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Affordance of Internet of Things for educational resources management for E-learning domain

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ABSTRACT

The Internet of Things (IoT) offers dual dimensions of affordance for educational resources management (ERM), particularly in a Comprehensive open distance e-learning institution in South Africa. The affordance of IoT for educational resources management is not well articulated in a CODEL institution. The study aimed to establish the role of IoT in the administration and management of educational resources. Technology affordance theory is used to establish the role, perceptions, and causality of IoT affordance in ERM. The research opted for the qualitative approach to establish the role and causality of the IoT affordance of ERM. The study found that the CODEL institution is IoT-driven when handling ERM. The main contribution relates to two propositions such as South African higher education institutions, including the CODEL institution, require the articulation and realignment of an IoT-driven business enterprise system for the implementation of OER in tuition; and in an IoT-driven context such as CODEL, where OER are implemented, there is a motive for academics and institutions to develop an Artificial Intelligence or interactive robot for creating and locating OER. It suggests that CODEL should realign its business enterprise system with IoT-driven infrastructure and adopt artificial intelligence practices for OER advancement. Future research should investigate the availability of IoT in all South African higher education institutions.

Introduction

The Internet of Things (IoT) has been recognised in different organisations, including the education sector. IoT is the process of enabling different devices to communicate with each other over a network (Rath, Khang & Roy, 2024). Once the interaction and interaction of devices and technologies has happened, the systems afford human interaction (Rastegari, et al., 2023). Most processes and gadgets today use the IoT, a developing technology that has the potential to improve people's quality of life by making it easier to access certain information and services (Nassereddine & Khang, 2024). Globally higher education, including the education sector, has potential for IoT growth. The IoT encourages academics and students to use digital technologies to enhance their e-learning, and a variety of tools have been used to integrate formalised learning environments in teaching in higher education. (Alenezi, 2023). The proper implementation of the IoT architecture of e-learning in universities and colleges can improve their distance learning programmes and increase efficiency without affecting their academic activities (Haque, Haque, Zeba, Kumar, Ahmad, Rahman & Ahmed, 2023). Furthermore, IoT has a significant impact on education in several ways that allow institutions to make better informed decisions to enhance student learning experiences, operational efficiency, campus security, and many other factors (Bekturdiyev, 2023).

The accessibility of IoT affordance in open distance and online learning is advancing for better innovation. Affordance is the process that allows the exploration of IT artefacts, in turn, facilitates the analysis of interactions between IT and users within the organisation and improves the understanding of affordance existence and affordance perception (Kalimullina, Tarman, & Stepanova, 2021). In education, IoT affordance is recognised when then there is an interaction of physical and virtual objects embedded with instructional technologies, mobility applications, and cloud computing (Pachouri et al., 2024). The instructional technologies include LMS such

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as Blackboard, Sakai, and Moodle. IoT technologies also enable the integration of mobile learning applications used by learners to manage learning and used by instructors to administer assessments and teach through simulations and gamification (Tsakeni, 2021). The cost of IoT equipment has potential growth because many higher education institutions rely on the Internet to learn where online resources are appropriate for tuition.

The most popular educational resources are Open Education Resources (OER). All types of higher education institutions, such as distance education, open institutions, blended learning, and contact institutions, have appropriate OER for tuition and learning. This artefact emerged during a meeting of the United Nations Educational, Scientific, and Cultural Organisation (UNESCO) in 2002. OER are resources that encourage open access to information for educational purposes, including whole courses, course materials, modules, textbooks, exams, tools, materials, and approaches (Oelfke, Sadowski, Ramseier, Iremonger, Volkert, Dykman, & Baumann, 2021). The UNESCO Ministerial Statement (2017:301), which was adopted during the Second World OER Congress, held in Slovenia, states that "For OER to reach its full transformative potential to support the realisation of Sustainable Development Goal 4 (SDG4), OER must be more integrally a part of educational policies and practices from early childhood education to postsecondary, technical vocational educational training, higher education, lifelong learning, and teacher training. " OER is kept and processed within the information systems platforms, which are connected to the Internet (Mncube, 2022). OER relates to IoT affordance since are created, retrievable and appropriated online.

