Semantic Web Application and Framework Development in South African Higher Education Institutions

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Abstract: The evolution of the Semantic Web (SW) and its application marked a turning point in how students could benefit from a range of educational web tools and applications enabled by the SW, also referred to as Web 3.0 technology for academic purposes to meet their demands. This shift afforded students the opportunity to obtain meaningful information, collaboration and data filtering to suit their needs. It also offers freedom in how and where they choose to learn. SW tools and applications are progressively being used at several universities worldwide. However, educators' ability to integrate the use of these tools and applications in teaching and learning appears to be a major problem in almost every development plan of education and educational reform efforts. Moreover, very few educators integrate web tools to their full potential in teaching. This paper probed the integration and use of SW tools and applications in higher education institutions (HEIs), and developed a framework for its adoption in academic processes. The objectives aimed to establish the credible features and benefits of SW tools and applications in HEIs, and how the integration supports students' academic goals. It is anticipated to improve learning interaction and collaboration, and build a social presence and cohesion among students. The paper employed a systematic literature review, and information and communication technology theory of adoption. The developed framework ultimately suggests that SW tools and applications are beneficial and useful in positively impacting the pedagogical setting. Findings revealed that certain challenges with human factors (technophobia, beliefs), infrastructure, security concerns, ethical and legal issues were identified as a hindrance to be considered during integration. Despite the challenges, these tools and applications provide variety and a new wave of teaching and learning in South African HEIs, which is crucial for meeting the demand of the Fourth Industrial Revolution (4IR) era.

Keywords: Higher education institution (HEI), information communication technologies (ICTs), intelligence, interoperability, personalisation, virtualisation and Semantic Web (Web 3.0).

1. INTRODUCTION

In this era of information technology and invention, new technologies have continued to structure and change the content and application practices in the pedagogical environment. The emergence of the Semantic Web (SW) marked a turning point in how students could benefit from a range of educational technologies. The SW is widely being used in universities worldwide to support teaching and learning processes (Hussain, 2012). Teaching and learning activities are thus undergoing a transition from the traditional education system approach to technology invention, enabled by SW tools and applications (Ohei & Brink, 2019a). SW tools and applications for teaching and learning practices offer various learning platforms, namely E-learning, ICT, the blended and integrated-learning approach, flipped classroom, virtual teaching and learning, synchronous and asynchronous video conferencing, Google Apps, and Chrome Book, to name a few (Nirmala & Sivakumar, 2019).

SW tools and applications have continued to influence higher education institutions (HEI) in various aspects. These tools are content-oriented, semantic and context-sensitive services based on technologies that encourage semantically enhanced tools and applications that support educational tools and applications. Tsiotakis and Jimoyiannis (2016) argue that SW tools not only promote learning that is rich in collaboration, but also provide intelligent solutions to web searching, document management and the organisation of content. Ohler (2010) added that the SW would impact education in terms of knowledge construction, personal learning network maintenance, and personal educational administration. Since educators play an essential role in technology-enabled learning, it is obligatory that educators attend developmental training and are appropriately educated to fully unitise these tools and applications in their teaching processes. It will also enable educators to meet the demands of keeping up-to-date with rapid technological changes. Fundamentally, educators should be able to handle the various teaching techniques or approaches, and they should equip themselves in terms of advanced web tools and applications (Ohei & Brink, 2019a, 2019b; Nirmala & Sivakumar, 2019).

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The problem with training educators in the educational uses of SW tools so that they can use it successfully in teaching and learning appears to be a key factor in almost every development plan of education and educational reform efforts. Presently, very few educators use web tools in their teaching. Despite institutions' efforts, educators still lack the information and communication technology (ICT) skills required to successfully administer lectures with web technologies. The South African HEI has been experiencing pressure to meet the demands of social transformation and skills exposure needed for the new South Africa in recent decades. There is also a constant burden on improving strategic policy and delivery performance (Tsiotakis & Jimoyiannis, 2016; Jimoyiannis *et al*., 2013; Jaffer *et al*., 2007). Therefore, the necessity to venture exclusively into the SW, known as Web 3.0 technologies, becomes paramount.

Tsiotakis and Jimoyiannis (2016) emphasise how HEIs could scale up by taking advantage of the power of technologies. Moreover, several authors (Jimoyiannis *et al*., 2013; Jaffer *et al*., 2007; McLoughlin & Lee, 2008; Minocha, 2009; Gray *et al*., 2010) aver that SW tools can play a central role in the education context. Web 3.0 technologies can transform, accelerate, develop, and improve skills; encourage and involve learners' participation; strengthen teaching; and help universities' administration processes. The researcher probed SW tools and applications to develop a framework for the integration and use of web tools in HEIs in an attempt to overcome the challenges created by the traditional style of teaching and learning. These Web 3.0 tools are exceptional tools for facilitation and learning. This paper acknowledges that educators are a dynamic link in HEIs and, in order to use these tools effectively and efficiently, educators require exposure to technologies so that they display competency and advance their skills in applying them. The researcher thus developed a few research objectives that will serve as a guide. The paper explores the benefits and how the integration of SW tools into HEI will support educational goals. It is anticipated to improve students' learning interaction and collaboration, and build a social presence among students.

2. DESCRIPTIVE LITERATURE REVIEW

This paper presents a descriptive literature review which assists in identifying philosophies in the literature that justify the specific approach to the theme and the selection of methods. The literature review not only supports the selection of appropriate methods, it also enables the development of knowledge, simplifies concept expansion, and makes a meaningful contribution to the body of knowledge (Livingstone, 2015). A descriptive literature review process unveils the key principles, variables and associations that relate to the research problem. This section will discuss the themes that emerged from the literature that relate to the paper's objectives. The themes include the role of ICT; the evolution of the Web; SW integration in HEI; and the application of SW technologies and controversies. The purpose of this section of the paper was to develop a theoretical foundation by means of a descriptive literature review.

2.1. The Role of Information Communication and Technology (ICT)

Within the context of education technologies, the focus in recent years has been on the advancement of ICTs and the significant role it plays in HEIs in the 21st century (Noor Ul Amin, 2013; Moges, 2013; Madhukar, 2013; Nwosu & Ogbomo, 2012). ICT has the power to directly inspire how learners learn and are taught (Moges, 2013; Madhukar, 2013). Based on the activities and practices routinely carried out in HEIs, the advancement of ICT will have an effect on the facilitation of learning and business processes. Its benefits also entail quality and ease of access to education, learning enthusiasm, and an improved learning environment and ICT usage (Moges, 2013; Noor Ul Amin, 2013; Madhukar, 2013).

ICT has the ability to improve access and the methods through which education is offered so that learners are able to access information at any given point in time or place. This has a direct impact on the ways in which learning is transferred to learners (Madhukar, 2013; Moges, 2013; Bonifacio, 2013; Noor Ul Amin, 2013; Jaffer *et al*., 2007). Therefore, ICT-supported education will ultimately lead to the democratisation of education (Madhukar, 2013). This, in turn, will develop lifelong learners. The role that ICT played has grown exponentially (Madhukar, 2013; Moges, 2013; Bonifacio, 2013; Noor Ul Amin, 2013) as it has been deployed in solving education-related challenges, such as low pass rates and poor-quality education in South Africa. ICTs are found to be transformational tools which, when adopted efficiently, can enhance students' learning enthusiasm by improving collective learning motivation and engagement, and enabling the acquisition of general skills and techniques (Madhukar, 2013; Moges, 2013).

Moges (2013) maintains that ICT plays an essential role that not only affects how learners learn, but also creates a shift in curricula from content-centred to competence-based. Course distribution has now shifted from an educator-centred form of distribution to a learner-centred form of distribution (Moges, 2013).

