, recorded a weak negative correlation, which suggests that with a decrease in ICT challenges, student academic achievement will increase marginally. This pattern held true for correlations between this construct and the other individual constructs. Table 4 ranks the constructs in terms of their weight.

Table 4. Construct ranking by weight

Constructs and sub constructs	Correlation coefficient	Weight
B: Course activities using ICT	0.8269	Strong
D: Student ICT literacy	0.8169	Strong
C: Student engagement		
C1: Individual attitude	0.6982	Medium
C2: Diligence	0.6771	Medium
C3: Preferences and interests	0.6316	Medium
E: Challenges of ICT use	-0.2514	Weak

Regression model assumptions.

The model assumptions satisfied the linearity criteria, except for Construct E: *Challenges of ICT use,* which was observed to be nonlinear. To restore linearity, the construct was split into two groups, namely C*hallenges_E1* (normal) and *Challenges_E2* (quadratic), treated as two separate constructs, and included in the regression analysis as either model 1 or model 2. This resolution resulted in hypotheses 4a and 4b.

H4a: Challenges_E1 (normal) has a negative impact on student academic achievement. H4b: Challenges_E2 (quadratic) has a negative impact on student academic achievement.

The multicollinearity criteria were also satisfied when Construct B: Course activities using ICT, Construct C: Student engagement and Construct D: Student ICT literacy were treated as equally important, without distinguishing one item from the other.

Regression analysis

Tables 5 and 6 list the multiple regression coefficients reported for model 1 and model 2. Except for Challenges_E_1 (normal) (Table 5), all constructs were found to be statistically significant. When Challenges_E_1 (normal) and Challenges_E_2 (quadratic) were removed in model 2 (Table 6), the unstandardised and standardised values of the remaining three variables were slightly affected, while the significant values remained relatively unchanged.

From these results, and for purposes of prediction, a multiple regression equation [50] was used in predicting class marks (Y) for model 1: $Y = b_0 + b_1$ *Course activities using ICT* $+ b_2$ *Student engagement* $+ b_3$ *Student ICT literacy* $+ b_4$ *Challenges of ICT use (normal)* $+ b_5$ *Challenges of ICT use (quadratic).*

Table 5. Multiple regression coefficients for Model 1

Constructs	Unstandardized Coefficients		Standardized Coefficients	t Ratio	Sig.
	B	Std. Error	Beta		
(Intercept)	2.565	1.984	0	1.29	0.1973
B: Course activities using ICT	5.954	0.383	0.430	15.55	0.0001*
C: Student engagement	1.086	0.436	0.076	2.49	0.0133**
D: Student ICT literacy	8.030	0.388	0.533	20.71	0.0001*
E_1: Challenges of ICT use (normal)	-1.578	1.039	-0.147	-1.52	0.1296
E_2: Challenges of ICT use (quadratic)	0.389	0.186	0.202	2.10	0.0370**

* Significant at $p < 0.01$, ** Significant at $p < 0.05$. Dependent variable: Class marks

Table 6. Multiple regression coefficients for Model 2

Constructs	Unstandardized Coefficients		Standardized Coefficients	t Ratio	Sig.
	B	Std. Error	Beta		
(Intercept)	0.906	1.016	0	0.89	0.3736
B: Course activities using ICT	5.848	0.389	0.422	15.03	0.0001*
C: Student engagement	1.140	0.446	0.080	2.56	0.0111**
D: Student ICT literacy	8.201	0.383	0.545	21.44	0.0001*

* Significant at $p < 0.01$, ** Significant at $p < 0.05$. Dependent variable: Class marks

Summary of multiple regression analysis

A summary of the multiple regression models 1 and 2 are presented in Table 7.

Table 7. Summary of multiple regression analysis (n = 302)

Construct & fit	Model 1 Unstd/Std β	Model 2 Unstd/Std β
B: Course activities using ICT	5.954 (0.430)*	5.848 (0.422)*
C: Student engagement	1.086 (0.076)**	1.140 (0.080)**
D: Student ICT literacy	8.030 (0.533)*	8.201 (0545)*
E_1: Challenges of ICT use (normal)	-1.580 (-0.147)	
E_2: Challenges of ICT use (quadratic)	.389 (0.202)**	
Summary of fit		
R Squared	0.930	0.926
R Squared Adjusted	0.928	0.925

* Significant at $p < 0.0$; ** Significant at $p < 0.05$

For regression model 1, the results of the four constructs, namely Construct B: Course activities using ICT ($B = 5.954$, $p < 0.01$), Construct C: Student engagement ($B = 1.086$, $p < 0.05$), Construct D: Student ICT literacy ($B = 8.030$, $p < 0.01$) and Challenges_E_2 ($B = 0.389$, $p < 0.05$) were significant. Challenges_E_1 ($B = -1.578$, $p > 0.05$) was insignificant. As indicated earlier, for regression model 2, Challenges_E_1 and Challenges_E_2 were removed to test for impact factor changes. Analysis of the remaining three

constructs for model 2, namely Construct B: Course activities using ICT (B = 5.848, p <0.01), Construct C: Student engagement (B = 1.140, p < 0.05) and Construct D: Student ICT literacy (B = 8.201, p < 0.01) all showed a significant positive impact on class marks. In both models 1 and 2, Construct D: Student ICT literacy returned the strongest positive predictive impact factor on class marks, followed by Construct B: Course activities using ICT and, lastly, Construct C: Student engagement. The effect of the removal of Challenges_E_1 and Challenges_E_2 in model 2 was thus marginal, and model 1 is considered appropriate. R^2 was 0.930 for model 1 and 0.926 for model 2, while R^2 adjusted was 0.928 for model 1 and 0.925 for model 2. The results of model 1 are summarised in Table 8.

Table 8. Model 1 summary

Model	R^2	Adjusted R Square	Root mean square error
1	0.930	0.928	2.938975

Predictors: Construct B: Course activities using ICT, Construct C: Student engagement, Construct D: Student ICT literacy, *Challenges_E_1, Challenges_E_2* **Dependent Variable**: Class marks

Using all the predictors together, 0.930, or 93%, of the variance in class marks for this particular course can be predicted from Construct B: Course activities using ICT, Construct C: Student engagement, Construct D: Student ICT literacy, Construct E_1: C*hallenges_E_1 (normal)* and Construct E_2: *Challenges_E_2 (quadratic).*

Analysis of variance (ANOVA)

The ANOVA results presented in Table 9 were used to establish the level of significance of model 1.

Table 9. ANOVA (Analysis of Variance)

	Degree of freedom (df)	Sum of squares	Mean square
Regression model	5	33240.634	6648.13
Error	291	2513.535	8.64
Total	296	35754.168	
F Ratio	769.6750		
Significance F	0.0001		

Predictors: Construct B: Course activities using ICT, Construct C: Student engagement, Construct D: Student ICT literacy, Construct E_1: Challenges of ICT use (normal), Construct E_2: Challenges of ICT use (quadratic). Dependent variable: Class marks

The result was significant and a good fit of the data with F (5,291) = 769.6750, p < 0.05, R^2 = 0.930.

Research question synopsis and confirmation of hypotheses.

The results of our hypotheses testing are presented in Table 10.

RQ1: To what extent do course activities using ICT have an impact on academic achievement? Construct B: Course activities using ICT, returned a strong positive correlation with and prediction (2nd in weight (β) out of 5 predictors) of student academic achievement. *H1: Course activities using ICT have a positive impact on student*

academic achievement was supported, since a significant positive relationship was established with models 1 and 2 (Unstd β = 5.954 and 5.848, $p < 0.01$).

Table 10. Variable items and hypothesis testing results for models 1 and 2.

