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Internet of Things facilitates e-learning

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Past scholars highlighted the dissatisfactions of learning in traditional teachings which is a vital concern for the Higher Education Institutions (HEIs). This is especially due to the numerous concerns of scholars pertaining to the declining teaching learning quality. This study reviewed literature to explore what role Internet of Things (IoT) and students' Learning Style (LS) has on learner expectations, through the Learning Outcomes (LOs) of HE students. Though this stage is a research in progress, instructors can improve curriculums using complimentary LS and LOs through the help of IoT, after reading the reviews of literature portrayed in this article. And, HE instructors can extend their reach to students via the e-learning environments as the model for this study was examined within the e-learning context. This was to confirm that IoT and LS do facilitate the achieving of LOs through an interdisciplinary model proposed in this paper. Implications to theory and practice are also expressed.

Key words: *Higher education, Internet of Things, Learning outcomes, Learning styles, e-learning.*

Introduction

Higher Education Institutions (HEIs) suffer from declining quality in Teaching and Learning (T&L) particularly due to poor curriculum design as indicated in student surveys (Akalu, 2016; Harrison & Risler, 2015; Subbiondo, 2013). Though some researchers identify some remedial measures, they point out that more should be done to address sustainability and delivery of HEIs quality (Lu et al. 2017; Fiselier et al. 2018). An essential literature gap for addressing this issue is to improve HEI T&L quality.

Scholars have identified various factors like Learning Outcomes (LOs) and Learning Style (LS) in multinational HEIs context can enhance T&L quality (Caspersen et al. 2017; Hill, 2012). However, the nature of the relation between these factors and T&L quality is poorly understood; implying that investigating such factors can help arrest the declining HEI T&L quality. With the prevalence of the use of technology in the T&L activities, several technology-related factors can also have been heavily researched in this context. Internet of Things (IoT) have emerged as a strong contender to integrate in T&L activities (Davalos et al., 2016).

One area that attracted researchers and practitioners are LOs given their high potential to reverse the decline in HEI T&L quality while another is understanding the role of IoT within all this phenomenon (Farhan et al., 2018). Moreover, researchers argue that the relation between IoT, LSs and LOs, for improving T&L quality, is under researched with contradicting current knowledge underpinned by lacking consensus (Farhan et al., 2018; Caspersen et al. 2017; Hill, 2012). Such a holistic integration of IoT, LSs and LOs can deepen the under researched understanding of LOs for solving the declining HEI T&L quality.

Moreover, a lack of consensus and contradictions amongst researchers pertains to factors affecting LOs and HEI T&L quality providing an uncertain and inconclusive knowledge (Huang et al. 2018). For instance, literature reveals that some contributing factors in enhancing T&L quality, other than LOs and in addition to IoTs, are teaching methodology, faculty development, learning strategies, self-efficacy, learner and instructor interaction. From the perspective of IoT, this is not surprising since education sector tends to be slow at adopting information and communication technologies (Sultana & Haque, 2018; Huang et al. 2018; Reich et al. 2016; Canfield et al. 2015; Tong et al. 2015; Caspersen et al. 2017; Hill, 2012). However, limited literature was found on how and to what extent those factors affect LOs and hence T&L quality, or if these factors can reliably predict how HEIs deliver better T&L quality.

This research studies the relation between students' perceived use of IoT, and its effect on LS and LOs. Such a model is motivated by the concerns of the past scholars who report that HEIs' LOs generally do not account for LS. Furthermore, since IoT is considered by scholars as in its blossoming stage, everyone is trying to define this field as per their own interpreted vision. In doing so there are now many field terms including web of everything, (WoT), Cloud of Things (CoT), Internet of Everything (IoE) and Machine to Machine (M2M). IoT already faces several challenges pertaining to its interoperability, scalability, efficiency, storage, availability, and security (Čolaković & Hadžialićb, 2018; Jesus, 2018; Mircea et al., 2017; Miraz et al., 2015). This is not surprising since from a theoretical perspective, LOs are weakly grounded on established theories, thus applying current knowledge into practice is questionable (Rajaram & Bordia, 2013). Furthermore, the literature expresses no comprehensive explanations to link curriculums LO, on the one hand, with students perceived use of IoT and LS, on the other. Using currently available theories (hence any new knowledge linking LOs and LS) can shed insight on HEI T&L quality.

Literature Review

Effect of IoT on LSs, and LOs via e-learning

By 2022, it is forecasted that 29 billion devices will be connected and 18 billion of these devices will be IoT. Costing around 263 billion USD, these devices will get connected on the internet to enable the analysis of data for artificial intelligent decision-making (Ericsson, 2019; Gartner, 2014) and to connect smart technologies (devices) anytime and anywhere (Ashton, 2009). In an IoT environment various processes will be integrated to add value to services by grouping various IoT applications to support domains like healthcare, traffic, retail, etc. Still, IoT is considered by scholars in its blossoming stage since everyone is trying to define this field as per their own interpreted vision; making this field terms also as web of everything, though such Web of technology (WoT), Cloud of Things (CoT), Internet of Everything (IoE), or Machine to Machine (M2M); already faces several challenges pertaining to its interoperability, scalability, efficiency, storage, availability, and security (Čolaković & Hadžialićb, 2018; Jesus, 2018; Mircea et al., 2017; Miraz et al., 2015).

