A PEDAGOGICAL SMART LEARNING ENVIRONMENT IN SOUTH AFRICAN TERTIARY INSTITUTIONS

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ABSTRACT

With the rapid growth rate of technology innovation different sectors tends to keep up with the developing trends by implementing the latest technology with the aim of achieving their goals. Educational institutions deploy information systems in their teaching and learning environment to enhance performance. However, educational institutions usually struggle with smooth implementation of IT leading to its failure. Adopting various scientific methods such as content analysis, Principal Component Analysis and so on, contextual factors were identified for effective deployment of smart learning environments based on extensive review of exploratory research, analyzing data and study outcomes of ICT deployment educational institutes around the world. The identified factors were used to develop a framework which can inform the deployment of SLE.

Keywords: Smart learning environment, tertiary institution, South Africa

1. INTRODUCTION

In this age of rapid, dynamic growth and dependency on information, where the generation, storage, distribution, incorporation and manipulation of information is a substantial political, cultural, and economic activity. Information Technology (IT) has deeply influenced every sector of the society resulting in an exponential expansion of the digital world.

The influence of technology in the Teaching and Learning Environment (TLE) cannot be overemphasized. Technologies are deployed to TLE to enhance the seamless flow of information between educators and learners. Due to the rapid growth of Information Communication Technology (ICT), several schools have made conscious effort to upgrade their classroom environment by equipping them with modern technologies (McAlpine & Gandell, 2003). According to (DHE, 2018) there has been a steady increase in the investment trends (millions of rand) in post-school education (Universities and TVET colleges) and training in South Africa, to enhance growth within the educational sector. Intelligent tutoring systems designed with artificial intelligence features have been developed by several researchers since the 1980's in educational software (Seters *et al.*, 2012). Even though the form of learning on context-aware ubiquitous is promising, Smart Learning Environment (SLE) is still far ideal. Decision or action that involves stringent planning, innovation, cleverness, and resulting to a desirable outcome is referred to as smart (Spector *et al.*, 2015). SLE enables access to digital resources in real time and offers a

tailored hint, learning guidance and supportive tools to learners in real time. Smart learning system can be seen to be a technology-enhanced learning system with capabilities to advice learners in a learning environment (Hwang, 2014).

The emerging reforms in technology and pedagogy, has resulted in a significant change in education systems. Growth in education will be achieved by further integration of personalized learning into the smart learning environment, such as ubiquitous access to technology through continuously shifting mobile devices and mobile platforms, cloud-based services, big data, and dispersed learning environments will further emphasize the affordances of learning technologies. These changes are also being impacted by broader trends including population shifts, economics, employment, and other societal shifts (Price, 2015).

1.2. Problem Statement

There have been several claims that portray the dissatisfaction of ICT in academic institutions in this era of technology integration for teaching and learning. Reforms failures and bad practices are the worst scenarios (Trucano, 2010), which simply provide no significant difference in attaining student performance improvements in any cases (Sumadyo et al., 2018). Poorly aligned success factors can be deduced through a closer look into several studies. Much as SLE is universally perceived as one of the comprehensive teaching and learning system solution, its deployment is still at a perfunctory level in South African tertiary institutions. Though, several studies (Hwang, 2014; Chen et al., 2015; Mikulecký, 2015) have looked into SLE, no study have been done in SA. Hence, in order to address this, this study will develop a framework to inform the deployment of SLE in tertiary institutions in SA.

1.3. Research Question

The study seeks to address the research problem identified by answering the following research questions;

Primary Question

What framework will inform the deployment of SLE in tertiary institutions in SA?

Secondary questions

i. What are the contextual factors needed for the deployment of SLE within tertiary institutions in SA?
ii. How do the identified contextual factors influence the deployment of tertiary institutions in SA?

2. LITERATURE REVIEW
2.1. Smart Learning Environment

A smart classroom is generally referred to as a traditional classroom with multi-technology and media systems installed. By emphasizing monitoring and coordinating features in infrastructure, the installed technologies are expected to make the classroom environment sensitive to meet the teaching and learning needs (Chen *et al.*, 2015). Personal attributes of learners, the cognitive abilities of learners and learning methods are considered in individual learning. The condition, background and location are considered in contextual learning. The convergence of development in epistemology, psychology, and technology is referred to as intelligent learning. Implementation of the convergence is a smart learning environment (Spector, 2014). Different functions have been shown to aid specific activity needs in different classrooms in the design of smart classroom (Price, 2015).