Hypothesis	Model 1 UnStd/Std β	Model 2 UnStd/Std β	Model 1 (remark)	Model 2 (remark)
H1: Course activities using ICT	5.954 (0 .430)*	5.848 (0.422)*	Supported	Supported
H2: Student engagement	1.086 (0.076)**	1.140 (0.080)**	Supported	Supported
H3: Student ICT literacy	8.030 (0.533)*	8.201 (0.545)*	Supported	Supported
H4a: Challenges of ICT use (normal)	-1.578 (-0.147)	N/A	Unsupported	N/A
H4b: Challenges of ICT use (quadratic)	.389 (0.202)**	N/A	Unsupported	N/A

* Significant at $p < 0.01$, ** Significant at $p < 0.05$

RQ2: To what extent does student engagement (with ICT) have an impact on academic achievement? Construct C: Student engagement, had a moderate positive correlation with class marks and returned 3rd in weight (β) out of four predictors of class marks. *H2: Student engagement (with ICT) has a positive impact on academic achievement,* was supported when a significant positive relationship was established for models 1 and 2 (Unstd β = 1.086 and 1.140, $p < 0.05$).

RQ3: To what extent do Student ICT literacy have an impact on academic achievement? Construct D: Student ICT literacy, had a strong and significant positive correlation with and prediction (1st in weight (β) out of four predictors) of class marks. Since a significant positive relationship existed in models 1 and 2 (β = 8.030 and 8.201, $p < 0.01$), *H3: Student ICT literacy has a positive impact on academic achievement,* was supported.

RQ4: To what extent do challenges of ICT use have an impact on academic achievement? Construct E: Challenges of ICT use, had a weak negative correlation with and prediction (4th in weight (β) out of four predictors) of instructor-assessed class marks. H4 were split into H4a:*Challenges_E_1 (normal)* and H4b:*Challenges_E_2 (quadratic)*. Neither were supported when a significant negative relationship was not established between the two variables in model 1 Challenges_E_1 (Unstd β = -1.578, $p > 0.05$) and challenges_E_2 (Unstd β = 0.389, $p < 0.01$). *H4a and H4b: Challenges of ICT use have a negative impact on academic achievement*, were therefore rejected.

5 Discussion and conclusions

The broad focus of this study was on three statements as they relate to the impact of ICT use on student academic achievement in a developing country context. A review of the literature firstly suggested a focus on postgraduate students, and secondly assisted in the development of appropriate research questions, hypotheses and a suitable questionnaire. By using instructor-assessed class marks in the place of self-reporting, an appropriate research environment was available. The study was guided by 4 research questions and hypotheses. To investigate patterns of use, several main and sub-constructs were proposed. After data collection and exploratory factor analysis, and to

investigate correlations with instructor-assessed class marks, the five revised main constructs were subjected to further analysis

In the specific setting this study reports on, Construct B: Course activities using ICT, included sub-constructs teaching with the aid of ICT, presentation and discussion of classwork with ICT and suitability of classwork for ICT integration. The construct returned the highest overall correlation with class marks. This finding is best explained by the significant and linear correlation between the extent to which instructors made use of ICT in teaching the course and student achievement, which is in line with results from several other studies [2, 4, 15, 16, 51 -54].

In terms of student use of ICT, academic achievement improved marginally but significantly when ICT was used outside the classroom for purposes of classwork. Whereas this effect held true for both genders, it was more marked in favour of males. Although gender research is subjected to a range of factors that make comparisons difficult, the results nevertheless corroborate various studies that have reported an ICT gender impact in favour of males [52, 55, 56]. In the current case, the variance that existed can be explained by the male cohort reporting more years PC/laptop and tablet experience, the notion that such experience plays an important role in studies at both tertiary and postgraduate level.

In terms of the impact and nature of student engagement with ICT, results were varied. The behavioural sub-constructs of Construct C: Student engagement with ICT, that is, individual attitude towards the use of ICT and student preferences for and interests in ICT, were found to be moderate contributors to academic achievement, with general attentiveness excluded after exploratory factor analysis. The behavioural construct of general student diligence, however, was a necessary co-occurrence, and in line with previous research results [5].

Student ICT literacy, as investigated with Construct D, considered exposure to ICT, student use of and competence in ICT, as well as the enhancement of various personal skills when using ICT for classwork. Combined, these sub-constructs returned the second-highest correlation with class marks. This finding is consistent with positive results from previous studies which investigated the effect of factors ranging from ICT use to self-efficacy and the use of web-based education on student achievement [12, 23, 57], but is not in line with other research which reported a negative correlation between most student ICT activities (e.g. participating in online discussion forums, e-mailing instructors and others, doing homework on a computer) and student academic achievement [6, 57]. The latter studies, however, were conducted at lower secondary level.

Construct E: Challenges of ICT use, which considered the sub-constructs anxiety over the use of ICT, privacy, safety and security issues and barriers to ICT use, somewhat surprisingly revealed known ICT challenges in developing countries to have a weak and insignificant correlation with academic achievement. At first, the result appears to be partly in agreement with research that showed internet and campus technology to have a significant negative effect on student academic achievement [53]. However, the current research setting of a private institution, which in general offers better ICT facilities than its public counterparts, may have allowed successful teaching with ICT and higher student ICT literacy to negate any negative impact normally associated with ICT use in developing countries.

Overall, despite differences in the factors studied and research settings, the findings of this study support previous research [2, 4, 15, 19, 30, 32, 53, 57, 59] which found the use of ICT to have an impact on student academic achievement. However, the findings are also in contrast with several other studies that reported no impact [3, 6, 8, 9].

Have we achieved our goal of contributing to the research gaps identified? We are confident that we have demonstrated the following: a postgraduate research setting is ideally suited to ICT integration; the constructs employed in this study have succeeded in describing the impact and nature of ICT use, student engagement with ICT as well as general engagement with studies, on student performance; and by employing instructor-assessed class marks as the dependent variable, we were able to confirm positive results from previous studies that were conducted at different levels of education, in different subject areas and where student self-reporting on learning achievement was utilised. Finally, given that the students in our subject pool were doing a Research Methodology course, the results have confirmed the potential benefits of integrating ICT in further postgraduate activities, such as the supervision of students and student work on a dissertation [59].

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Validation of Skills Categories for Business Intelligence Professionals: A Content Analysis of Job Advertisements in South Africa

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Abstract. Business intelligence (BI) is a strategic tool for organizations to make informed decisions. The skills required of BI professionals are hence important to examine in order to ensure optimal value is derived from BI. The purpose of this research is to validate a skills typology for BI professionals using online job advertisements as data source. 190 advertisements were collected and analyzed descriptively. The job advertisement profile shows that most BI jobs are being offered in the Gauteng area followed by Western Cape. The applicants are typically required to be holders of a degree in Information Systems, Computer Science or Information Technology. A few jobs require a combination of a qualification and a certification. The preferred certifications relate to SQL server services (SSIS, SSAS, SSRS). The key skills were validated as being in the domains of BI Strategy, BI Project Management, Business Analysis, BI Design and Coding, BI Reporting, Business Analytics, Knowledge Management, and Soft Skills. The findings can be used by education and training providers to help shape what ought to be covered in BI curricula to satisfy industry requirements.

Keywords: Business Intelligence, Skills, Job Advertisements, Content Analysis.

1 Introduction

Business Intelligence (BI) is a process of collecting, analyzing and interpreting data for decision making as well as predicting future events of an organization [1, 6]. BI focuses on adding value for organizational decision-making through the use of BI tools and techniques [2]. BI enables organizations to extract useful information from the historical and current data to solve business problems [3]. The use of BI tools such as IBM Cognos and Tableau assists managers to identify opportunities and threats before their competitors do [4].

Skills planning and demand in South Africa, indicates that not enough effort has been made to improve employee skills [5]. Few studies have investigated BI skills requirements in South Africa [7]. De Jager & Brown [8] conducted a study on requisite

skills for BI professionals using interviews with BI professionals to develop a skills typology. The typology was developed based on 10 interviews. The purpose of this study is to validate and refine the typology using online job advertisements to provide further generalizability. Job advertisements are used as data source as they reflect the current needs of industry. The findings from such an analysis can feed into efforts by education and training providers to improve relevance of BI courses and programmes to satisfy the needs of South African industry.