Wood (2015) and Abdullahi (2014) claim that teaching and facilitation that involve diverse ICT conveyance approaches provide learners with the ability to absorb content in a way that fits a distinct learner. Today's learners thrive on digital technologies. However, many educators are not on par with their learners with respect to digital language. The pedagogical problems that arise with the use of ICT by educators who are digital immigrants therefore affect the facilitation approach used in education (Wood, 2015). Hence, several authors argue that the benefits of using ICT for improving quality education, abound (Wood, 2015; Jimoyiannis *et al*., 2013; Madhukar, 2013; Moges, 2013; Bonifacio, 2013; Noor Ul Amin, 2013; Nwosu & Ogbomo, 2012; Dotsika, 2012; Lal, 2011; Woo *et al*., 2011; Deng & Yuen, 2011; Ching & Hsu, 2011; Tse *et al*., 2010).

ICT plays a crucial role that empowers learners to uncover and introduce new concepts or innovations from professionals worldwide through the use of enabling SW tools. The presence of ICT at an HEI is vital in assisting educators to monitor a learner's development and conduct frequent evaluations. Nwosu and Ogbomo (2012) highlight even more benefits that may be derived from the use of SW technologies for better quality education. These authors speak of active, collaborative, creative and integrative learning through the use of ICT to improve the quality of education.

2.2. The Evolution of the Web

The rise of the internet in the 1990s has provided an incentive for web-based revolutions in education. Web 1.0 technologies were the first generation of the Web (O'Reilly, 2005). During this phase, the focus was primarily on building the Web, making it accessible, and commercialising it for the first time. The key areas of interest were protocols for HTTP; open standard mark-up languages, such as HTML and XML; internet access through ISPs; the first web browsers; web development platforms and tools; web-centric software languages, such as Java and JavaScript; the creation of websites; the commercialisation of the Web; and web business models. Figure **1** shows the evolution of the Web up to the point where it is used in the teaching and learning context (O'Reilly, 2005).

The prospect of enhancing teaching and learning practices has led educators to introduce dedicated SW applications into the course environment (Schroeder *et al*., 2010b). These applications allow users to create highly dynamic content, often created in collaborative ways with peer-based quality assurance. Early forms of SW tools, such as discussion boards, date back to the origins of the Web. Others, such as blogs, social networking sites and wikis, only started to become

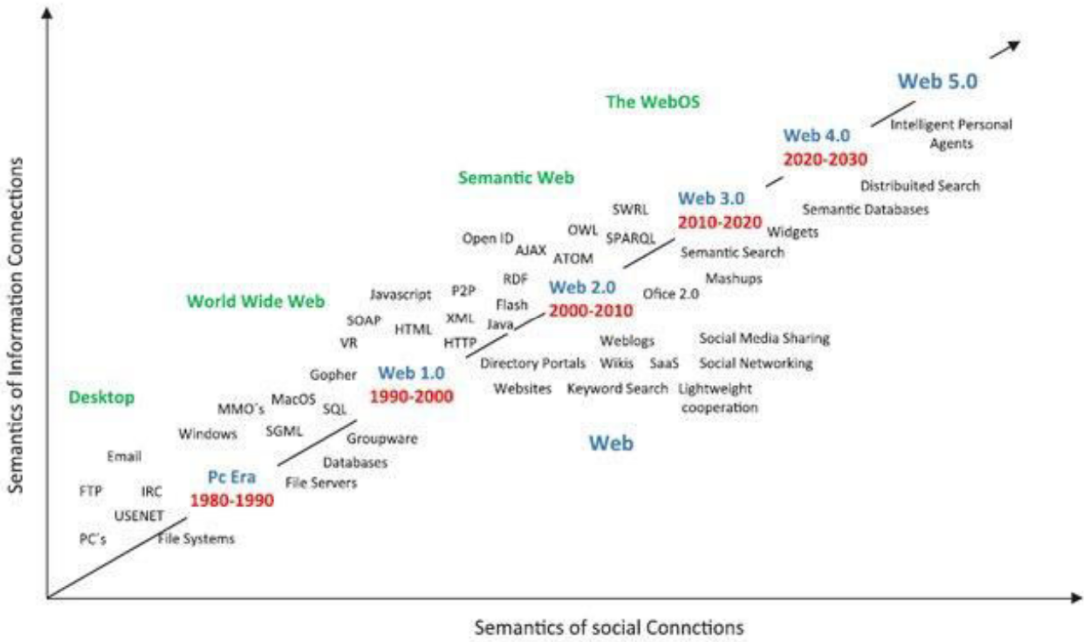


Figure 1: The evolution of the Web (Adopted from Pileggi *et al*., 2012).

popular in the early 2000s, but have gained widespread acceptance in social, educational and business contexts. Yet others, such as social bookmarking tools (e.g. Delicious) and micro-blogging applications (e.g. Twitter), are still in the early phases of acceptance by mainstream internet users (Schroeder *et al.*, 2010b).

2.3. Semantic Web Integration in Higher Education Institutions

In this modern civilisation with a high level of connectivity and pervasive, goal-driven learning, there is a need for HEIs to develop a pedagogical vision so that learners are vigorous participants as opposed to passive consumers of content. Several authors are of the opinion that the emergence of SW technologies is opening doors for effective learning and have the potential to support lifelong competence development (McLoughlin & Lee, 2010, 2008, 2007).

The SW, known as Web 3.0, plays a vital part in enhancing universities' business processes towards information management, decision-making, the integration of knowledge creation and use (Aghaei *et al.,* 2012). The author further asserts that Web 3.0 attempts to link, combine, and analyse data from several data sets to attain a new information stream. It is capable of increasing data management and sustaining accessibility, improving creativity, innovation and clients' satisfaction. Moreover, semantic tools are becoming affordable, efficient, cloud-based, global, standardised, and mobile, and also more personalised and effective in meeting individual and educational needs. It supports group interaction towards establishing communities and creating and exchanging content (Aghaei *et al.,* 2012).

A framework application is proposed for integrating SW technologies in education due to the possible features of community-based sharing, user-created content and personalisation (McLoughlin & Lee, 2008, 2010; O'Reilly, 2005). Tools such as blogs, wikis, media-sharing applications and social networking sites were found to be capable of supporting and encouraging informal conversation, dialogue, collaborative content generation and the sharing of knowledge, giving learners access to a wide range of ideas and representations. Used appropriately, they have the potential to make student-centred learning a reality by promoting learner agency, autonomy and engagement in social networks that straddle multiple real and virtual communities, independent of physical, geographic, institutional and organisational boundaries (McLoughlin & Lee, 2008, 2010; O'Reilly, 2005).

Minocha (2009) sustained that SW tools encourage a wider variety of expressive capability in the sense that it provides learners with new opportunities to be self-determining in their study and research. The importance of using SW tools as an educational platform cannot be overemphasised, which is why various universities have continued to adopt SW tools into higher education. Crook *et al.* (2008) mention how UK universities vigorously integrated both blogs and wikis (e.g. Newport University). This medium delivers an online learning environment for students, offering information about the university activities, study material, email, file storage, library resources and frequently asked questions (FAQs). Moreover, the University of Warwick adopted blog space in 2004, which is available to all students, teachers and staff. According to Minocha (2009), the logic behind the publishing of this blog space was that learners' blogging would perhaps build a community, promote social interaction and foster collaboration. Social interaction is associated with learner fulfilment and it increases performance on learning outcomes. It cannot be overemphasised that the use of SW grants the student some form of liberty. As with other distance training programmes, it creates a right of space and time, freedom to pace, choice of learning means, it places the individual over the subject, and establishes an opportunity to engage in a learning relationship with peers.