In the advent of online education, there is a crucial need for Educational Resources Management (ERM). Educational resources are administered and manageable through ICT systems. Learning management systems, Google Classroom, cloud cloud-based systems are examples of ERM (Kassim, 2024) suitable for tuition. Creation and administration of educational resources are appropriated through learning management systems, cloud, and many other digital platforms. The essence of ICT facilitates student-centred tuition by allowing content and learning pace to be adapted by students and academics (Cabellos, Pérez Echeverra & Pozo, 2023). Digital space enhances the administration, storage, distribution, and access of educational resources (Jeremiah, Yang & Park, 2024). Higher education institutions must continue to capitalise on the benefits of IoT systems and skills to provide academics and students with better use of educational resources. However, there is little knowledge about the benefits of IoT for ERM. The study sought to close this gap and increase knowledge related to access to IoT for ERM. Therefore, the objective of this study is to investigate how IoT affordance plays a role in ERM in a Comprehensive Open Distance E-Learning Institution (CODEL). To answer this question, the affordance theory is deemed relevant for this research.

CODeL Institution (e-learning domain)

The University of South Africa (UNISA) is a leading comprehensive open distance e-learning (CODEL) institution in South Africa and Africa, with more than 370,000 students (Unisa, 2024). It is the largest university on the continent and one of the world's mega universities. UNISA offers a wide range of courses and degrees, as well as flexibility through online classes. Despite being a developing nation, South Africa's position in the ODL is unique. The university offers authorised degrees at all academic levels, accredited short courses, certificates, and diplomas in all of its colleges and departments. MyUnisa, an institutional e-learning platform with Moodle integration, is the most popular system in a CODEL institution. It allows students and academics to communicate remotely using tools such as the World Wide Web, email, audio recordings, video recordings, broadband, optic fibre, video conferencing, video calls, the Internet of Things, and cloud computing (Sevnarayan, 2022). This has reduced communication between students and instructors by reducing the need for telephone communication.

Both academics and students can express their opinions and concerns about their teaching and learning on MyUnisa. Additionally, myUnisa allows students to interact with each other through discussion boards. Students can use myUnisa to develop and create study groups by posting their contact information to other nearby students. Academic staff and students can also access announcements, discussion forums, and social conversations on myUnisa (Nsamba, 2019). In 2010, it was suggested that the amount of communication between students and instructors by telephone may be significantly reduced (Van der Vyver, 2010). Because Unisa employs an internet platform for tuition and the present Unisa provision is entirely online, this goal has already been realised. For easy access for students on the continent and abroad, feedback on assignments and exams can be provided on the portal. The portal also gives students the option to submit electronically, saving them time, as they are no longer required to send assignments and exams to the university by post or courier service.

Theoretical Framework

The affordance theory was used in this study to investigate academic perceptions of IoT affordance during ERM. According to Volkoff and Strong (2013), the term "affordance" has been widely used in information systems research to explain and analyse various artefacts. Affordance theory is "particularly well suited to helping information systems scholars build theory about ICT use" (Majchrzak, Markus, & Wareham, 2016:272). Although other researchers have investigated the advantages associated with various types of IT solutions (Strong et al., 2014), some researchers have developed theoretical advantages models (Volkoff & Strong, 2013). This study focused on the relationship between the information and communication technology infrastructure and the use of these technologies by people. (Gibson, 1977).

To explore academic perceptions and answer research questions, this study used three concepts of affordance developed by Lanamäki, Thapa, and Stendal (2016): technology capabilities, human ability, and affordance use capabilities. During the technology capabilities phase, the relationship can be between a class of an artefact and a social convention; between a designer, an artefact and imagined users; between an artefact and actual users; or between an artefact and another artefact (Lanamäki, et al., 2016). On that note, by investigating IoT perceptions for OER implemented by academics, this phase assisted in discovering the relationship between the artefact and the actual user. The affordance capabilities assist us in developing a more nuanced picture of how technology affects the human actor and how technology is used (Lanamäki et al., 2016). As a result, affordance utilisation capabilities are deemed useful in addressing the IoT systems and academic capabilities used for ERM.