2 Conceptual Background

BI is an important tool in organizations that assists managers and workers to gain new insights on how to operate and sustain businesses using historical and future data [3, 4, 9]. BI is of high value to Chief Information Officers (CIOs) and is recognized as being strategic in achieving business performance. BI can amongst other things help improve customer products and relationships, and operational efficiency [10]. BI professionals require a range of skills in order to deliver a BI service that yields value to organizations. The sections that follow aim to unpack the skills that BI professionals ought to have. Information Technology (IT) skills can be broadly categorized into two groups as hard and soft skills [35]. Hard skills are an individual's expertise in carrying out specific IS tasks whereas soft skills deal with interpersonal relationships such as teamwork and understanding of cultural differences [9, 35]. BI skills have often been categorized as business, analytical and IT [8]. De Jager & Brown [8] further articulated more precise categories as shown in Table 1 below, which can be broadly labelled as: (1) BI Strategy, (2) BI Project Management, (3) Business Analysis, (4) BI Design and coding, (5) BI Reporting, (6) Business Analytics, (7) Knowledge Management, and (8) Soft skills respectively. Each will be discussed in detail in the next section.

Table 1. BI Skills Categorization

Skill Description [8]	**Derived Label**
Develop strategic long-term BI roadmap that links to corporate strategy	BI Strategy
Manage stakeholders and project and operational tasks	BI Project Management
Understand business processes in order to effectively extract user requirements	Business Analysis
Design and code sustainable solutions	BI Design and Coding
Prepare data for SME, analyst or other external party for further analysis	BI Reporting
Apply simulation modelling, statistical techniques and provide business insight	Business Analytics
Absorb and distribute knowledge	Knowledge Management
Soft skills	Soft Skills

2.1 BI Strategy

BI professionals play a role in preparing a BI strategic road map [8]. The BI strategy of an organization entails long term benefits of BI which need to be aligned with organizational goals [12]. BI strategy formation assists top management to measure success and progress of the business. Therefore, an organization will decide whether to continue with the same BI strategy or to change it [13].

2.2 BI Project Management

BI professionals are involved in managing and executing BI projects. The professionals are required to carry out several project-related tasks to deliver business needs, e.g.: (1) define the BI project scope, (2) understand the needs of a business, (3) plan and execute a BI project, (4) adapt to, and manage change [8, 14, 24].

2.3 Business Analysis

Business Analysis is also referred to as BI Analysis or Systems Analysis. The main expectation of BI Analysts is to understand business processes, then identify and define business BI requirements through communicative processes [8]. BI Analysts can also suggest ways to incorporate new changes and BI reports [12].

2.4 BI Design and Coding

Design and coding skills are important for BI professionals so as to apply design principles to the development of BI solutions based on quality data that fits with the organizational IT infrastructure [8, 15].

2.5 BI Reporting

BI professionals ought to able to discover patterns through data extraction and reporting. The patterns identified will further be used to transfer knowledge for the purposes of BI in an organization [16]. BI reporting involves improving the business decisions through data extraction, analysis, identification and presentation of patterns [9].

2.6 Business Analytics

BI and business analytics are closely related in achieving organizational goals. In a business environment, BI professionals are expected to have an in-depth understanding of analytics, e.g., data mining techniques, text mining, and statistical analysis for effective decision-making in an organization [17].

2.7 Knowledge Management

Knowledge management is a process of identifying, transferring and applying knowledge at a lower cost. Knowledge management is a strategic tool in improving the performance of a company [18]. BI professionals should have the ability to learn new emerging skills and to provide training to BI teams and BI users [19].

2.8 Soft Skills

Soft skills can be referred to as 'non-technical', people skills [20, 24]. Soft skills are regarded as important in most professions including BI. Examples of soft skills include, the ability to communicate effectively, teamwork, interpersonal skills and problem solving [21, 24, 35]. Soft skills are cross-cutting in that they are required for successful execution of all the aforementioned skills categories.

3 Research Methodology

The purpose of this research is descriptive, so as to validate a categorized skills framework for BI professionals in South Africa [8]. A content analysis of online job advertisements was conducted. Content analysis seeks to, "analyze data within a specific context in view of the meanings someone - a group or culture-attributes to them" [33]. Job advertisements have been used as a method to collect data in content analysis studies, especially in library sciences [22, 27, 29], information technology research [23, 30, 35] as well as other domains [31]. Job advertisements have been noted as cheaper to communicate with both employees and companies compared to the traditional means such as newspaper advertisements [27]. Online job portals have become an effective source of data in research as they show current skills required by organizations [29].

3.1 Data Collection

Job advertisements were collected on a weekly basis over a period of two months in the latter half of 2018. The aim was to collect 200 advertisements. Five online job portals were used to collect data, these being Career Junction, Career24, Indeed, LinkedIn and Pnet. These have been recognized as widely used for job advertisements in South Africa [36, 37] 190 advertisements remained after duplications and other advertisements that had insufficient information for the study were removed. Table 2 below shows the process of data refinement:

Table 2. Data refinement process

Original data collected	200
Duplicates removed	6
Filtered out job advertisements based on content	4
Remaining records	190

The five online job portals used to collect data are shown in Table 3. 40% of the adverts were found from LinkedIn, followed by Indeed (32.6%). Most recruiters posted jobs on these five main portals in South Africa.

Table 3. Online Job portals [36, 37]

Job Portal	Frequency	Frequency (%)
Career Junction	20	10.5%
Career 24	11	5.8%
Indeed	62	32.6%
LinkedIn	76	40%
Pnet	21	11.1%
Total	**190**	**100%**

3.2 Data Analysis

A point of departure in the data analysis stage was to record the data into the following categories in Microsoft Excel spreadsheet: Advertisement reference number, Location, Job portal, Qualification, Certification, Years of experience, Knowledge, then BI skills mentioned by category, i.e. Strategy, Project Management, Business Analysis, Design and Coding, Reporting, Analytics, Knowledge Management and Soft skills. Soft skills were further refined into Interpersonal, Organizational Skills, Team skills, Independent working, Adaptability, Communications (Verbal and Written), Analytical thinking and Problem-solving [35]. Two coders were used to test for inter-rater reliability. The study analyzed data from the adverts using thematic analysis. Thematic analysis can be defined as, “a method for identifying, analyzing and reporting patterns, categories or themes within data”, [34]. The next step was to refine the identified high -level data by identifying themes and skills relevant in each category.

4 Results and Analysis

Tables and graphs are used to visually show the findings obtained from the study.

4.1 Job location

Five of the nine provinces in South Africa were identified as having BI jobs offered (see Table 4). The four where BI jobs were not represented included Mpumalanga, Free State, Northern Cape and North West. Gauteng had the greatest number of BI jobs which amounted to 53.2%, followed by Western Cape which had 39.5% of BI jobs advertised. 0.5% of jobs were not specified as to location.

Table 4. Business intelligence jobs by location

Province	Frequency	Frequency (%)
Eastern Cape	1	0.5%
Gauteng	101	53.2%
KwaZulu-Natal	11	5.8%
Limpopo	1	0.5%
Western cape	75	39.5%
Not specified	1	0.5%
Total	**190**	**100%**

4.2 Job industry

Industries specified as offering BI jobs amounted to eight. The two most prominent industries that required BI professionals were: IT Services which accounted for 36%, followed by Financial Services 21%. (see Table 5).