Within our evolving society people feel the need for knowledge and learning through their cognitive and social skills by integrating both personally and professionally through their familiar social and interaction ties (Razzaque et al., 2013; Sambo & Lucky 2016). This is possible using technologies like knowledge management tools (e.g., virtual communities) (Razzaque & Eldabi, 2018), which is one success story of a technology since the technological revolution of the 1990s went live with the World Wide Web (Budd, 2019). It was not long before the adoption of such technologies became manifested within the education sector even though there are scholars who consider the education sector to be slow at adopting information and communication technologies (Sultana & Haque, 2018). The most important development within the education sector is the ability for individuals to choose to accept the adoption of any technological application. Changes only occur when most of the individuals accept to adopt a technology like e-learning solutions which are successful when facilitated by intelligent system. These are based on the standards of quality teaching blended with ICT for achieving a ubiquitous learning experience. This occurs when IoT and cloud computing, also known as cloud learning in education research, assimilate mutually benefiting intelligent systems and form smart learning. This is usually furnished as a Smart Education as a Service (SEaaS) which is a concept still under scholarly debate (Razzaque, 2019; Stoica, et al., 2018; Sánchez, et al., 2016).

Technological developments are impacting on the 21st century economic, political, cultural, and social changes (Bodura et al., 2019). In the 1990s Kevin Ashton, who was one of the developers of the Radio Frequency Identification (RFID) community, introduced the concept of IoT and practicalized it with increasing mobile phones extended with sensors (i.e., things that reside virtually to collect and process information through cloud computing and data analytics for decision making). Internet of Things connects various smart objects since it enables objects (devices / things) that were not meant to talk to each other interact smartly (Ashton, 2009). Since the 1990s several scholars have expressed interest in the application of IoT within the education sector (Magrabi et al., 2018; Mershad & Wakim, 2018; Shyr et al., 2018; Tan et al., 2018; Burd et al., 2017; Bagheri & Movahed, 2016). Such research is essential considering that the deployment IoT is foreseen to generate 300 billion USD through 26 billion IoT devices on the Internet by 2020 which will end up surpassing the total population on Earth (Ager, 2019; Elyamany & AlKhairi, 2015).

In the education sector, the use of IoT has shown prosperous practical implications from the prism of its influential connectivity for educating learners. Additionally it will enable instructors to improve their teaching methods via a blended T&L infrastructure (Elyamany & AlKhairi, 2015). This is possible through the use of sensors (e.g., Super Mechanical's Twine7 like ubiquitous objects in HEIs) (Cisco Consulting Services and Cisco EMEAR Education Team, 2013). The adoption of IoT is also quicker for instructors and learners since IoT by both HEI stakeholders is an attractive concept (Chin & Callaghan, 2013). For instance, in the English language curricula, IoT is interfaced with learners by their LSs achieved through visual and audio sensors which correct the pronunciations (Chin & Callaghan, 2013). Another example is the aligning of IoT with learning strategies within the program language curricula through wireless sensor networks that are interfaced with cloud computing and data mining. Learners can analytically learn while they tap into the educational resources of their intelligent/digital campuses (Davalos et al., 2016; Cheng & Liao, 2012; Wang, 2010). Cheng and Liao provide an excellent analysis when differentiating intelligence from a digital HEI campus through the application of cloud computing and IoT such as smartboards, tablets, smart phones, e-books, attention trackers. Together, this is integrated with scored face detection via the learner monitoring through video camera system for tracking for tracking learner connection/s or interaction/s with their instructor and learning management systems like ILIAS, Sakkai, or Moodle (Abdel-Basset et al., 2018; Farhan et al., 2018; Malik et al., 2015).

From our experience and observation, instructors are involved in various decisions when they refine their curriculums to suit students' needs for achieving learning outcomes by assuming appropriate learning styles. Decisions are based on choices that lead to cascading actions. Here, a Decision Support System (DSS), (i.e., computerized algorithm driven by analyzed data from various sources), supports decision-making (Sauter, 2014). The term data here is a composition of its two time-periods. Initially it was referred as internal data, residing in database/s and understood in structure format (i.e., in the form of specialized reports) and during the second period the same data has been termed as "big data". This is when new approaches, like Instructive Information Mining (IIM) and e-learning assessment tools for understanding learners LS and formulating an environment for instructors to work out how to accordingly improve learning materials to reach the desired Los. (Sallis et al., 2016; Garrick & Pende, 2014; Hess & Saxberg, 2014; Sauter, 2014; Arenas-Gaitán et al., 2011). Within the T&L context, IoT value adds given its human-centric and smart environment. It does so by smartening up the surrounding environments by personalizing learning via personalized hybrid learning methods (blending of formal and information learning activities outside classrooms: e.g., learning through gaming) and through an arrangement of IoT devices referred to as "*ubiquitous computing*," and "*smart learning*" (Patel & Patel, 2016; Abualkishik & Omar, 2013). Previous research has indicated the importance of IoT on learning. Scholars have identified how motivation and learner experience are important factors for students to participant in e-learning environments (Hess & Saxberg, 2014; Krause et al., 2014).