Minocha (2009) points out that it is difficult to accurately measure the extent to which online forums, wikis, blogs, podcasts, and so on, are actuality fused in virtual learning environments (VLEs), while McLoughlin and Lee (2008) reveal the power of SW innovation to support learner-centredness in educational systems. It is thus crucial to discuss and elaborate on the existence and usefulness of these applications in the next section to determine how best it can be utilised to foster quality education delivery. The first part of the section provides a short introduction to the application of SW technologies. The second part discusses SW tools in HEIs and all its attributes, characteristics and features in relation to the educational context.

2.4. The Application of Semantic Web Technologies

Over the past decades, SW technology tools, specifically blogs, wikis, e-portfolios, social media, podcasting, social networking, to list a few, have gained strong education awareness. They are used for diverse learning groups, from aspects of life (Tse *et al.*, 2010; Woo *et al.*, 2011; Jimoyiannis *et al.*, 2013) to

higher education (Ching & Hsu, 2011; Deng & Yuen, 2011; Jimoyiannis *et al*., 2013), vocational training, and teachers' professional development.

In the education context, there are shifts in the vision of education's purpose, with increasing discussions on the need to allow and support not only the ability to grasp information and knowledge, but also to advance the skills and resources that are essential for SW and technological changes to improve learning throughout life (McLoughlin & Lee, 2008, 2010). Dotsika (2012) highlights the technological aspect of SW and its applications. The present applications that support knowledge distribution and interoperability among incompatible information repositories depend on annotating data and preserving a syntactic reliability. Web 3.0 and Web 2.0 are two distinctive approaches to web information technologies, even though they stem from the same needs. They meet certain requirements and embody two diverse, but equally prominent trends (Dotsika, 2012).

Web 2.0 (O'Reilly 2005) was named as such by Tim O'Reilly in 2005, and is a collection of technologies and applications rather than an architecture (Dotsika, 2012; Ciccarese *et al.*, 2011). Its emphasis is on community collaboration, end-user participation and knowledge distribution. 'Social media' is a term broadly used to label any number of technological systems related to collaboration and community (Kaplan & Haenlein, 2010), and the evolution of social media and other SW technologies is unprecedented (Tess, 2013). In this section of the paper, the researcher uses the terms 'Web 3.0' and 'SW' interchangeably. Berners-Lee announced the SW in 2001 as a form of web content where knowledge representation is standardised and relies on languages expressing information in a machine-processable form by means of a framework based on a resource description framework (RDF) and ontologies (Tess, 2013; Dotsika, 2012). The information modelling is predominantly top-down and is done formally, without the participation of end-users. The educational aspect of the SW is based on system interoperability and adaptive, personalised information access.

Interoperability addresses heterogeneity issues present in data and administrative processes, and it ensures information integration across systems, a process too costly for any institution. Interchange, distribution and creative reuse are an SW-inherited standard, while scalability is dependent upon increasingly powerful implementations (Ankolekar *et al.*, 2007). Adaptive technologies facilitate the tailoring of information access according to given user profiles. Intelligent information integration and agents, such as information brokers, filters, personalised search agents and knowledge management services, are examples of innovative applications (Tess, 2013; Dotsika, 2012). The SW framework consists of XHTML, XML, and the RDF and Ontology Web Language (OWL). The RDF (Tess, 2013; Dotsika, 2012) is an XML-based, standardised semantic annotation method and, as such, interoperable. The OWL (Dotsika, 2012) is a family of languages built using XML/RDF syntax. The RDF schema (RDFS) adds basic ontology description power to plain RDF and many of its components are included in OWL. Together with RDF, they form the SW's RDF layer, which adds semantics to web content and enhances machine processability. The model is scalable and searches are improved as the information can be processed in relation to the modelled relationships between data and/or resources. The SW framework is occupied by ontologies; sets of shared, explicit and formal concepts used to organise and classify content (Tess, 2013; Dotsika, 2012).

From an educational point of view, ontologies are used to accurately and consistently model the originality of information and processes, enabling automatic reasoning, concept-based searches, process composition and knowledge discovery by means of intelligent agents.

Bittencourt *et al.* (2009) aver that the development of SW-based educational systems is a multifaceted undertaking which faces several issues with regard to software engineering and synthetic intelligence parts, including extensibility; interoperability; contextualisation and reliability of metadata; active structure of learning and contents; the incorporation and reusability of content and artificial intelligence techniques; and the distribution of services and new models of learning. All these concerns have been affected by the intention to demonstrate information on the Web in such a manner that computers may comprehend and be able to make use of such data. Therefore, SW-based educational systems are the innovative leap that practices SW technologies to produce more custom-made, flexible and intellectual education systems (Lefever & Currant, 2010; Bittencourt *et al*., 2009).

Learning with Web 3.0 tools involves the active involvement of internet users and collaboration within societies through the SW, such as blogs, wikis and social networking (Lal, 2011). The application facilities

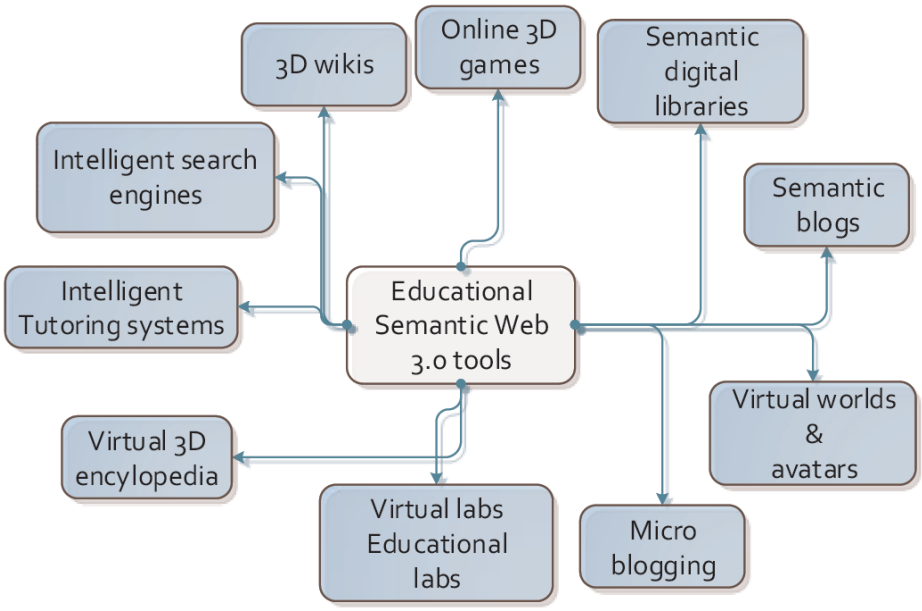


Figure 2: Semantic Web tools in education (adapted from Lal, 2011).

and tools of Web 3.0 technologies introduce open approaches to learning. The SW technologies also offer various tools and services for educational activities and web applications on the internet, as illustrated in Figure **2**. Some of these tools are briefly discussed to gain insight into the incredible features that SW tools provide (Lal, 2011).

The educational SW tools contain collections of web tools and applications that enable end-user communication and sharing of data with peers, mainly through networks (Minocha, 2009). As seen in Figure **2**, blogs, wikis, social networking websites, such as Facebook and Flickr, and social bookmarking sites, such as Delicious, and 3D environments such as Second Life are examples of some of the tools being used to distribute and collaborate in pedagogical, social, and business contexts. Moreover, the outstanding feature of these tools is that it includes broader involvement in the construction of collective information (Minocha, 2009).