Table 5. Industries offering BI jobs

Industry	**Count**	**%**
Advisory and Consultancy Services	4	2%
Financial Services	39	21%
Health and Medical Care	6	3%
IT Services	69	36%
Manufacturing & Construction	5	3%
Marketing & Advertising	5	3%
Retail and Consumer Goods	5	3%
Staffing & Recruitment	10	5%
Not Specified	47	25%

4.3 Years of Experience

BI roles that were advertised required experience related to working in a "business intelligence environment". Figure 1 illustrates the minimum number of years required for BI professionals in South Africa. The required years were split into a range of five groups. The most required experience ranged from "4-6 years", followed by "0-3 years", however a few jobs that were advertised required experience that ranged from "7-10+ years" with an exception of a few jobs that did not specify the experience required.

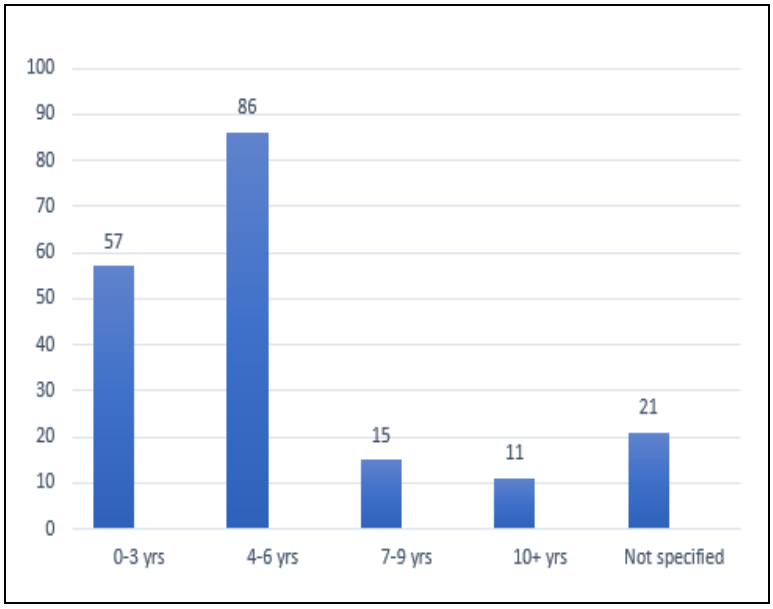

Fig. 1. Requisite years of experience for BI professionals

4.5 Qualifications and Certifications

As depicted by the Word cloud in Figure 2 below, 79% of jobs indicated a preference for a degree, with 33% specifying a Diploma as suitable. The most prominent specializations mentioned were Computer Science (28% of adverts), Information Systems/Informatics (28% of adverts) and Information Technology (25% of adverts). Others mentioned included Statistics, Engineering and Business Science. The most frequently mentioned certifications were SSIS (12% of adverts), SSAS (10% of adverts) and SSRS (9% of adverts). Certification, hence, is not a prerequisite for most BI jobs in the sample.

Fig. 2. Word cloud for preferred qualifications

4.6 BI Skills Categories

Each job was analysed, and the skills mentioned were classified into the eight skills categories. These categories were found to be complete, as no other category emerged from the data. Table 6 below shows a sample of how coding was done, and emergent themes per category.

Table 6. Emerging themes from the Skills Categorization

Category	Description of skill from Advertisement	Sample Themes
BI Strategy	"translating business strategies into actionable goals and BI projects aligned to strategic objectives, strategic thinking, strategic planning"	• Strategic Planning • Strategy formulation
BI Project Management	"Project management, ability to manage projects, project delivery, BI project implementation"	• Project management • Project implementation
Business Analysis	"requirements gathering, understand user requirements, business requirement writing, business process analysis"	• Gather and write requirements
BI Design and Coding	"programming, ETL and design and implement BI solutions"	• Programming
BI Reporting	"design reports, report building, report writing, data analysis"	• Design reports • Build reports • Write reports
Business Analytics	"data mining, highly analytical, interpret statistical information, apply statistical knowledge"	• Apply statistical knowledge • Data mining
Knowledge Management	"willingness to learn, provide mentoring and guidance, provide support to staff, process and systems knowledge to staff, learning agility, desire to learn new systems, knowledge sharing"	• Learning agility • Training
Soft Skills	"interpersonal, independent, communication, problem solving, teamwork, critical thinking"	• Problem solving • Critical thinking • Communication

From amongst the eight categories of skills identified, BI Design-and-Coding was the most prominent (67% of adverts). This is evident in the Word cloud of Figure 3, where phrases such as "data modelling", design, programming and coding are apparent. Soft skills [e.g. problem-solving, analytical thinking, communications] (54%), Business Analysis (51%) and BI Reporting (50%) were the other categories which had skills appearing in more than half of the adverts. Business Analytics (28%), BI Project Management (22%), BI Strategy (8%), and Knowledge Management (6%) followed.

Fig. 3. Word frequency for BI Skills

4.7 BI Roles

Six BI roles were identified in the job advertisements (see Table 7), these being BA (Business Analyst), Arch (BI Architect), Consult (BI Consultant), Dev (BI Developer), Spec (BI Specialist) and Lead (BI Team Lead). BI Developers and Business Analysts were the most commonly mentioned roles. Table 7 shows the importance of the skills categories for each role. As expected for the Business Analyst role, Analysis and Design-and-Coding predominate, as is the case for BI Architects. For BI Consultants and Developers, Design-and-Coding is the most prevalent skill mentioned. BI Specialists and Team Leads were only mentioned twice, so no pattern could be reliably inferred from the data. Soft skills are mentioned as required for all roles.

Table 7. BI Roles and Skills

	BA	Arch	Consult	Dev	Spec	Lead	Total
Ads	**64**	**4**	**16**	**102**	**2**	**2**	**190**
BI Strategy	13%	50%	0%	3%	50%	50%	8%
BI Proj Mgt	28%	0%	31%	17%	0%	50%	22%
Bus Analysis	**63%**	**75%**	31%	46%	50%	0%	**51%**
BI Des & Coding	**59%**	**75%**	**81%**	**71%**	50%	0%	**67%**
BI Reporting	44%	50%	50%	**55%**	0%	50%	50%
Business Analytics	30%	0%	44%	25%	**100%**	0%	28%
Knowledge Mgt	3%	25%	0%	7%	0%	50%	6%
Soft Skills	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

5 Discussions and Implications

De Jager & Brown [8] conducted an exploratory study amongst a small group of BI professionals to identify the requisite skills categories for the BI profession. These categories were labeled in this study as BI Strategy, BI Project Management, Business Analysis, BI Design and Coding, BI Reporting, Business Analytics, Knowledge Management and Soft skills. Through an analysis of 190 job advertisements published in 2018, this categorisation has been validated. In addition, this study reveals that the predominant roles in the BI domain are Business Analysts and BI Developers. As expected, for Analysts, Project Management, Business Analysis and Design and Coding are important skill categories, whereas for BI Developers it is mainly Design and Coding. For all roles soft skills are important, particularly problem-solving, analytical thinking and communications.

The findings are useful for education and training providers and suggest what topics ought to be included when designing BI curricula and courses, and where the emphasis should be.

6 Conclusion

In South Africa, five job portals are commonly used because of their popularity and coverage of most provinces in the country [36, 37]. This study reveals that Gauteng province offers the best prospects for BI professionals, followed by the Western Cape. The industries most heavily recruiting BI professionals are the IT industry and Financial Services. The most prominent job roles advertised were BI Developers, and Business Analysts. The most preferred qualification for a BI professional is a degree in Information Systems/Computer Science/Information Technology with a minimum experience of 4-6 years. Skills required of BI professionals include BI Strategy, Project Management, Business Analysis, Design and Coding, Reporting, Analytics, Knowledge Management and Soft skills. Future research can be conducted with BI

professionals using the Delphi technique to more clearly define the key skills required in each of the main categories. As Big Data Analytics (BDA) becomes more established in organizations, the effect of BDA on skills required of BI professionals can also be assessed.