Accordingly, the potential criteria of an SLE are summarized as follows (Hwang, 2014):

1. A smart learning environment is context-aware; that is, the learner's situation or the contexts of the real-world environment in which the learner is located are sensed, implying that the system can provide learning support based on the learner's online and real-world status.
2. A smart learning environment can offer instant and adaptive support to learners by immediate analyses of the needs of individual learners from different perspectives (e.g., learning performance, learning behaviours, profiles, personal factors) as well as the online and real-world contexts in which they are situated. Moreover, it can actively provide various personalized support to the learners, including learning guidance, feedback, hints and learning tools, based on their needs.
3. A smart learning environment can adapt the user interface (i.e., the ways of presenting information) and the subject contents to meet the personal factors (e.g., learning styles and preferences) and learning status (e.g., learning performance) of individual learners. The user interface is not necessarily a conventional computer. Instead, learners can interact with the learning environment via mobile devices (e.g., smartphones or tablet computers), wearable devices (e.g., Google Glass or a digital wristwatch), or even ubiquitous computing systems embedded in everyday objects. Therefore, it is a challenging issue to adapt the user interface to meet the learners' needs in a smart learning environment.

2.2.Smart learning environment components

Metacognitive abilities (learning factor that emphasizes the personalization of learning) may differ in learners who processes similar cognitive ability which can result in different cognitive development. Adopting metacognitive skills improvement techniques, the ability for self-learning, and awareness activities of self-knowledge can be achieved. Components in SLE-metacognitive are arranged in the form of modules connecting students, inference engines, environments and supporting databases (Sumadyo *et al.*, 2018). Five components in the form of modules were outlined. Firstly, a student's cognitive ability detection module. This component captures prior knowledge possessed by students. Secondly, metacognitive technique module. This component

contains steps that provide direction for improvement of metacognitive ability. Thirdly, learning content management module. This component provides
instructional materials that are sequential and staged according to the level of content understanding.
Fourthly, adaptive assignment module. This component receives prior knowledge
information, and metacognitive level information. Fifthly, inference engine. As part of intelligent technology, is an intelligent device that contains various algorithms to define the student's cognitive level status, determines the metacognitive status of the students so that students can be helped to decide the choice in planning their knowledge enhancement. Figure 1 below, shows the relationship between each component.
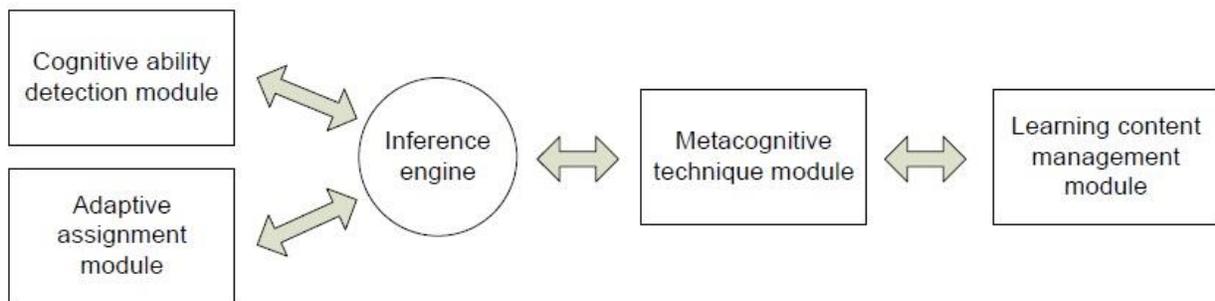

Figure 1: Relationships between components (Sumadyo *et al.*, 2018)