2.4.1. Learning with 3D Wikis and Virtual 3D Encyclopaedias

Three-dimensional wikis (3D) is a kind of wiki system that enables one or more students to build shared knowledge in the form of interlinked web pages by means of creating, inserting and editing web pages. According to Aghaei *et al.* (2012), a wiki is a network page (or set of web pages) that can easily be altered or edited by an individual who has the privilege to access it. As opposed to blogs, it has distinctive features, namely wiki mark-up language, simple site structure and navigation, simple template, ability to support multiple users, built-in search features and simple workflow. Wikis can play an essential role in content creation, publishing, editing, revising, and collaborating for knowledge creation. This implies that students are able to carry out their learning activities collaboratively (Lal, 2011; Chisega-Negrila, 2012). Lal (2011) argues that a virtual world is the combination of 2D and 3D gaming technology, amplified reality, and a virtual environment, power-driven with internet technology where users relate through movable avatars. Learners can create their own avatars on the Web and reside in these worlds. Virtual worlds can herald a new era of e-learning as they offer learners the opportunity to role-play, do 2D/3D demonstrations, simulations, express creativity and actively participate. Recently, several web-based 3D virtual worlds, such as Second Life, IMVU and Active Worlds, have gained the attention of students and teachers for education and learning purposes worldwide (Lal, 2011).

The features of virtual 3D encyclopaedias enabled by SW means that these tools may improve constructivist learning enthusiasm, especially for distant learning (Vrellis *et al*., 2016). Nevertheless, the 3D virtual worlds do not provide the full abilities of virtual reality (VR), although research shows that the pedagogical use of virtual 3D would provide students with the capacity to view an object or situation from several dimensional viewpoints. Considering the nature of 3D, Warburton (2009) affirms that virtual

environments and virtual technologies should be described as a virtual representation that compels the student (or students) to gain a logical view, presented in a given setting as opposed to the setting they are really in by allowing learners to interact with that environment and giving the learner a strong sense of being there. What is important to note is that web tools can grant educators and students the platform to schedule meetings, conferences, presentations, and digital displays. The integration of 3D virtual worlds can be very helpful when combined with a variety of programmes (Lal, 2011).

2.4.2. Intelligent Search Engines

In the past few years, the diffusion of the Web has allowed a whole new pedagogical progression where there are more flexibilities for retrieving resources for learning (Lal, 2011). The World Wide Web (WWW) has come to be a valuable, convenient and frequently used source of information. Intelligent search engines help to efficiently manage the massive volumes of data and information on the Web. The goal of the intelligent search engines was to help with the activities of filtering and retrieving meaningful, suitable and relevant information in multimedia form for its end-users (students). In the Web 3.0 era of agent-based search engines, they can find not only the keywords in a search, but also interpret the context of an individual request. It returns relevant results and suggests other content related to one's search terms.

Lai (2011) maintains that Web 3.0 offers end-users richer and more appropriate experiences. That means that if two different students each conduct an internet search using the same keywords and the same service, they will receive different results. This is because every end-user will acquire a unique internet profile based on that user's browsing history. Learners are also advantaged by the information being structured driven by the SW. The ontologies aspect of the SW can connect the student's requests and individualistic characteristics so that tailored agents can search for study resources that are constructed based on the student's needs and requests (Lal, 2011).

2.4.3. Online 3D Virtual Labs/Educational Labs/Simulations or 3D Web

The rich online 3D user platforms or interfaces that use graphical representations serve as a dynamic interface for learners. They can actively participate in and execute collaborative activities, distribute results and exchange data among various participants in a more accepted way. The application of an online 3D virtual lab can enable a class to visit different places that students cannot reach in a small space of time. For instance, students are able to see the Egyptian pyramids or visit an Egyptian community by means of a 3D simulation. With this method, students can work on tasks together and are capable of experiencing learning at a distance. Virtual science laboratories, where students can do experiments, can perhaps also be beneficial to learners. Students may then choose to go offline into a real science lab to perform the correct experiment and see how it works. High-level scientific experiments can be carried out virtually and technical exercises requiring a significant level of skill can be given (Lal, 2011).

2.4.4. Learning with a Semantic Blog/Micro-Blogging

Micro-blogging is the most recent SW sensation. Minocha (2009) points out that the innovative practices of semantic/micro-blogging such as blogs, wikis, podcast and social networking sites, Facebook, Twitter, Flickr, and social bookmarking sites, such as Delicious, enable end-users to put their thoughts online in an open podcasting platform where end-users record it. There is even videoblogging (also known as vlogging) where the sender delivers messages in video format. Micro-blogging allows students to exchange short messages within their community or simply write in brief to the general public on the Web. This new form of blogging permits students to broadcast short and brief text to multitudes on the Web by different communication means.

In addition, authors claim that web tools as listed in Figure **2** can be integrated to provide inspiring and reliable content that will engage the students in the education process (Madhukar, 2013; Moges, 2013). Madhukar (2013) asserts that research evidence shows students are more likely to be motivated, given the aforementioned tools as opposed to traditional methods of learning or the stereotypical 45-minute lecture. Students were of the opinion that a mode of learning that involves web tools would be much more favourable and effective as opposed to the monotonous monologue lecture situation where the educator presents lectures from a raised podium and the learners listen to the presentation. On the same note, web tools can be deployed to perform the task of facilitating intellectual advancement, improving the acquisition of generic intellectual capabilities as needed for life in our information society. Web tools allow students to explore and discover, rather than merely

listen and remember (Madhukar, 2013; Moges, 2013; Bonifacio, 2013; Noor Ul Amin, 2013).

2.5. Controversies

Interacting with students in the public domain raises the issue of data protection and privacy, as it is the duty of institutions to protect students who have to use public tools for assessment (Schroeder *et al*., 2010b). Pereira *et al.* (2013), Dotsika (2012) and Schroeder *et al.* (2010) argued that the legal aspects associated with the use of SW in the public domain should be considered. Moreover, cultural issues such as privacy, reputation and identity, have raised notable concerns among academic writers. Arguably, Sellen *et al.* (2009) contend that the digital native essentially lives with technology and uses it. This undoubtedly signifies that a wider set of dynamic factors will emerge. Controversies with security issues arise in terms of privacy, content ownership, IPRs such as ethical and legal issues, and the misuse of these SW tools and applications in education settings. All these factors have an effect on how people interact with and by means of computers (Pereira *et al.,* 2013). Studies suggest that there are recurring uncertainties, specifically those created by the application tools enabled with SW. These worries tend to be focused on student bullying, and has received much attention since students are able to use SW tools and applications to torment their educators and peers. Dotsika (2012) also refers to the misuse or inappropriate use of SW tools and applications for education purpose. Conversely, Crook *et al*. (2008) raised a number of other issues, for instance, intellectual property rights and control (IPRs), as supported by Dotsika (2012), and many other related issues (Minocha, 2009).

Table **1** is a list of the reviewed literature pertaining to the paper which shows that there has been substantial activity in information systems (IS) research. The research was carried out at several strategic institutions around the world. To date, there has not been a single exceptional theorist who has been able to consolidate all the different trends in research. No author can claim that their theory or approach is the most accurate, nor can they offer decisive evidence of the accurateness of their respective approaches. Therefore, this paper developed a framework for integrating SW tools in HEIs that addresses some of the issues that were not previously tackled. The next section introduces problems associated with educators' inability to fully integrate SW tools into HEIs.

2.6. Educators' Challenges

Several research studies have shown that effective teacher preparation is an essential factor in the successful integration and sustainability of web tools' use in education (Davis *et al.*, 2009). Most ICT teacher professional development initiatives tend to focus on technical aspects (i.e., how to use various tools) while pedagogical and instructional issues (i.e., why and how to use the tools to enhance learning) are often taken for granted (Jimoyiannis *et al.*, 2013; Noor Ul Amin, 2013; Moges, 2013; Madhukar, 2013; Nwosu & Ogbomo, 2012). In this context, it is important to conceive the educational use of Web 3.0 not in terms of a special event or supplemental tool to the traditional instruction, but in terms of well-defined pedagogical dimensions (Jimoyiannis *et al.*, 2013).