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General Papers – short

Factors supporting quality research output at universities

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Abstract. This paper explores research at the tertiary level with the emphasis on the individual researcher and the environment in which research takes place. The academic has the difficult task of balancing the quantity, diversity, and quality of research output in an environment that does not seem to have a balance between teaching and producing research output. We found that the research subsystem should be seen as a service system for the university. We also found that personal commitment is an essential building block in providing high quantity and quality output. By using case study research, interviews were conducted with researchers at a research-driven university in South Africa. We applied the Work System Theory (WST) as the preferred framework to confirm that long-term sustainable research output is possible. The article concludes with a conceptual framework to better understand how the elements of the research environment interact within the context of a typical tertiary institution.

Keywords: Work systems theory, research framework, higher education institutions, university, knowledge management.

1 Introduction

Universities are societal institutions with the specific responsibility to create, interpret, and disseminate knowledge to the external constituencies [19]. Tsichritzis [25] states that the academic environment focuses solely on information and knowledge to dispense education. Between knowledge creation and education, there is a narrow space that contains the research process. This narrow space is the sole provider of content to feed the natural and commercial environments. Hampson-Jones [16] added that the academic environment could be seen as the creator of knowledge rather than the processor of information. It is an active data warehouse of resources to facilitate the distribution of knowledge and not just a library of the knowledge itself. It is a dynamic system to create usable knowledge.

In this paper, we argue that universities need to manage all critical resources as a service to the academics to enable them to provide quality research output.

2 Universities and the problem of research output

The problem of research output was highlighted already in 2012, in a media statement by the Minister of Higher Education and Training introducing the Green Paper for Post-School Education and Training. It highlighted the fact that the current system of Higher Education is not performing as it should. The Green Paper stated, "in terms of quality, our universities are the strongest and most stable component of the post-school system. However, even some of these institutions are beset by serious problems and are unable to fulfil our peoples' expectations" [11].

The Department of Higher Education and Training (DHET) policy did not change much in 2014 with the release of the White Paper for Post-School Education and Training. Quantity, diversity, and quality were still viewed as significant obstacles. Yet, the focus shifted towards increasing research and innovation, improving the quality of research, staffing of universities, and retaining academics [12]. The focus on intellectual assets as the main driving force behind knowledge creation cannot be ignored.

Currently, the focus on innovation and quality of research remains a significant obstacle, especially for the managers of research. For top management to attain the strategic research goals of growth, differentiation, and real innovation, the gist of the research strategy must have buy-in, especially in the lower levels of management. For this to happen, the lower levels of management need to implement workable short-term goals (tactics) for the long-term strategic goals to work. Academics need to balance their tactics within the broader strategy to create and maintain research output.

Even though specific changes, as advocated in the government policies, had positive outcomes in the research and innovation system, it is still under pressure to produce more and more output. A widening gap between the ideal world (strategies) and reality (research environment) in universities began to appear because the solutions proposed by the DHET, other management bodies, and individuals were based on statistical measures. The contexts of the research function inside the university as an entity has been discounted. Nonaka [21], in 1991, already knew this and stated that knowledge is not merely the processing of objective information but that one must also take into account the tacit knowledge in an organisation. "The key to this process is personal commitment, the employees' sense of identity with the enterprise and its mission" [21].

Is a lack of personal commitment or identity in universities the reason for low levels of quality research? We also advocate that individual commitment to quality service is embedded in the research process of each department in a higher education institution. This perspective considers that academics are the main driving force responsible for research and that more long-term output gains can be achieved by adequately understanding the environment in which they operate.

3 Research is a system, a service system

Within a university, the processed and assimilated information is typically dispersed among multiple employees. It seldom resides in just one single person. The fluid mix

of framed experiences, values, and contextual information provides a framework for evaluating and incorporating new experiences and information [10].

To create usable knowledge is effectively narrowed down to three tasks: the process of making comparisons on how the information relates to similar situations in the past, the process of evaluation of consequences and implications of the decisions on the future and lastly, making connections with other information to find out how a particular bit of information relates to others. This, in essence, is the beginning of a work system. It is a system where humans perform work using information, technology, and other resources to produce products, services, or both [5].

The service system is more human-centred, recognising the human differences and values of participants; it also acknowledges the fact that systems are far more ambiguous. The innovative research products and services rendered by universities are intangible commodities and are diffused into the community. *The university is a pure service-providing organisation with the industry, government, and community as the primary beneficiaries.* A work system may exist and produce output over extended periods while service systems are created as temporary systems (projects) designed to produce a particular output and then dissolve.

Due to the service rendering role of universities, the processes of information creating- and knowledge delivering structures are well developed. The academic's role is to make use of these structures and apply it using his or her knowledge to make sense of the information. The significance of this information must also be communicated through thinking and physical actions. The university as an organisation of academics is a pure service-providing structure with innovation, talent, free flow of ideas, technology and tolerance as necessitates by the environment [7].

4 Research methodology and design

Knowledge creation and sharing can only be created by utilising people. The type of investigation that suits the knowledge phenomenon can only be achieved by qualitative research with an underlying interpretative epistemology. The assumption of an interpretative study is that data are not detachable from theory and that facts themselves have to be reconstructed in the light of interpretation. The study of academics, their viewpoints and research output through the flow of knowledge (from academics to industry, communities and students) as well as their behaviour and social rules and research outputs produced, cannot be viewed without including its meaning [20].

To find a relationship between individual strategies, the dissemination of knowledge and research output, the basic knowledge questions should be asked: "What?" (knowing what?) and "How?" (knowing how?). *Knowing-what* is often based on assembling information and eventually by applying it. By applying the knowledge, it generates *knowing-how* to do something. For this type of knowing it is necessary to understand an appropriate sequence of events and the ability to perform a particular set of actions. *Knowing-how* to do research is fully learned by actually experiencing a situation. Through these two types of reasoning, the *knowing-why* can be synthesised and create

the causal knowledge of why something occurs. This includes values and beliefs and determines the interpretation of organisational knowledge [10].

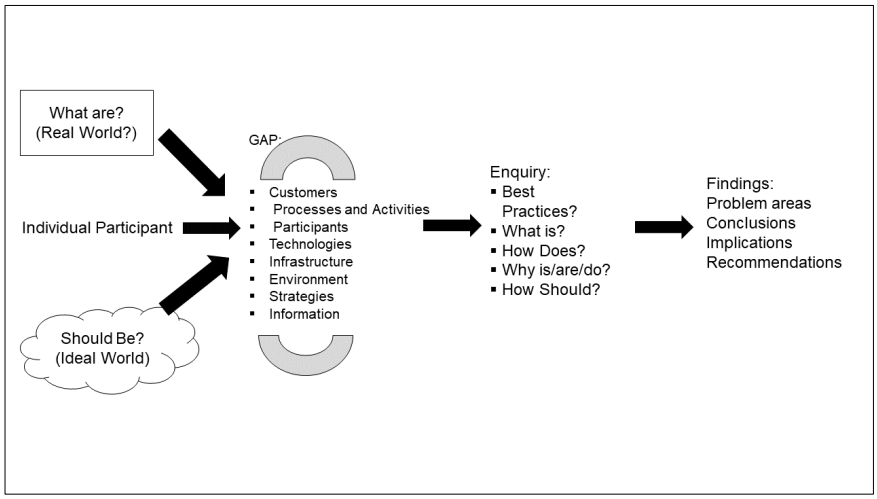

Fig. 1. Determining best practices of the research work system (Developed by authors)

Figure 1 diagrammatically depicts the method that was followed to find the strategies within the different research environments and individual researchers. The secondary consequence of doing the analysis in this way is that best practices can be compared to the ideal situation, leading to identifying the problem areas that exist in the current research service system.

The approach followed, is to select research individuals at a research-intensive university that have unrestrained success in producing research output, in the same environment as researchers that are struggling to produce research output.

The top 15 individuals were selected from high impact faculties and were chosen according to the volume of research produced by them. No distinction was made between accredited and non-accredited output, and only the total quantity of output that was captured in the official Research Management Database of the institution was considered to identify the researchers.

Table 1. Top Researcher Profiles.