Furthermore, the technical features of SLE (awareness, tracking, connecting and the easy learning, recognizing, engaged learning and effective learning), are also a functional requirement of SLE. This is denoted as "TRACE3" functional model of SLE (Huang *et al.*, 2016) as shown in Figure 2.
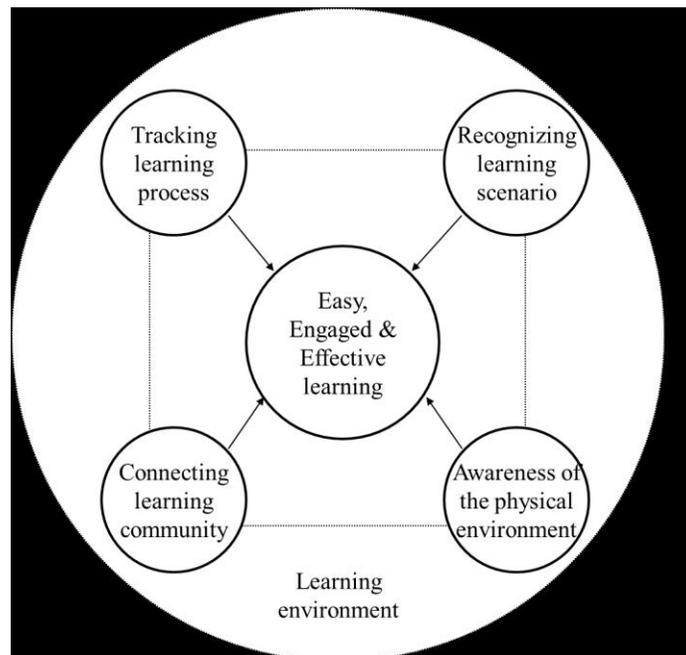

Figure 2. TRACE3 Functional Model of Smart Learning Environment

3. METHODOLOGY

3.1. Research Design

This study adopted a mixed method approach. The mixed method helps when a study must use a method to inform another method. For example, using a qualitative approach to identify variables and then study those variable with a large sample of participants using a quantitative approach (McKim, 2017). Hence, related literature was extensively reviewed to determine secondary data; this leads to the identification of various factors relating to SLE deployment. The study performed textual analysis on the secondary data to evaluate and eliminate recurrences of factors hence reducing and categorizing them. To contextualize the factors, Principal Component Analysis (PCA) was used on the data collected from experts (expert judgement). A conceptual theoretical framework was designed leveraging on the factors identified. SPSS tool was used to analyse data gathered from the closed-ended instrument designed from the identified contextual factors.

4. DATA ANALYSIS

After an intensive review of the literature (using content search technique), various factors were identified and grouped into distinctive factors namely; environment, security, system quality, information quality, vendor, and technology. The identified factors were then subjected to textual analysis following the systematic approach, the factors were reduced to 29 as shown in Table 1.

Table 1: Ranking of Factors

Item	Category	Metric	Frequency
1	Environmental factors	government regulations	32
		Loans and grants	16
		technical support	14
		Network provider policies	19
		Customer needs	17
		changing trends	8
		perceived barriers	22
		partnership/collaborative working opportunities	13
		Wireless Vulnerabilities	4
		Environmental uncertainty	7
2	Security factor	Information Security Policy	29
		User privacy	36
		Data privacy	27
		Authentication of users	31
		Security Awareness	6

		Security Culture	6
		Network Security Architecture	9
3	System Quality	Response time	33
		Ease to use	28
		Graphical User Interface	30
		User satisfaction	27
		SLE platform	24
4	Information Quality	Information reliability	27
		Information accuracy	29
5	Vendor	training session	23
		Vendors/technicians location	25
6		Data Usage	25
	Technological characteristics	storage capacity	15
		Maintenance procedure	19

A transcribed questionnaire completed by experts within the research context/domain was analyzed using Principal Component Analysis (PCA). The identified factors derived from textual analysis were used to design the questionnaire. This approach was adopted to contextualize the factors. The PCA technique bases its elimination method by deriving the eigenvalue for each attribute as well as the total variance explained. According to (Ganesh & Mehta, 2010; Pallant, 2005) attributes whose eigenvalue were under 1 must be excluded. Also, the percentage of variance of any reliable and relevant factors must be greater than 50 percent, as well as the cumulative percent(Ganesh & Mehta, 2010).

Table 2: Reliability Statistics

	Component	**Total Variance Explained** **Initial Eigenvalues[a]**		
		Uni-TVE	% of Variance	Cumulative %
RAW		5.483	67.873	75.783
		2.846	61.853	80.479
		1.453	57.838	87.018
		2.072	53.079	89.652
		1.861	56.682	91.870
		1.987	51.523	93.783
		3.763	57.873	97.108
		6.934	69.675	99.054
		3.445	62.766	97.082
		1.004	50.863	100.000
		9.757	79.653	100.000

	1.864	51.765	100.000
	1.963	58.876	100.000
	2.863	63.766	100.000
	1.747	51.532	100.000
	1.064	50.753	100.000
	1.775	50.565	100.000
	1.074	50.428	100.000
	1.476	50.648	100.000
	1.644	51.238	100.000
	7.987	78.787	100.000

Extraction Method: Principal Component Analysis.
a. When analyzing a covariance matrix, the initial eigenvalues are cogent across the raw and rescaled solution.