Jaffer *et al.* (2007) argue that educators' choice to select a suitable teaching and learning activity is solely dependent on factors such as curriculum specifications or module objectives, the aim of the facilitation and learning, the educator's favourite teaching styles, the instructional learning approach of the learner, and the nature of the curriculum content (Jaffer *et al.*, 2007). Educators should make use of a method of delivering learning content that suits their paradigm of facilitating learning. It is often said that the educational use of technology offers educators the chance to traverse an entire continuum of possibilities as may be appropriate to their teaching requirements (Jaffer *et al*., 2007).

Due to the prominence of SW tools in educational settings and society, it is perhaps important to highlight the possible challenges that educators face with regard to the integration of these tools in education (Bingimlas, 2009). The challenges can be divided into several categories. Bingimlas (2009) mentions that various research studies have emerged that categorise these challenges as extrinsic and intrinsic challenges. Extrinsic challenges include access, time, support, resources and training. Intrinsic challenges are cited as attitudes, beliefs, practices and resistance (Bingimlas, 2009).

Additional challenges found in the literature could be divided into educator-level challenges and institutional-level challenges. Extrinsic challenges are related to organisations as opposed to individuals, and intrinsic challenges are related to educators, management and individuals. Bingimlas (2009) classifies and groups the challenges according to its applicability; whether it relates to individual (educator-

Table 1: Summary of the Issues and Concerns Related to SW

Author (s)	Year	Keywords	Journal	Central argument
McLoughlin & Lee	2010	Students as producers	Proceedings (ITHET)	Personalised and self-regulated learning
Moges	2013	ICT enhancing quality education	Journal of Research in Commerce, IT & Management	The role of ICT in enhancing education
Hosein	2013	Social Technologies and informal knowledge sharing	Studies – Dissertations	ICT conditions to integrate differences in learning: Contextual learning theory and a first transformation step in early education
Schroeder *et al.*	2010	SWOT of using social software in education	Journal of Computer Assisted Learning	Explore the various implications of introducing social software into a course environment in order to identify the associated benefits, but also the potential drawbacks
Lal	2011	Web 3.0 in education & research	Journal of Information Technology BVICAM	The benefit of Web 3.0 in education alongside the potential characteristics; the intelligence, interoperability, personalisation and virtualisation
Ciccarese *et al.*	2011	An open annotation ontology for science on Web 3.0	Journal of Biomedical Semantics Proceedings	An investigation to ascertain whether the annotation ontology meets critical requirements for an open, freely shareable model in OWL, and annotation metadata created against scientific documents on the Web
Almeida *et al.*	2013	e-Commerce business models in the context of Web 3.0 paradigm	IJAIT	Web 3.0 promises to have a significant effect on users and businesses
Hussain	2012	E-Learning 3.0 = E-Learning 2.0 + Web 3.0?	Conference (CELDA)	The study describes the way both previous generations of e-learning (1.0 & 2.0) emerged with the prevalent technologies in their kin web versions (1.0 & 2.0 respectively)
Loureiro *et al.*	2012	Embracing Web 2.0 & 3.0 tools to support lifelong learning	Procedia – Social and Behavioural Sciences	Learning in a digital age
Aghaei *et al.*	2012	Evolution of the World Wide Web	IJWesT	Provides a background of the evolution of the Web from Web 1.0 to web 4.0

level) challenges, which involves a lack of time, lack of confidence, readiness, and resistance to accepting change; or to the institution (institutional-level) challenges, such as a lack of effective training in solving technical problems and a lack of access to resources.

3. THEORETICAL FRAMEWORK

A theoretical framework is a conceptualisation of a specific complex research phenomenon, including the salient constructs and their interconnection (Livingstone, 2015). In this paper, this framework develops the concepts involved and expands the body of knowledge. More specifically, the benefit of this proposed framework is that it broadens insight into the phenomena being studied. It facilitates understanding and exposes the theoretical foundations of complex research phenomena through visual exposition (Webster & Watson, 2002). Additionally, frameworks facilitate web information modelling, semantic annotation and information retrieval, enable system interoperability, personalisation, virtualisation, intelligent agents, and enhance information quality.

This paper assessed the existing technological tools and applications used in learning and business administration processes, with the focus on whether these tools are effective to support collective, interactive, constructive and transformative learning. The contribution of this paper is the development of a framework for the integration of SW tools and

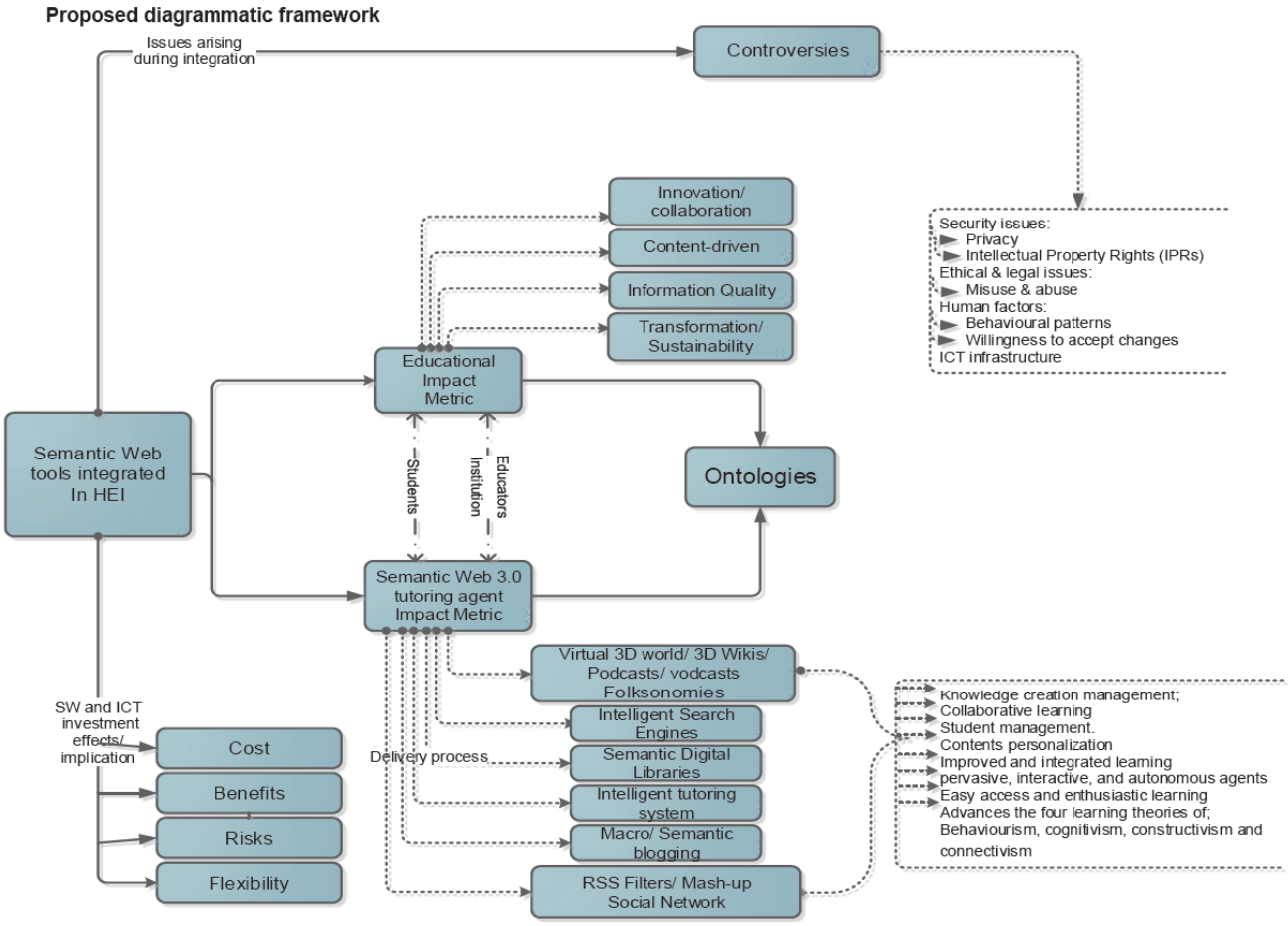


Figure 3: Diagrammatic framework for semantic web integration (Ohei & Brink, 2019).

applications in HEIs to allow learners to choose how and where they want to learn (Moges, 2013). Next, the detailed framework is discussed and presented diagrammatically. This is followed by brief illustrations of all the nodes represented in the diagram in Section 5.