Researcher	Total Output	Field of study	Rating	H factor
1	153	Genetics/Microbiology & Plant Pathology	A1	32
2	71	Genetics	B2	26
3	23	Chemical Engineering	C2	5

4	30	New Testament Studies	C2	3
5	11	Private Law	-	-
6	9	Legal History; Commercial Law and Legal Philosophy	-	-
7	61	Zoology and Entomology	A2	12
8	24	Practical Theology	-	2
9	14	Business Management	-	1
10	24	Communication Pathology	P	7
11	16	Philosophy	Y1	1
12	30	Mechanical and Aeronautical Engineering	B2	9
13	14	Engineering and Technology Management	-	1
14	14	School of Public Management and Administration	-	-
15	21	Private Law	-	-

A question guide was constructed according to the elements of the Work Process Theory as stipulated by Alter [1] [2] [3] [4] [5] [6] and includes a section on Customers, Products and Services, Process and Activities, Participants, Information, Technologies, Infrastructure, Environment and Strategies.

The data gathered was analysed and divided into Strengths, Weaknesses, Opportunities and Threats according to the elements identified in a typical work system.

To reach a more practical understanding of knowledge in the workplace, a soft system approach was used to study how people operate in the research environment [13]. The approach endorsed the finding that although processes are essential to produce knowledge, the environments in which these processes operate, are more critical. This study, therefore, focuses on best practices within a research creating environment to highlight the contextual nature of knowledge.

5 The context of research

There is a strong relationship between tacit knowledge and the Know-what part of knowledge management as context plays a major role in knowledge integration. The context can be described as a social context [8] [14]. The social context offers a reflective view of customers' perspectives, products and services, the environment, strategies and infrastructure. Tacit knowledge is an essential complement to explicit knowledge in that it supports the acquisition and transmission of explicit knowledge through tacitly held constructs, such as research processes and activities within universities.

Within the research processes the transfer of knowledge starts at the research-creation processes and continue through to the testing activities. There are direct knowledge transfers as well as indirect knowledge transfers happening. The researcher initiates research to find an answer to a specific problem. The researchers mainly use students, but also other researchers and collaborators that are internal, or external to research structures, to complete the product or services. During this process of collaboration and conversation, knowledge is being directly transferred. The ripple effect from this

is also being felt in the teaching function where this knowledge is being used or directly transmitted to students or the community. With the research submission, the knowledge is also transferred to external evaluators and departments. This can be considered an indirect method of knowledge transfer. After the acceptance of the research by these external agents, knowledge diffusion takes place in the form of publishing it through various means, such as national and international conferences, articles in popular scientific or specialist's books, textbooks or even technical and or policy reports or products, patents and other development services. Most of the output from the research system is also used in the teaching and learning system of universities. This imparts an upward spiral of learning.

6 Towards the upward spiral of learning: finding the enablers

Following the research process principles, 15 experienced researchers were interviewed according to the work systems methodology. Several enabler groupings were identified that gave more insights into what can be considered as research enablers.

6.1 A supportive environment (from peers, research supporting structures and management)

Researcher 1: "It is a nice idea to think that we are going to have nicely constructed lectures and what I consider overgrown high school teachers … and students love it but it does not stretch their minds in giving that (lecture) in a nicely package deal for them."

"Realistically, the kind of money the NRF and Government provide is limited."

"Part of the deal I have with the faculty is that I do not lecture undergraduate students."

Researcher 2: "When I started out, I had a very good mentor."

Researcher 3: "Since 2009, my freedom was rather taken away and I felt it was expected of me to do research, and that I was free to do so. It is no longer so. Today I feel that one obstacle after another prevents me from doing research. Enablers are required."

Researcher 3:" There must be someone who is willing to spend time with you and to walk a long way with you. For me, it was a miracle that I had someone like that"

Researcher 4: "He (the dean) opened the door to the Netherlands, my supervisor there was certainly one of the top three historians in the world, and he taught me to do research."

Researcher 6: "Unfortunately, personnel are appointed and left to their own devices. A culture needs to be created where senior researchers take upcoming researchers under their wing – and that is why I sternly believe that doors need to be open, not only to mentor students but also to mentor the mentors"

Researcher 6: "The structure has helped achieve my output. One cannot complain and say that there is no support. The university structures do not inhibit research in any way. I have never had trouble in my career and have experienced only support and the doors were always open."

Researcher 7 "There were mentors – my senior colleagues meant a lot to me – not in terms of research, but in an educational relationship."

Researcher 10: "There is no support from the government."

6.2 Freedom to do research

Researcher 4: "My colleagues do not write enough. Most are too lazy to write … there is no such thing as laziness, it is called beginner's reluctance."

Researcher 5: "… and many think the department exists for lecturing only; consequently, we are not all on the same level and do not feel the same about research. I need to be on top of my field and read a lot. One important thing is that I can practice what I research"

6.3 All about networking and collaboration (national and international)

Researcher 2: "I have a lot of experience with other universities and how they run things. They had to meet every three months and had to present and listen to one another and then they caucus; all the universities collaborate – here in South Africa and in the university, it is lacking. The collaboration level at the other universities was amazing. You could use all their facilities"

Researcher 8: "Networks are very important and provide opportunities. I am a chairperson of more than one international conference. If you start getting an international profile, more people will invite you"

Researcher 10: "I work mostly with colleagues and other universities on master's and doctoral level"

Researcher 11: "Networks are important and offer opportunities. Money does not fall out of the sky. One needs to work to get it. One needs to use the opportunities and needs to get into one's car, drive to industry and build a relationship with them. One needs to prove to them that one's research can meet their needs."

Researcher 12: "Networking is essential, fellow researchers that are established internationally. There are projects that result from such collaboration and students are then the researcher. I think it is still remarkable, it's easier to work with an overseas researcher than with a researcher next to your office. Subsidy models do not allow it." "Graduate students have an important role to play."

Researcher 13: " In my line of work it is extremely difficult to obtain cooperation"

6.4 Autonomy

Researcher 2: "One can run research as a business here and give exposure to the students, but research is not as commercialised as at the CSIR."

Researcher 6: "On the one hand, one needs to manage research by relevance and on the other hand by publishing internationally. If one does not have wisdom, it becomes dangerous. Policing and micromanagement have a tremendously negative impact on research"

Researcher 12: "I have an open-door policy; students can come and go and papers are the first priority. Outputs constitute the key performance; therefore, papers are important, a network of people, students, open door policy and the use of journal papers only, instead of dissertations, to produce output"

Researcher 11: "As you start getting to know people and become aware of relationships, opportunities for cooperation develop."

6.5 Freedom (to decide scale and type of research)

Researcher 2: "At the NRF you should absolutely specialise in a miniscule portion of the field that you do research in. You cannot take a subject and try to do research on each facet of it. This is detrimental to the lecturer"

Researcher 5: "When they tell me there are institutional topics, I need to do research on, then I am going to run away and that is what they do. I have no interest in it, I will still do research on what I want. If not? Then I will resign"

Researcher 6: "I find the pressure to publish internationally interesting and a negative phenomenon. I do not think the managers have assessed all the consequences. It is a very negative phenomenon in our country that the only top and prominent researchers are recognised as international researchers. It has a negative effect on research and is, in my opinion, wrong"

Researcher 7: "It is a huge problem that we get instruction from management to publish internationally only and not in South Africa. This inhibits research, especially for younger researchers"

6.6 Freedom (to go away to do research)

Researcher 1: "One should know that to do research will take up all one's time. The illusion of freedom, local peer support and open environment help a lot. It is about the time one puts in and how one structures it."