Based on the deduced contextual factors as shown in Table 2, the study developed a conceptual theoretical model to inform the deployment of SLE in South African tertiary universities.
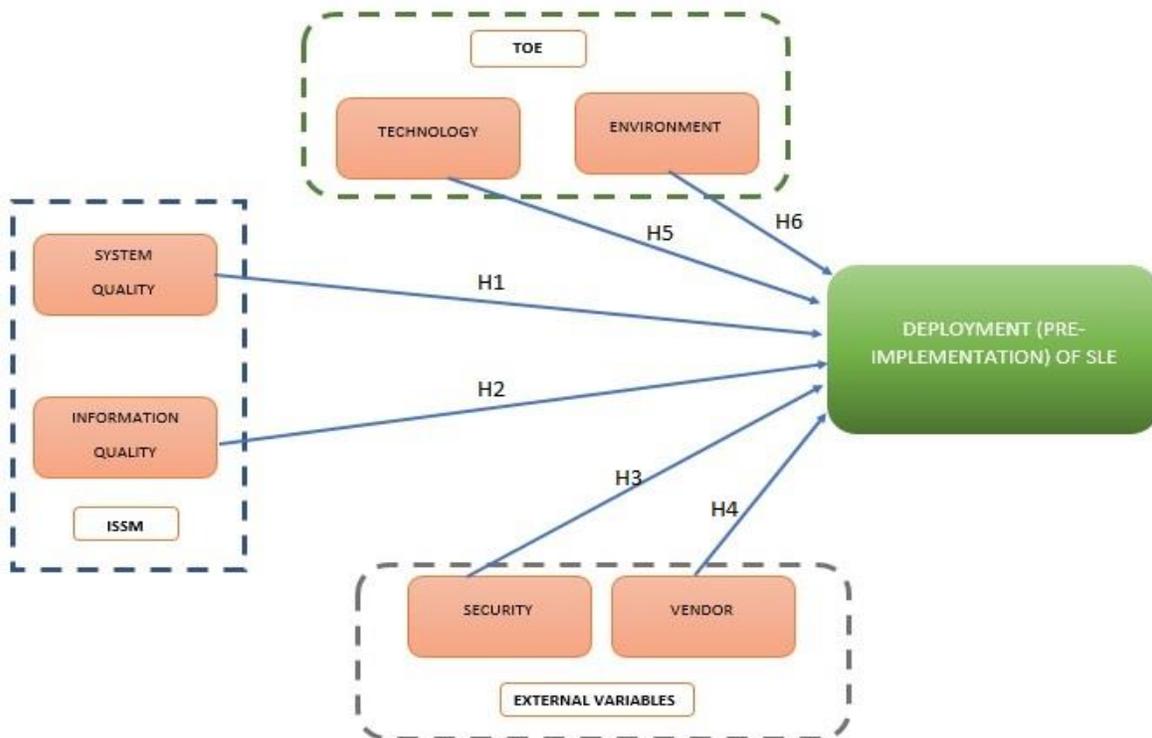

Figure 3: Conceptual framework

Figure 3, shows there are six hypotheses to be tested, namely; H1: System quality will influence deployment of SLE; H2 Information quality will influence deployment of SLE; H3: Security will influence deployment of SLE; H4: Vendor will influence deployment of SLE; H5: Technology will influence deployment of SLE; H6: Environment will influence deployment of SLE

4.1. Descriptive Analysis

The study used descriptive statistics to obtain concise statistical outcome regarding the distribution, variability, and central tendency of continuous variables. These values include statistics such as mean, sum, standard deviation, variance, range, minimum, maximum, S.E. mean, kurtosis, and skewness

Table 3: Descriptive Results

	N	Minimum	Maximum	Mean		Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error
TEC	131	2.00	5.00	3.8723	.06651	.75838	-.338	.212
ENV	131	1.00	5.00	4.7230	.10417	1.18769	-1.098	.212
SQ	131	2.00	5.00	3.8734	.10212	1.16438	-.932	.212
IQ	131	1.00	5.00	3.2740	.06264	.71420	-.561	.212
SEC	131	3.00	5.00	4.8480	.08849	1.00890	-1.061	.212
VEN	131	2.00	5.00	4.9732	.06557	.74758	-.420	.212
Valid N (listwise)	131							

In Table 3, six theories (i.e. TEC, ENV, SQ, IQ, SEC, and VEN) have an average (or mean) score above 3.50. Rounding off all six constructs gives us a value close to 4.00. The conclusion drawn from the descriptive statistics results shows that most respondents agree that the constructs being tested have a direct impact on the deployment of SLE within tertiary institutions in South Africa.