4. METHODOLOGY

The paper recognised a triangulation approach and followed the theories of ICT adoption models to unravel the underlining adoption models. It focused on the theory of reasoned action (TRA), the theory of planned behaviour (TPB), the technology of acceptance model (TAM), technology readiness and acceptance model (TRAM), and jointly the systematic literature review (SLR) or systematic review (SR) (Boland *et al.,* 2017). This paper followed SLR, since the contents are based on existing literature studies identifying research needs and gaps, collecting or gathering lines of thoughts, or researchers' views on SW tools, analysing their thoughts and findings, reporting on the gaps, and concluding through the development of a proposed framework. The framework aimed to guide HEIs in the successful integration of educational Web 3.0 technologies to facilitate teaching and learning in HEIs.

5. DISCUSSION OF THE SW FRAMEWORK

The diagrammatic framework proposes four precise aspects that govern institutional transition and is schematically exemplified by a tree structure. The first aspect of the diagrammatic representation of the framework illustrates the conditions for transitioning and addressing the expected educational impact. The second aspect deals with the significance and facilitation of learning through an SW tutoring agent matric. The third and fourth aspects deal with the problems surrounding SW and ICT investments and their effects. The transition involves the integration of SW tools in HEIs, and it complements the five core nodes, namely educational impact, SW or Web 3.0 tutoring agent impact, ontologies, controversies, and SW and ICT investment considerations.

The diagrammatic representation expands on the above and categorises the educational impact of the

basic structure into four leaves, namely innovation/ collaboration, content-drivenness, information quality, and transformation/sustainability. The SW tutoring agent root is categorised into six leaves, namely the virtual 3D world of wikis/podcasts/vodcasts/ folksonomies; intelligent search engines; semantic digital libraries; intelligent tutoring systems; macro/semantic blogging; and RSS filters/mash-up/social networks. These leaves relate to education delivery processes and are briefly discussed in the sections to follow.

The third aspect governing the integration of SW tools in HEI is the controversies root, which can be categorised into four leaves; security issues, ethical and legal issues, human factors, and ICT infrastructure. The security issues relate to privacy and IPR. Ethical concerns include the misuse/illegal use of SW applications tools. Human factors divide into behavioural patterns and acceptance/willingness to use these tools. The fourth aspect, which is SW and ICT investments and its implication, is categorised into costs, benefits, risks arising from software crises, and flexibility. All the components of this framework are discussed as the paper proceeds.

5.1. Semantic Web 3.0 Tools

The first part of the discussion focuses on the positive aspects of the framework presented above. Such a framework may assist different users (learners, educators and the institution itself) in achieving their goals. The framework includes a new cohort of SW tools and applications that are useful for enhancing and improving business processes and the quality of service delivery through the use of SW technologies (Bittencourt *et al.*, 2009).

In the framework, the two dotted double-edged arrows point towards the educational impact, and the SW tutoring agent root signifies the dynamic between the learners and educators/institution in the SW-integrated framework. The learner's role involves the eagerness of learners to collaborate with pedagogical technologies in an attempt to develop their knowledge and achieve their learning goals (Dotsika, 2012; Ohler, 2010). This communication/interaction can only be made attainable through personalised and adaptable educational Web 3.0 content. The educators/ institution's role entails numerous pedagogical events involved in the SW-integrated framework, including collaboration abilities, information quality, content-drivenness and the transformation of instructive teaching and learning, curriculum design and authoring. Moreover, educators play a role in assessing learners' collaborations (problem solving, assessment, etc.) and helping learners construct approaches that best suit them. The processes described above are bidirectional and interlinked as learners and educators/institutions are all key components in the SW-integrated framework (see Figure **3**) (Dotsika, 2012). The next discussion of the SW-integrated framework deals with the transitioning aspect, which includes the educational impact of the integration of SW tools into education.

5.1.1. Educational Impact

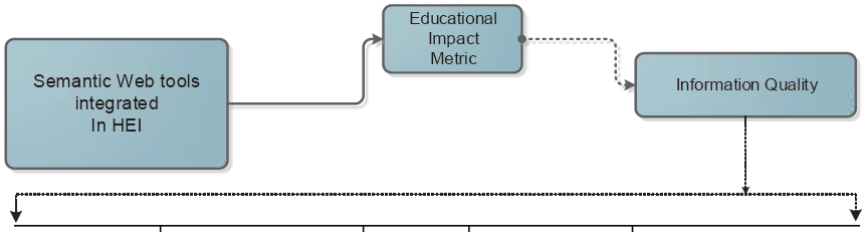
As mentioned above and illustrated in Figure **3**, the root representing the educational impact metric has four leaves, namely innovation/collaboration, content-drivenness, information quality, and transformation/ sustainability (Ohler, 2010; Dotsika, 2012). These are briefly discussed below.

Innovation/collaboration: Innovation refers to the use of technologies associated with SW tools and applications to support semantic content innovation in education. It involves semantic content representations, pedagogical curriculum course design with accuracy and reliability, allowing instinctive thinking, idea-based searches, and process configuration and information discovery.

Content-drivenness: This aspect relates to content generation, distribution, reposition, reuse, retrieval and distribution. The content generation processes result in improved enactment, with delivery lagging behind. Progressive automation allows networking to be content and user-directed.

The information quality category: Information quality has a direct impact on educational goals, accomplishment and profitability. Good quality information is associated with certain traits (applicability, assessment, added value, timeliness, comprehensiveness and capacity), proper representation (clarification, ease of comprehension, concise and reliable representation), user-friendliness/access, safety, and inherent document qualities (correctness, impartiality and consistency) as illustrated in Figure **4**.

Transformation/sustainability: This aspect is associated with educational change away from a highly centralised model of learning to the inclusion of emerging web technological tools enabled by SW,



Classification	Dimension	Web 1.0	Web 2.0	Web 3.0
Basic Information Quality	Accurateness	☞	less control	enriched
	Objectivity	☞	less control	better quality
	Credibility	☞	less control	improved
	Reputation	☞	control mechanisms available	control mechanisms available
Contextual Information Quality	Relevance	☞	enhanced	more advanced
	Added value	×	enhanced	✓✓✓
	Suitability	☞	upgraded	✓✓✓
	Completeness	×	enhanced	advanced
	Quantity of Information	☞	improved	Advanced
Openness/ Convenience	Accessibility	✓	✓✓	more advanced
	Access Security	✓	✓✓	advanced
Representation	Interpretation	✓	✓✓	✓✓✓
	Ease of Understanding	✓	✓✓✓	✓✓✓
	Concise Representation	✓	✓✓✓	✓✓✓
	Consistent Representation	✓	✓✓	✓✓✓

Figure 4: Comparison of information quality using four classifications (Web 1.0, 2.0 & 3.0).

allowing institutional developments, new functions, standards and control. When compared with the Web technologies of the past, the current Web 3.0 technologies have improved web application functionalities and have transformed data management and information discovery (Green, 2011; Dotiska, 2012). In other words, web information quality management has developed beyond traditional Web 1.0. Generally speaking, it is sensible to reflect on the present and potential impact of internet growth, such as the mode of delivery and learning assessments. In terms of learning assessment, the intelligent tutoring/tagging agent helps learners and educators to devote less time to searching unlimited amounts of data. Several authors advise that semantically intelligent searching can address some of the concerns related to digital literacy and information management (Yuen *et al*., 2011).