Opted Research Methodology

This study used an interpretivism paradigm and a qualitative approach, with the case study (the CODeL institution) as the research design chosen. Because the initial participants were chosen from a diverse institution with eight colleges, 18 schools, and 70 departments, snowball sampling was used. A total of 42 lecturers – consisting of Junior Lecturers, Lecturers, Researchers, Senior Lecturers, Associate Professors and full Professors (P) - participated in the semi-structured interviews. Due to their flexibility, semi-structured interviews appear to be the most effective method for qualitative research (Gillham, 2005). The interviews lasted for 25–60 minutes. The selection criteria were based on the fact that lecturers are responsible for teaching and rely on OER. One of the ways to collect data in this study was to analyse documents. The documents, including the OER plan, the Open Distance Learning Policy, and the UNISA Annual Reports (2013 and 2019), were analysed as part of the triangulation of existing data.

The data collection process was followed by thematic data analysis. NVIVO was used to store and manage the collected data. After being anonymous, the transcripts were coded in NVIVO and analysed. After rereading the interviews and codes, NVIVO memos on various topics were created by returning to the individual interviews and further analysing the data. At this point, the researcher began to look for themes. The researcher went over all the coding, themes, and links between the primary themes and began to redefine and rename the final themes after identifying or combining concepts, and completed the analysis. The ethical clearance letter and permission to conduct research at Unisa were obtained. Following ethical guidelines is essential, including those relating to informed consent, confidentiality about participants, sponsors, and co-workers, the importance of the benefits of the study to participants over the hazards involved, and participants' requests that go above and beyond social standards (Lipson, 1994). Therefore, the identities of the participants were kept private in the presentation and discussion of the findings, as all participants were referred to as 'academic 1 - 42'.

Result and Discussion

System affordance for ERM

The three key systems of a CODeL institution for ERM are MyUnisa, which is integrated with Moodle, institutional repositories, and library guides. These systems make it easier to adopt OER at a CODeL university. Academics rely on the current LMS (myUnisa) to use OER. Some academics have demonstrated their dependence on myUnisa because it is the official system used by the CODeL institution. They decided to continue using the current institutional system because it appeared to meet their tuition and research goals, and because the LMS and library systems were already in place and could handle OER. Some academics said that they liked myUnisa because of its simple graphical user interface, which enabled quick engagement and participation. They also praised myUnisa for its adaptability and familiarity, which allows student interaction and the ability to embed a variety of media modalities relevant to teaching and learning.

'I think MyUnisa is the key to any academic right, and our students have been aligned with MyUnisa so directly that there are no other systems that I am using other than MyUnisa' (Academic 6).

Other academics expressed their reliance on the current system due to institutional policy, which allows and requires it. This is in addition to myUnisa's utility, familiarity, and usability. Some argue that using additional systems is unethical because they must follow the institutional role policy.

'We are not allowed to use other systems such as YouTube and others' (Academic 15).

However, some professors agreed that, despite its shortcomings, myUnisa allows them to manage OER, communicate and teach their students. MyUnisa provides all the necessary teaching aids, however, larger files cannot be shared. MyUnisa has several limitations because it can only upload 10 megabytes at a time. If OER audio and video files are uploaded, the process may take longer to complete.

Some professors created OER, which were then stored in the institutional repository. They believed that library locations would be beneficial in promoting OER. According to the librarian, the academic library served as the administrative hub of its institutional repository, which housed all the data generated by the institution. The primary goal of the institutional repository was to store, mamaged and disseminate the institution's intellectual output to the world for the benefit of other academics and learners. Although the institutional repository provides some benefits, creating resources and saving them takes time. The CODeL institution has designated space for the OER created by its professors.