Researcher 12: "I have children at home so I can only start doing research at 21:00 or 22:00 in the evening. I generate the best output when I am out of the country"

6.7 Freedom (with no forced targets, how and with whom to do research)

Researcher 2: "I do not get support for funding from the NRF, so I go to industry. They need to understand the research. My problem is that I could not get funding in only one area of research – I started out with a lot of small projects and that was a problem because it did not enhance research. At this stage I have very diverse funding and this forces me to have more than one focus area. Management discourages it (collaboration) and also the points awarded discourage it. Research here is individual. Here they try to glorify the individual and not the effort and group. One should use others' skills in research. Multi-disciplinary research is the future – they do different aspects and add value to each other's stuff. We are far away from one another."

"(The University) … is too strict on hiring people with the necessary qualifications. Everything is too boxed in and there are many people who can do the work."

Researcher 12: "I had resources; I was appointed to a chair. Never in my career did I have a problem boarding a plane to attend a conference. I had my support and my admin load was little. It is not like that anymore"

6.8 Money support

Researcher 1*:* "Industry is important and short-term. We use the industry to leverage the stuff and then do the long-term projects. One cannot be innovative/creative in a stressed environment. Financial stress (we) need to make sure post-grads have access to bursaries and that they at least have a place to sleep. Funding is very important, and one needs to be careful, especially from the funding body's perspective that one does not work for their competitors as well."

Researcher 2: "I need more access to bursaries for my students …"

Researcher 11: "The biggest challenge is to raise money and bursaries for my students. All my Ph.D. students are from abroad. I do not have any local Ph.D.'s.

Researcher 12: "We struggle to get students to do a full-time Ph.D.'s; there are major challenges facing South Africa"

6.9 Having enough students and focusing on students for research

Researcher 1: "Research is incidental, and the main focus should be on the students. The university is an education institution and we are totally dependent on students to do research. They are the vehicles in order to do research."

Researcher 2: "I am inclined to prefer working with students rather than with colleagues. The university is an education institution and we are totally dependent on students to do research. They are innovative and especially on the post graduate level training is concentrated mainly on research."

Researcher 3: "My research is geared towards two things. To give my students resources for teaching, and I have to provide continued training and feedback on comments for those in instructional practice."

Researcher 4: "I believe the university is primarily there to provide instruction."

Researcher 6: "The most important contribution for me is the knowledge I can give to students. A lecture contribution."

Researcher 7: "My involvement in networking is very important, even here in South Africa to expose students to new ideas."

Researcher 8: "Students are the most important resources for my research output."

Researcher 9: "I do co-publishing through students. The student has the first right."

Researcher 11: "I had one permanent student and one that did a full thesis. The rest of my students are all from industry and they were very important for my research output."

Researcher 12: "Networking is essential with fellow researchers that are established internationally. There are projects that result from such collaboration and students are then involved from within. Graduate students have an important role to play."

6.10 Research Space (and time)

Researcher 1: "Some buildings are awful, and I wonder how they can operate"

Researcher 2: "No, the environment is not conducive to research. The Research Office can be much better. Support is lacking, much more focus is needed to make things done. They must help you to make things done. It does not happen. There are departments that are very well equipped but got the money from outside, but our department is under stress concerning space. I do not even have an office. Space is an issue"

Researcher 5: "… in general our department is more structured than before, so it is much better than before"

6.11 Cooperation between government and universities

Researcher 10: "There is no support from the government"

6.12 A rating system that is in line with research objectives

Researcher 2: "Management discourages it (collaboration) and also the points awarded discourage it. Research here is individual. We need to rate a research group that will bring in continuity. Here they try to glorify the individual and not the effort and group"

Researcher 5: "What is disturbing is the fact that each month we need to fill in forms on what we have done. I guess the process needs it but I get extremely irritated if I have to fill in a revolving list every month"

Researcher 6: "The term international is a relative concept and I am concerned about the unilateral way in which management regards international output"

6.13 Accept research as a long-time project and use the structures of the university.

Researcher 2: "It is important to read technical literature and they (colleagues) are not on top of their field. One needs to develop one's field and it takes time to get there."

Researcher 7: "One has to be a teacher to be here. The rest of it comes with time."

Researcher 11: "In my case I made all the mistakes I could. I was the first generation and the first researcher to write an article in our department. I have grown up without any mentors."

The researchers had more intrinsic goals when it comes to their research and measured themselves on the implicit, in addition to explicit, qualities of their research output. There is a strong sense to measure themselves against:

- content consistency,
- value added to their respective field of study,

- clarity of research,
- completeness of understanding,
- quality of decisions and conclusion,
- degree of consensus including range of viewpoints considered,
- publisher and peer satisfaction and
- justifiability of research decisions.

7 Research strategies followed by experienced researchers:

- Avoiding micro-management and reduce the administration load of managing the researchers.
- Create research space in buildings. There are problems within the creative process of the research process and that is due to a lack of research or office space. Many buildings are not creating a milieu of research.
- The structures of the NRF was highlighted and fitting the NRF structures onto the unique and non-profit seeking research environment creates unnecessary competition and conflict.
- Competition and researcher ratings count more in some faculties than in other faculties. This is not in line with the research environment principles.
- The constraints of the current research system do not preserve clear roles and responsibilities. Many academic researchers are playing dual roles in that they have clashing interests in both the teaching and learning work system and research. Many successful top researchers have an agreement with not having to lecture undergraduate classes. They are focused only on postgraduates and producing research products. Many of the academic researchers complain about time, administration and being rated by the same structures as the fulltime researchers. Academic researchers should be approached with more understanding and focussed roles.
- Defining a clear role to research will be advantageous: Too much emphasis on research products but that the focus on the one hand is too many undergraduate students and on the other hand, more research. This creates coordination problems and uncertainty.
- By increasing the stature of the research work process leads to sub-optimisation of the research and teaching and learning work system. The findings have shown that the system is secondary to the function of the university and that the research system should be an accidental but necessary outflow of the teaching and learning function of the university.

8 Supporting research output: A proposed framework

Managers, to support quality research output, need to take into account that the research system is an open system and cannot exist without the teaching and learning system. There is a clear rearward shifting of knowledge into this system.

There is also a direct relationship between the customers and individual researchers (participants) of the research work system. Customers (industry and community) determine the type of knowledge to be produced and the need is transformed into action by researchers. By using their investments (honours, master's and to a lesser degree doctoral students) and connections, researchers use actions, information, and technologies to produce knowledge. This knowledge is integrated into the teaching and learning system and feeds in turn the research system with new knowledge resources and investments. Some of the knowledge is also transferred to industry to acquire and maintain infrastructure for long-term research.

The research output is directly related to the management of the departments and provides the necessary supporting structures that include time, resources, information, and subject fields. The individual departments also have the purpose of acting as a control subsystem where research output per lecturer is being evaluated. In the past, the decentralised departments also controlled the standard and type of research being done, but in most cases, a research unit took over that function.

To build a research culture, knowledge is harnessed and explicitly shared. This also include to a lesser degree external entities in the form of textbooks, conferences, session chairs and industry reports, to name but a few.

Conversely, external constraints or directives from higher management levels, the environment, strategies (individual and managerial) as well as infrastructure limit the type of output produced.

The number of outputs produced by the researchers is determined by the relationship they have with the teaching and learning work system. The framework differentiates between academics (lecturers as researchers) and pure researchers. The more integrated researchers are within the primary system of the university that is, teaching and learning, the more difficult it is to produce the same output as pure researchers.

Researchers focus on research only through postgraduate students and do not have undergraduate classes. These types of researcher have minimal impact on the teaching and learning work system structures and according to the framework, have a minimal impact on transferring knowledge directly to the teaching and learning work system. Academics have a more direct responsibility in transferring knowledge created by the research system to the teaching and learning system by using the products as subject matter directly or indirectly. Indirectly, they use subject information created by other researchers and participants as well.

Evidence of the data also indicates that knowledge is integrated into the industry only through short-term projects to gain long-term infrastructure to achieve long-term sustainable research output. Industry gains knowledge from the research work process through technical and policy reports, product development and services, and to a lesser degree, patents.