Web 3.0 technologies have a far-reaching effect on educational settings. They inspire cooperative intelligence, support interoperability, improve sustainability, and bring about a revolution that can give an institution a competitive advantage (Dotiska, 2012).

The next section presents the second aspect of the SW-integrated framework, which deals with the impact and facilitation of learning through SW tutoring agents. The tutoring agent impact entails the methods of delivery, followed by the third and fourth aspects.

5.1.2. SW Tutoring Agent Impact

In the SW-integrated framework, the SW tutoring agent branches out into six leaves as represented in Figure **5**, namely the virtual 3D world, wikis/podcasts/ vodcast/folksonomies; intelligent search engines; semantic digital libraries; intelligent tutoring systems; macro/semantic blogging; and RSS filters/mash-up/social network. These categories relate to education delivery processes.

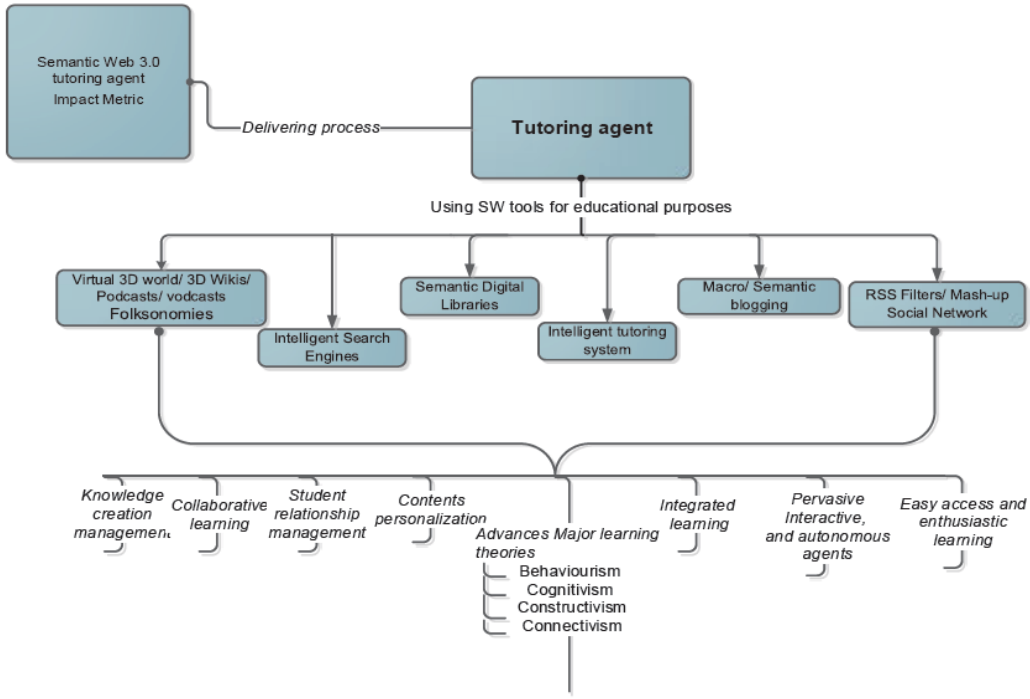


Figure 5: The tutoring agent's learning delivery processes (adapted from Dotiska, 2012).

Figure **5** depicts how these tools and applications encourage knowledge creation management; collaborative learning; students' management; content personalisation; improved and integrated learning; pervasive, interactive and autonomous agents; easy access and enthusiastic learning; and improved learning theories (behaviourism, cognitivism, constructivism and connectivism). There are insightful examples of educational institutes that have integrated SW in their administration and facilitation processes. This section expounds on these web applications as they relate to improving learning theories (specifically connectivism) as it is more appropriate for the digital native in an educational context.

5.1.2.1. Connectivism Learning Theory

Learning theories have developed and changed rapidly as a result of changes in learning methods. Facilitation approaches have evolved due to new technology applications that have emerged. Studies suggest diverse views and various effective learning processes, but connectivism is regarded as the learning theory of the digital native (Siemens, 2014; Hussain, 2012). It serves as a replacement of behaviourism, cognitivism, and constructivism.

Judging from Figure **5** and a connectivism point of view, information and intellectual ideas are disseminated through contemporary networks that involve individuals and technology. Learning is therefore perceived as the process of interconnecting, developing, and navigating these networks (Siemens, 2014).

Collective tasks allow learners to connect, interrelate, ask questions, discuss answers, and assess learning topics. Teamwork with fellow peers makes learning more convincing. Students may learn from each other provided that they have the platform to participate in critical discussions and therefore inspire each other (Pileggi *et al.*, 2012). As a result of the applications empowered by the SW, students may conveniently discuss problems from diverse perspectives, suggest countless solutions, and evaluate information in a group context to reach decisions. In addition, students' commitment is improved when they have the prospect of communicating ideas and learning materials with other students. They can talk and write about what they are learning, conceptualise and virtualise it in their own context, and apply their newly attained knowledge to their day-to-day activities.

Notably, Web 3.0 supports creativity, innovation and improves learning satisfaction. Also, SW technologies turn out to be realistic, efficient, standardised, more personalised and effective in meeting individual and educational needs.

The next section addresses the negative aspects which relate to the SW-integrated framework. The third

aspect is thus the controversies root, and it branches out into four leaves, namely security issues, ethical and legal issues, human factors, and ICT infrastructure. Security issues, in this case, are associated with privacy concerns and IPR. Ethical issues that arise include the misuse/illegal use of SW tools and applications, and human factors associated with behavioural patterns and acceptance/willingness to use the tools.

5.1.3. Controversial Issues

5.1.3.1. Human Factor and ICT Infrastructure

In the SW-integrated framework, the researcher discussed the concerns relating to the controversies. The paper explored how human behavioural patterns and people's acceptance of or willingness to use SW tools influence this integration process by using the theories that underlie integration or adoption models. The researcher highlights a few concepts and theories of adoption that are relevant to the HEI. Notably, Omona *et al.*'s (2010) studies on ICT adoption models result in three core fundamental approaches, namely the TAM, the TRA, and the TPB.

5.1.3.2. The Technology Acceptance Model (TAM)

The framework suggests that during the integration process of SW tools in the education context, there are a set of beliefs that influences the adoption process either negatively or positively. This paper examined the TAM. Omona *et al.* (2010) suggest that when users are presented with new technology, several factors influence their decision regarding how and when they will use it. This includes its perceived usefulness, ease of use, external variables and the intentions or attitudes of users. However, there are other associated factors that the TAM does not consider, such as personal control, economic factors, outside influences from suppliers, customers and competitors.

The TAM highlights the need for a learner/educator to use SW technological tools and applications for educational purposes. The different elements of the theory may impact acceptance either positively or negatively. The decision for an educator or student to integrate SW tools can be a challenging step in the process. A brief description of the different elements is presented next.

External Variables

External variables influence perceived usefulness and perceived ease of use, for instance, demographic variables.

Perceived Usefulness

Perceived usefulness refers to the degree to which an individual believes that using SW tools and applications for education will improve their work performance (Venkatesh & Davis, 2000).

Perceived Ease of Use

Perceived ease of use is the degree to which a person trusts that using the SW tools and applications for educational settings will be convenient and easy (Venkatesh & Davis, 2000).

Attitudes Towards Use

Attitude towards use describes the user's interest in or attraction to using SW tools within the educational context (Malhotra & Galletta, 1999). Notably, perceived usefulness, alongside perceived ease of use, are the key determinants of a person's attitude towards Web 3.0 tools. The perceived usefulness and perceived ease of use are derived from external variables and attitudes towards use. More significantly, there is a relationship between behavioural intention and actual use. Attitude, joined with perceived usefulness, causes behavioural intention, while the behavioural intention, in turn, influences actual use. In an attempt to do away with the limitations that the TAM brings, the TRA emerged. It is a more suitable theory that embraces four broad concepts, namely behavioural attitudes, subjective norms, intention to use, and actual use.