4.2 Correlation Analysis

The Pearson correlation analysis was done in order to investigate the relationships between hypothesized relationships. The study conducted a correlation analysis on SPSS to examine the relationship amongst variables using coded statistics from the survey. Results in Table 4 below have a positive correlation and show that all variables hold a positively high linear correlation, and it appears that the variables are significantly highly correlated with each other.

Table 4: Correlation Analysis

	TEC	ENV	SQ	IQ	SEC	VEN

		TEC	ENV	SQ	IQ	SEC	VEN
TEC	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	131					
ENV	Pearson Correlation	.428[**]	1				
	Sig. (2-tailed)	.000					
	N	131	131				
SQ	Pearson Correlation	.447[**]	.618[**]	1			
	Sig. (2-tailed)	.000	.000				
	N	131	131	131			
IQ	Pearson Correlation	.504[**]	.845[**]	.887[**]	1		
	Sig. (2-tailed)	.000	.000	.000			
	N	131	131	131	131		
SEC	Pearson Correlation	.552[**]	.801[**]	.624[**]	.811[**]	1	
	Sig. (2-tailed)	.000	.000	.000	.000		
	N	131	131	131	131	131	
VEN	Pearson Correlation	.539[**]	.755[**]	.738[**]	.810[**]	.743[**]	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	131	131	131	131	131	131
**. Correlation is significant at the 0.01 level (2-tailed).							

4.3. Regression Analysis

After correlation analysis, the study conducted a linear regression analysis. The variables that were suggested by correlation to be included in the regression analysis were: TEC, ENV, SQ, IQ, SEC, and VEN. Table 5 the linear model's R-Square is 0.687; hence, the coefficient of determination is 0.687. Therefore, 68.7% of the variation is predicted by the model developed. The results imply that all constructs (independent variables) included within the model were adequate in motivating the inclusion of these constructs in the research conceptual model for SLE deployment within tertiary institutions in SA.

Table 5: Regression Model Summary (n=131)

Model	R	R Square	Adjusted R Square	Std. The error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.828[a]	.683	.667	.54647	.687	37.541	6	123	.000

P-value is referred to as the probability of the outcomes occurring by chance, expressed numerically as ranging from zero to one. The convention is to accept a p-value of 0.05 or less as being statistically significant. For a construct to be termed significant, its Sig. value should be below 0.05; and according to the results in Table 6, all the variables are significant.

Table 6: Regression Analysis (N = 131)
Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t.	Sig.
TEC: Technology will influence the deployment of SLE	-.284	.075	-.367	-3.783	.027
ENV: Environment will influence the deployment of SLE	-.352	.099	-.390	-3.564	.034
SQ: System quality will influence the deployment of SLE	-.040	.107	-.070	-.374	.019
IQ Information quality will influence deployment of SLE	.080	.115	.137	.696	.007
SEC Seurity will influence deployment of SLE	.130	.126	.136	1.032	.022
VEN Vendor will influence deployment of SLE	.255	.088	.376	2.883	.019

4.4. Hypothesis Analysis

Analysis of the hypothesis was done in order to test the hypothesis suggested for this study. The results are illustrated in Table 7.

Table 7: Hypothesis Analysis

Construct	Hypothesis	Significance Value (P Value)	Action
TEC	H1	P = 0.027< 0.05	Accepted
ENV	H2	P = 0.034 < 0.05	Accepted

SQ	H3	$P = 0.019 < 0.05$	Accepted
IQ	H4	$P = 0.007 < 0.05$	Accepted
SEC	H5	$P = 0.022 < 0.05$	Accepted
VEN	H6	$P = 0.019 < 0.05$	Accepted

5. DISCUSSION OF FINDINGS

The research questions that were set for the study are revisited in this section. This is to establish whether the questions were answered and whether the intention of the questions was achieved. The primary research question of the study was: What framework will inform the deployment of SLE in tertiary institutions in SA?

To address the primary research question, the following two secondary questions were asked:

I. What are the contextual factors needed for the deployment of SLE within tertiary institutions in SA?

II. How do the identified contextual factors influence the deployment of SLE in tertiary institutions in SA?

Research question one

What are the contextual factors needed for the deployment of SLE within tertiary institutions in SA?