The top researchers see research as an 'accidental' but necessary outcome of the function of the university. Mentors played an enormous role in starting out and many of them currently make use of mentors in the form of colleagues as soundboards for their ideas. Research for them is a long-term plan with short-term goals.

Through the linkage of the research- and the teaching and learning system, investments in human capital are essential in producing sustainable knowledge output.

Based on the above, the following conceptual framework (Figure 2) is proposed for explaining the factors that support quality research output.

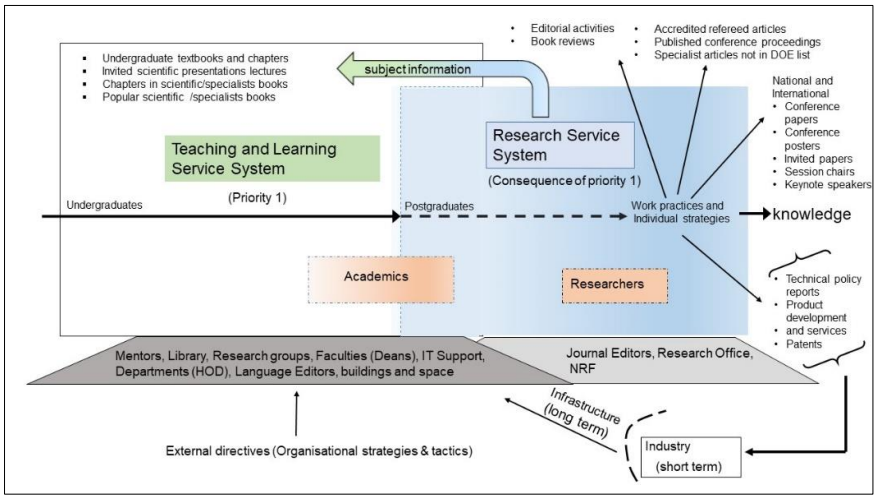

Fig. 2. A conceptual framework explaining the factors for supporting quality research output

9 Conclusion

By applying the Work System Theory to analyse the elements of the research system it also became clear that the research system needs to be seen as a service system which operates in the larger university service system. The "research enablers" need to be in place and managed well enough to foster commitment amongst researchers to do research of a high quality. An environment with enough research space, openness and trust, perceived freedom (time-wise) and an environment that is free from micro-management and conflict is considered the elements for commitment to research that will lead to a strong research culture that includes strong expectations of cooperation and knowledge sharing.

In other words, the research service system can only be sound if the environment (read university service systems) in which it operates to support the research service system. The paper proposes a conceptual framework which not only explains the complexities of the research environment of the university but also gives support for understanding it better. As such, the conceptual framework could help decision-makers to create a better research environment for all researchers at the university level, and this should contribute to higher throughput and improved research quality.

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Discussion Paper

The TANKS coding app – using tangible tokens to teach coding without a computer

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Byron Batteson

1. Introduction

Within the context of the Fourth Industrial Revolution and the scarcity of software skills in South Africa, it is important to introduce learners at a young age to coding. Since the majority of schools in the country do not have computer laboratories, this poses a grave challenge to the country.

2. Background

Various role players in the country are often referring to the Fourth Industrial Revolution (Section 2.1) which creates major opportunities to the country, but also important challenges. To address these challenges, it is important to introduce learners to coding at a young age (Section 2.2).

2.1 The challenges of the Fourth Industrial Revolution, within the SA context

Klaus Schwab [5] states that the powerful effects that digitization and technology have on different work areas are leading to a Fourth Industrial Revolution. He worries about how automation will get to replace certain jobs and how larger countries will be able to dominate the new economy. President Cyril Ramaphosa, in his 2019 State of the Nation Address declared that he had appointed a presidential commission on the Fourth Industrial Revolution [4]. He furthermore drives the introduction of coding and robotics from Grade R in all South African schools.

A major challenge for South Africa is that software development is seen as one of the scarcest skills. According to the latest CareerJunction Index Report for September 2019 [2], Information Technology remains the top employment sector.

2.2 Coding for Children

There are various solutions which look at teaching children coding to create an interest in technology, such as Scratch and Lego Mindstorms.

Scratch [6] is a project of the Lifelong Kindergarten Group at the MIT Media Lab. It is provided free of charge via the internet. With Scratch learners can program their own interactive stories, games and animations making use of basic coding constructs. It is designed for children of ages 8 to 16, and millions of children use it across the globe.

Lego Mindstorms™ is often used in schools. The idea for creating a robot to teach coding was first created by Papert [3] and his laboratory at MIT. His laboratory created the LOGO educational programming language and a programmable robotic turtle. When the Lego CEO at the time found out about Papert and his lab he discovered that they had similar goals, with the result that LEGO and MIT started a collaborative project which they called LEGO Mindstorms [8].

The problem with many kids' coding solutions such as Lego Mindstorms and Scratch is that they either need expensive equipment (eg robots) or computers. Therefore, they are not cost-effective, accessible or tailored to the children of South Africa. The National Education Infrastructure Management System as of March 2018, reported that 11858 Primary schools and 3590 High schools do not have computer labs [7]. This shows how inaccessible computers are to a large part of the South African youth.

3. The TANKS coding application

TANKS was developed by Batteson [1]. It uses tangible tokens (customised puzzle pieces), image recognition and a mobile app to allow learners to construct instructions that are executed on a mobile device. No computers are thus needed to introduce coding concepts such as linear logic, loops (if and while), if contructs, nested constructs as well as optimized code.

Since the launch of the app in November 2017, coding bootcamps have been presented to over 20000 learners across the country, often in very disadvantaged areas. The great value of TANKS is that an introductory coding curriculum can be offered with literally 6-8 smart phones at a cost of around R10000, compared to a computer lab estimated at an average cost of R1 Million [7] for the over 15000 schools in our country without laboratories.

4. Roll out in Nelson Mandela Bay – October 2019

As anchor partner the Nelson Mandela Bay Science and Technology Centre (NMBSTC) in Uitenhage collaborated with Department of Computing Sciences, Nelson Mandela University, as well as S4 Integration to roll out TANKS in October 2019 to over 11000 learners. This formed part of Africa Code Week. Spearheaded by SAP in 2015 as part of its social investments to drive sustainable growth in Africa, Africa Code Week is a digital skills development initiative that has benefitted over 4 million young Africans so far. SAP and UNESCO are now joining forces with over 130 partners to offer free coding workshops for youth across 37 countries.

Learners could come to the Science and Technology Centre for workshops, but TANKS allowed for facilitators to visit numerous schools which do not have computer laboratories. Positive feedback was received from various teachers. Jarren Gangiah from Charles Nduna Primary School sees it as an opportunity of a lifetime for their learners, providing the opportunity for them to explore and expand into a world of

programming. Mbulelo Njamela from Cowan High School says TANKS brings fun and excitement to problem solving and critical thinking.

The main impact of this event was confirming the idea that TANKS, as indigenous solution, has huge potential in reaching disadvantaged learners with coding, even to the remotest parts of our country and continent.

5. Conclusion

The October 2019 project was successful in the sense that over 11500 learners from 60 schools were introduced to coding, many from schools without laboratories. TANKS made it possible for facilitators to visit these schools, at a fraction of the cost of daily transporting the learners to venues with laboratories. Feedback from headmasters, teachers and learners confirm that the intervention was highly appreciated and seen as something that added great value.

As an acknowledgement of the potential of TANKS, the project will be showcased in a plenary session at UNESCO's Mobile Learning Week in Paris, early March. This summit, attended by around 2000 delegates from across the world, is the United Nations' flagship education conference, focusing on education in disadvantaged communities.

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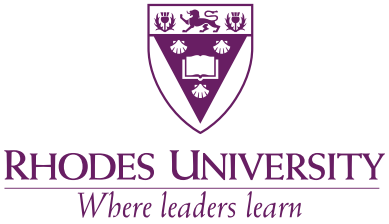

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