I will probably put it in the OER... UNISA has now got an OER repository through the library, so I will put it there (Academic 36).

IoT Applications

Some academics have gone so far as to develop original programmes that can be used with the smart devices that many students own. These devices were called "cell phones" and "tablets." Academics are encouraged to use specialised mobile apps, podcasts, and other venues to make open educational resources (OER) more accessible. Because many academics and students have access to or own smartphones, all of the aforementioned platforms or apps are easily accessible via smartphones. Because they can be used anywhere, including trains, restaurants, and gyms, academics prefer these applications and technologies because they are more convenient for their students. As a result, they do not always require a workstation desktop; instead, they need a smartphone or laptop to work on OER. They also suggested that file sizes and types should be kept to a minimum and be more appropriate for OER. Some academics also advocated the use of website builder software to create distinct web platforms.

'I developed a mobile app for practical teaching skills, so it is already there, I have the resources on it now' (Academic 22).

Academics perceived that organisations create shared platforms with OER-specific content organised by schools, colleges, departments, and subject-specific regions. In addition to online platforms, they recommended the need for relevant or suitable systems and application software that are compatible with OER. Academics believe that OER platforms should support all OER related to research and community participation. Academics suggested that when dealing with OER, colleges should consider artificial intelligence. Academics advised using machine learning to help create, accept, and spread OER due to the introduction of the fourth industrial revolution. They believed that investing in robotics for OER would help institutions accelerate the process once they started. When looking for an OER, academics believe that artificial intelligence is sometimes more accurate than human contact.

'If we integrate robotics, into the facilitation of OER... I mean that robotics can help you, they can talk to you, they can engage with you, they can lead you to the information you are looking for' (Academic 40).

The IoT allows social networks for tuition.

The Internet of Things (IoT) promotes the use of social networks in education due to their utility, practicality, features, and ease of uploading and saving content; social networks were their preferred option. The academics selected LinkedIn, Facebook, WhatsApp, YouTube, blogs, and ResearchGate. Facebook is becoming increasingly popular for open educational resources, as evidenced by the large number of academics who use it for work. Academics chose social media to support OER because it is less expensive and more widely available than other software. Others considered podcasting platforms that allowed them to create audio lessons about the topics covered in their modules. They believed that audio podcasts offered students a simple way to obtain OER. Some facilitated the creation of numerous brief instructional topics for the modules or subjects they teach.

Academics perceive social media platforms to be easy to use and accessible to students with smartphones. Some academics agreed that there is no need for social media seminars or training because anyone, regardless of their educational background, can explore and learn for themselves. Academics have added that the aforementioned social networks are well known and fashionable, particularly in the context of South Africa. Social media is regarded critical in the use, diffusion, and promotion of OER due to their easily recognisable interfaces and the minimal effort required for posting and downloading OER content. According to its list of institutional criteria, the CODeL policy also includes the use of social media as a requirement for teaching and learning. The institutional policy confirms the official CODeL use of social networks.

ODeL [institution] *will make effective use of educational and social technologies in learning programmes in appropriate and innovative ways that improve the quality of teaching and learning* (Policy 2).

Academics have praised Microsoft Teams as a fantastic instant chat-based interactive tool that allows document sharing, online meetings, and live lessons with students without any physical interaction. They claimed that Microsoft Teams can create OER that can be shared with students, teachers, and the general public before being rebuilt. Academics said that Microsoft teams helped maintain social distance because they were able to instruct and manage their students during the difficult moments of COVID-19. They claim that by using this platform you will be able to conduct meetings in the comfort of your own home, office, street, or any other suitable location while experiencing the atmosphere of a real lecture hall. Academics praised Microsoft Teams for allowing them to complete daily tasks, such as holding meetings with their organisations, seminars, and academic conferences in addition to assisting them with their coursework. Some professors recommended Zoom as an alternative to Microsoft Teams for OER because it allowed them to join the entire class at a predetermined time. This enabled academics to encourage participation among distant learners. They praised it because it allowed them to record meetings and later distribute them as payment for student support and tuition.