To address this question literature centred on Smart Learning Environment was reviewed. Peer-reviewed conference papers, books, websites for organizations, and journal articles were reviewed in this study. The study carried out a content search using several resources from the database to identify factors relating to SLE in tertiary institutions. Based on the literature reviewed from the content search, the factors were categorized into six criteria. These categories were; technological factors, security factor, environmental factors, system quality factors, information quality factors, and vendor factors. Applying content analysis, further lead to the identification of attributes fitting into different categories. This resulted in the creation of Table 1, which shows the summary of the metrics of the individual construct and the frequency at which they occur. Using Principal Component Analysis (PCA), the identified factors from content analysis were contextualized. PCA was used to spot patterns, trends in the data and form factor reduction. Twenty-one contextual factors from the six criteria were identified using PCA.

Research question two

How do the identified contextual factors influence the deployment of SLE in tertiary institutions in SA?

The influence of the stated factors on the deployment of SLE in tertiary institutions in SA was investigated in an effort to provide a satisfactory answer to the second question. The factors were structured into a questionnaire, then data was collected using that questionnaire. Thereafter, data were analysed statistically, with the conclusion from the hypotheses showing the factors that influence the deployment of SLE in tertiary institutions in SA.

H1. Technological characteristics factor will influence the deployment of SLE: The hypothesis was accepted, meaning that technological characteristics influence the deployment of SLE within tertiary institutions in South Africa. According to several researchers (Koltsov *et al.*, 2017; Mustapha & Obid, 2014), the successful deployment of technology, in general, is strongly influenced by its characteristics. Technology characteristics must meet the necessary requirements that are specific to each organisation.

H2: Environmental factor will influence the deployment of SLE. The second hypothesis predicted a positive relationship between the environment factor and deployment of SLE in this study. Most environmental factors attribute such as, government policies, perceived barriers, and customers need that characterized the hypothesis is supported by several researchers (Bavarsad, 2013; Oliveira & Martins, 2009) who acknowledged that environmental factors play a vital role in IT pre-implementation phase.

H3. System Quality will influence the deployment of SLE: The hypothesis was accepted, meaning that system quality influences the deployment of SLE within tertiary institutions in South Africa. Based on the results of a study conducted by Ranaweera (2015) on information technology applications indicates system quality as a crucial factor contributing to successful implementation of ICT projects in any organization.

H4. Information Quality influences the deployment of SLE: The hypothesis was accepted, meaning that information quality influences the deployment of SLE within tertiary institutions in South Africa in general. A study conducted on the information systems and the environment overview and perspectives by (Gorla *et al.*, 2010) shows a positive association between information quality and implementation of ICT technologies in an organization. Quality of information directly influence IT which in turn informs the successful use of ICT innovations, which could lead to successful implementation (Wu *et al.*, 2010).

H5. Security factor will ultimately influence the deployment of SLE: The hypothesis was accepted, meaning that security factor will influence the deployment of SLE within tertiary institutions in South Africa. The objective of every organization's to guarantee the confidentiality, integrity and security of its Information System (IS). This is done by guaranteeing information confidentiality, integrity as well as availability which are vital in terms of information security(Hannola & Ovaska, 2011; Hong, 2003). Taloni (2016) stressed the importance of information security in IT deployment and also encouraged basic security know-how at all levels of command throughout the organization.

H6. Vendor factor will ultimately influence the deployment of SLE: The sixth hypothesis predicted a positive relationship between the vendor factor and deployment of SLE in this study. The roles played by vendors by providing after sales services, training support, involving of users in systems upgrades have been recommended by numerous scholars for exploration. Several studies

(Agarwal, 2018; Krichen & Jouida, 2015; Stone *et al.*, 2018) recommends investigation of vendor's influence in information systems' deployment due to is importance.

6. CONCLUSION

Developing a framework that could be leveraged to inform deployment of SLE in South African tertiary institutions was the major objective of this study. Literature on SLE was reviewed and contextual factors categorised into six groups were identified using both content analysis and Principal Component Analysis. The contextual factors informed the study's conceptual framework. This was then followed by a collection of data from participants. The collected data was then coded and recorded in SPSS for analysis. The study results indicated that technological characteristics, environment, security, information quality, system quality and vendor are factors relevant for SLE deployment in South African tertiary institutions. In conclusion, this study has provided a framework to show the relationship between the identified factors and deployment of CRM in South African tertiary institutions to improve the teaching and learning environment.

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