5.1.3.3. The Theory of Reasoned Action (TRA)

The TRA is a widely studied model in social psychology (Malhotra & Galletta, 1999; Kwon & Chidambaram, 2000). It attempts to explain why people behave as they do in situations of 'reasoned action' by identifying causal relations between beliefs, attitudes, intentions and behaviour (Kwon & Chidambaram, 2000). Attitude is defined as the individual's positive or negative feelings about enacting a target behaviour.

5.1.3.4. The Theory of Planned Behaviour (TPB)

The TPB is an extension of the TRA that deals with settings where the individual has no control over behaviour. This is discussed as it resorts under controversies as part of the human factor/behavioural patterns in the SW-integrated framework that could impact or hinder SW tools and its application in pedagogy. Attitude is explained as a function of the combined effect of behavioural beliefs and outcome evaluations. The behavioural beliefs relate to the

favourable utilitarian, hedonic and social outcomes that can result from performing the behaviour (Venkatesh & Brown, 2001). Subjective norms reflect the perceived opinions of a person or group whose beliefs hold importance to the individual.

It is clear from the section above that human factors should be considered during the integration of SW tools in pedagogical contexts. The actions of individuals to either accept or reject a system may be associated with controversial issues surrounding SW tools' integration. The theories that describe behaviours around technology acceptance emphasise the process through which technology becomes an essential part of people's everyday lives.

The fourth aspect, as presented in Figure **3** of the SW-integrated framework, involves SW and ICT investments and their implications. These are considered next in terms of costs effectiveness, benefits, risks arising from software crises and flexibility.

5.1.4. ICT Investments

Investing in SW tools in HEIs has been motivated based on business processes. The reasons why institutions want to finance ICT investments are as follows: to establish quality service delivery; to invent new products or improve on the existing services/products (expansion); to replace or upgrade facilities and assets that have become obsolete (maintenance/upgrade); to reduce costs on current or future expenses (cost displacement); to change the old-style or traditional mode of operation (transformation); and most prominently, to meet the fast changes in technology. In this case, this paper investigated the application framework for SW integration in HEIs for the purpose of maintenance/upgrade, expansion, cost-effectiveness and transformation. There are four components of investment assessment as demonstrated in the developed framework, namely costs, benefits, flexibility, and risks (software crises).

The concern of the risks related to software crises has not yet been resolved. Haigh (2010) notes that the term 'software crisis' was coined in 1968 at the NATO conference on software. A software crisis is caused when there is no adequate budget, proper design and execution, when there is low productivity, a lack of quality in the software, and an inability to meet users' expectations (Colburn *et al.*, 2008). The framework revealed that HEIs should look into various aspects to arrive at a holistic view before investing in the integration of SW technologies in HEIs. The objective of this section is to critically analyse the issues that may arise during the integration of SW tools into an education system. The issues of costs implication, benefits and risk associated with a software crisis and flexibility are widely considered. Therefore, ICT investment, such as SW integration, should be financed in the most appropriate way so that it offers value for money, return on investment, has benefits and transforms the competitive edge of the business.

6. CONCLUSION AND RECOMMENDATION

The initial objectives of this paper have been achieved by assessing the existing technological tools and applications used in learning and business administration processes. The paper aimed to establish whether these SW tools are effective to support and share, and whether they are interactive, positive and transformative within the context of learning. This framework was based on the existing framework and literature supported with the diffusion theories of adoption. It is important to envisage that this framework developed for SW integration in HEIs cannot serve as 'one-size-fits-all framework'. Rather, this framework directs the integration of SW technologies and applications and is fundamentally hypothetical in nature. Therefore, the benefit of having to develop this framework is to assess the positive aspects of Web 3.0 in HEIs. To successfully implement this framework in practice, the concerns raised in the framework ought to be addressed. The framework depicts that the integration of these web technologies and its applications for academic purposes are fundamental as it will assist several users (learners and educators/institution) in an administrative platform to reach their precise goals. It includes the new cohort of SW-based tools that enhance and improve business processes and the quality of services delivery with SW technologies and applications. More specifically, the benefit of this framework is that it broadens insight into the phenomena being studied. Thus, the framework makes an original contribution to the academic body of knowledge and provides essential guidance and insight for SW tools' integration in HEIs.

With the successful integration of web tools into educational systems, learners can source and browse e-books, and have easy access to educational resources and personnel (mentors, experts, researchers, professionals, and peers-all over the

world). The framework demonstrated that the use and integration of SW technologies in HEI will not only assist students with their course modules, but also improve students' access to educational materials. It will promote quality education delivery, improve students' motivation, engagement, performance and collaboration with peers and educators. It fosters a learning process where the geographical position gradually becomes less of a concern; where learning is no longer restricted to the classroom, but can actually take place anywhere, at any point in time, regardless of the location. Furthermore, the proposed framework supports the arguments and suggests that SW tools have potential benefits for supporting educational goals.

With the proliferation and emergence of SW collaborative and participatory technologies, the SW presents a dynamic shift in the higher education environment that encourages better learning processes in the sense that SW in HEIs will foster social communication and teamwork through various approaches. It enhances a student's ability to express their uniqueness; increases responsiveness with the presence of peers; establishes social connections; and creates platforms for shared experiences and content publication. However, there are a few controversies that could prevent the use of these web tools. This includes security and ethical concerns, human factors, ICT infrastructure, ICT investment and other possible concerns (lack of student exposure). Some of these pose hindrances or prevent the integration of web tools in education. However, all the challenges are manageable if addressed. The framework also addresses the problem of a lack of ICT confidence and technophobia, and suggests there are factors that should be considered when investing in ICT at any given institution. These factors include cost implications, the risks involved, and the potential benefits that it will bring to the institution.

6.1. Delimitations of the Paper

6.1.1. What the Paper is Not

It is important to emphasise that there are two main approaches that guide research in any IS research discipline. This approach entails behavioural science and design science (Peffers *et al.*, 2007). The behavioural aspect aims to develop and verify philosophies or theories that seek to explain human or organisational behaviour. Behavioural research focuses on justification, the development of theories and forecasting. The design science focuses on extending the landscape or boundaries of the organisation or human capabilities in the sense that it seeks to create new and innovative artefacts (Peffers *et al.*, 2007).

Design science enhances artefact work, the standard, as well as the performance. However, both approaches are involved in IS research. This paper developed a framework for SW integration in HEIs. Therefore, the paper was theory-driven, with the aim to develop valid knowledge by describing, explaining and possibly predicting and producing shared understanding (Hanid, 2014). The paper was, however, focused on theoretical problem solving, which entailed narrative or solution-driven knowledge. The findings emerging from this paper through forecasting and an explanation of phenomena may be employed in providing or designing solutions to the problem in question.

The delimitations of the paper are as follows:

- This paper developed a framework for SW integration in HEIs based on existing literature and theories adopted, not to develop a prototype for SW integration in HEI.
- This paper did not entail the development of an HEI policy or curriculum framework.
- Most significantly, the paper does not test or measure the framework developed. The framework will serve as a guide on how to develop or solve the existing problem.

6.2. Recommendations for Future Research

Till the future, it would be important to involve educators and students across different disciplines and various universities to test this framework developed. There used to be 36 universities in South Africa, which were reduced to 23 public HEIs after the merging process. Six of these were classified as comprehensive universities. All the different types of universities should be studied in the future. Besides, research should cover a wide range of academic domains and faculties. To add to this, there is a growing need for SW and ICT web instructional technologies to be incorporated into teaching and learning platforms, offering another possible area of research.

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