'...so I think that Zoom and Microsoft Teams currently have these platforms to generate OER' (Academic 13).

OER in Google Scholar, where researchers present their work. They made the decision to do so that other academics could see what they have accomplished in terms of OER and cite them. Some people are inspired by their work as academics, who are concerned with disseminating ideas and making them available to the general public.

'Google Scholar for finding your work, people who read journal articles, but from that we talked about it with friends with groups without community engagement groups just talk up' (Academic 18).

YouTube was used by academics to access and share open educational resources. They also stated that students prefer to access OER on YouTube because of its usefulness and user-friendliness. They recommended YouTube because, in addition to their students, it has a large audience. YouTube is praised as a useful platform for OER because it promotes open access. Academics have also praised YouTube for its simplicity related to OER, owing to the lack of registration or subscription requirements. They advocated for open access and scholarly research and considered YouTube to be truly open. Although YouTube has been praised before, some academics believe that the CODeL institution is opposed to academics uploading instructional content to YouTube because doing so would violate the university's copyrights and intellectual property.

IoT Storage devices

Academics stored and retrieved OER using both on-line and physical storage devices. Academics have lauded these storage devices as reliable locations for storing and disseminating OER in CODeL institutions. Academics have recommended secondary storage devices such as Google Drive, iCloud, and OneDrive as the best online storage platform for sharing all educational resources based on subject or content. The academics stated that they could send files and documents to their students on-line drives at any time and from any location. Others relied on digital storage devices, which allowed them to instruct students and a large group of stakeholders. They praised these platforms, especially given COVID-19's global impact.

Discussion

IoT Possibilities, it is positively perceived for educational resources management in a CODEL domain. The IoT has opportunities to manage share, create, and disseminate OER so that academics can use them for teaching and learning. This indicates that academics and researchers in a CODEL domain recognise the impact of ICTs on teaching and learning methods, approaches, and strategies. Adoption, diffusion, and sustained use of ICTs in teaching and learning are highly dependent on the user's attitudes and positive perceptions (Kalimullina, et al., 2021; Osei, Kwateng & Boateng, 2022). Academics in CODEL have a positive attitude toward teaching using OER and IoT; however, academics cannot physically contact their students for tuition purposes; the university is focussing on technology to improve teaching and learning (Sevnarayan, 2022). This university has developed a centralised learning management system (LMS) called myUnisa to bridge the geographical divide between students, academics and the university itself (Mncube, Dube, & Ngulube, 2017; Nsamba, 2019). Online university such as ODEL has great opportunities when IoT is embraced.

The findings revealed that existing institutional LMSs such as the institutional repository and library guide are in sync because they are all integrated in myUnisa. Academic libraries play a crucial role in the advancement of OER for teaching and learning. Integration of systems and technology has the potential to improve e-learning (Azenezi, 2023; Bekturdiyev, 2023). This indicates that a CODEL domain's reliance on IoT affordance in OER implementation is successful. However, there are some inconsistencies regarding the limitations of data upload to myUnisa. The identification of MyUnisa as a standalone system is not one of the characteristics of the IoT. The IoT can be used to provide more storage space for data. Academics have recently expressed dissatisfaction with the limited space of the institutional LMS. This is an indication of a lack of an integrated system. IoT is better defined as the integration of devices, cloud storage, and LMS technologies for resource convergence, sharing, and storing for improved network services (Kalimullina, et al., 2021). Different points of view and opinions indicate that CODEL has not fully defined the current integration of IoT, OER, and LMS in collaboration with SGD 2030. They argue that higher education institutions should work to advance IoT and 4IR for tuition (SGD, 2030). The literature also confirms that business enterprise systems can help to standardise and improve an organisation's internal processes (Kouzari, Sotiriadis & Stamelos 2023).

Proposition 1: South African higher education institutions, including the CODEL institution, require the articulation and realignment of an IoT-driven business enterprise system for the implementation of educational resources management for teaching and learning.

A CODEL institution has recognised the IoT benefit for ERM. When implementing OER, academics rely on a variety of IoT technologies and applications. IoT can play an important role in facilitation, assessment, and feedback systems, examination, smart teaching environments, and interactive teaching tools in teaching and learning (Haque et al., 2023). The IoT has the potential to significantly improve learning opportunities while also helping academics' day-to-day work, university administration, and the provision of remote learning as one of the disruptive technologies (Zeeshan, Hämäläinen & Neittaanmäki, 2022). Academics in a CODEL institution have relied on IoT devices such as application software, social media, and storage devices. This is consistent with Haque et al. (2023), who argue that all education systems must be IoT-based and IoT-architected to improve distance learning programmes and increase efficiency without interfering with academic activities.

This indicates that the current context is progressing with IoT devices for OER implementation. The implementation of IoT services for learning activities has piqued the interest of the higher education sector (Alhasan, Hussein, Audah, Al-Sharaa, Ibrahim, & Mahmoud, 2023). Because the IoT has the potential to change business models, organisational structures, teaching, innovation, administration, access, openness, society, and research, it is now driving transformations that go far beyond internal process optimisation (Alenezi, 2023). With the advent of IoT, the implementation of OER is no longer an internal entity because it must be accessible globally as part of open access and collaboration.

Furthermore, the variety of technologies used by academics in a CODEL was very innovative, with some developing IoT-driven applications for OER. Furthermore, academics suggested artificial intelligence as a better tool for OER implementation, but none of them developed AI for OER. Several leading organisations have specifically focused on the use of AI technology to unleash the power of open educational practices in this context (Tlili, Burgos, & Looi, 2022). Since the United Nations Educational, Scientific and Cultural Organisation (UNESCO) (2019) organised a workshop on combining OER and AI for better learning practices. Some researchers have begun to investigate AI, realising that it has the potential to improve teaching and learning experiences based on open educational practice (OEP) (Tlili et al., 2021).

For example, Zhang et al. (2021) state that to help students learn about AI, they combined an open e-book with Jupyter, an open source web-based interactive development environment that can support a wide range of processes in data science, scientific computing, and machine learning. Adoption of AI adoption has not been explored or developed in a CODEL institution. To map all of these resources together and build OER recommender systems, sophisticated machine learning and natural language processing techniques can be used to analyse the generated metadata of published OER (Tlili, et al., 2022).

Proposition 2: In an IoT-driven context such as CODEL, where educational resources management are implemented, there is a motive for academics and institutions to develop an AI or interactive robot for creating and locating OER.

Conclusion

The objective of this study was to determine the perceptions of academics of the benefits of IoT in the implementation of ERM in a CODEL. In this study, the technology advantage model was used to gain insight. Choosing this theory allowed for the identification of LMS and IT technologies used by academics in a CODEL. As a research methodology, the Affordance Theory was applied following the qualitative approach. According to the study, CODEL is an IoT-driven institution. However, some inconsistencies were discovered in which institutional systems were not always integrated with the IoT. Academics, for example, have pointed out that the most commonly used LMS does not allow the upload of OER or any other teaching material with greater capacity. The maximum amount it can handle is 10 megabytes. This was found to be the primary antithesis of IoT characteristics because IoT encourages the integration and collaborative approach of sharing resources in shared spaces. The issue of space and data handling capacity is not specified in IoT-driven infrastructure. According to the findings of this study, academics and CODEL institutions should consider realigning their business enterprise systems and IoT infrastructure to meet the needs of the OER for tuition. The study recommends strategies for improving LMS functionality and encouraging the adoption of AI-driven tools that can enhance the teaching and learning. This study paves the way for future research to explore the IoT enablement for the appropriation of OER in all South African universities.

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