· P1: IoT plays a positively significant role on LSs.
· P2: IoT plays a positively significant role in LOs.

Effect of LS on LOs

LOs is recognized in HEIs for efficient and effective coursework quality, through student-centralized teaching statements outlining learner-expected knowledge / skills (Havnes and Prøitz, 2016). Accreditation agencies assure such evidenced-assessment tools, like grades for curriculum development (Michelsen et al. 2017; Prøitz et al. 2017; Davis, 2016; Reich et al. 2016; Canfield et al. 2015). LOs is demanded in research, and by employees expecting social, critical thinking, and soft skills from graduates (Caspersen, et al. 2017; Reich, et al., 2016; Fatmi et al. 2013; Hill, 2012; Ogundokun, 2011; Osters & Tiu, 2012). Havnes and Prøitz (2016) are one of few reporting LOs shortcomings, testifying that the two-fold LOs implementation (i.e. managerial quality assurance and course designing for T&L) harvests multiple LOs meanings, at different HEI levels. Therefore, curriculum designers are sceptical of LOs since their meanings vary at a cognitive, socio-cultural, and behavioural perspective of T&L. Limited research articulated a mutual understanding of LOs from T&L perspectives and therefore calls for a thorough investigation in Los. Given the meaning of LOs varies across geographical regions, making such investigation is vital as HEIs are currently realizing a high intake of international students (Jacob & Gokbel, 2018; James-MacEachern & Yun, 2017).

Furthermore, the limited quantitative research better understands how LSs predict LOs for better curriculum design as many scholars have contributed new theories and applicable models (Moylan & Razzaque, 2015; Strang, 2010). From 1970s, LSs research first expressed the Kolb's Model of Experiential Learning (KMEL) which includes concrete experience, reflective experience, abstract conceptualization and active experimentation (Knoll, et al. 2016; DiBartola, et al. 2001; McLeod, 2013). This model investigates LSs although it is criticized for theoretical problems as Kolb rejected the notion that LS depended on objective measures and LOs. To optimize LOs, a learner should know their preferred LS (Heffler, 2010). A weak underpinning of the KMEL instrument's research methodologies highlight statistical problems, making it invalid (Koob & Funk, 2002; Henson & Hwang, 2002). Later, Honey's and Lobley's (1986) LS theory was adapted by Charlesworth's (2008) who quantitatively assessed LSs on Chinese, Indonesian and French HE students. This was to understand the importance of their cultural backgrounds since classrooms function differently in different cultures. Charlesworth's LS model, adapted from Honey's and Lobley, was four-dimensional: theorist, activist, reflector and pragmatist. Charlesworth's findings were aligned with Honey and Lobley. That is, activist learners flourish when challenged with new experiences, but uninterested in implementing such experiences. Reflector learners on the other hand, stand back and listen to consider all possibilities before concluding, while pragmatist learners deliberately analyze and search new ideas. They dissect and reassemble problems while applying their new learnt ideas. Theorist learners keenly learn theories, thus detached analytically and cannot appreciate ambiguous experiences (Kappe, et al. 2009; Charlesworth, 2008; Honey & Lobley, 1986). A strong link resonates between LS and LOs since learning occurs in four stages. In each stage, every LS plays a vital role. The first stage is gaining experience, appreciated by activist learners. The second is reviewing experience, appreciated by reflector learners. The third stage is concluding an experience, appreciated by theorist learners. The fourth is the planning stage; appreciated by pragmatist learners (Goldfinch & Hughes, 2007).

LOs are cognitive traits of learning performance by absorbing knowledge. To optimize HE quality, instructors should design curriculum with clear LSs customized to what is being studied (Ogundokun, 2011) since teaching styles interact with students' preferred LS. Curriculum designing can incorporate student preferred learning approaches or use complementary LSs to improve learners' weak LS/s or apply a wide range of LSs catering for all students (Yu et al. 2010). The literature reported four LSs: active/reflective, sensing/intuitive, visual/verbal and sequential/global. Active learners solve problems while reflective learners loiter thinking and learning. Sensemaking learners memorize to comprehend. Intuitive learners mathematically solve problems. Visual learners learn through diagrams while verbal learners learn through interpretations. Sequential learners' micro-understand before comprehending the big picture. Global learners learn from a holistic sense for problem solving (Yu et al. 2010; Ogundokun, 2011; Yousef, 2016; Knoll et al. 2016).

Holt, et al. (1974) is one of first few scholars expressing the importance of LS for LOs.

Various scholars express contradicting results towards this role. McCann (2006)'s quantitative assessed LS on students' performance (LOs) in face-to-face interaction, e-learning with minimal instructor interaction and e-learning with high instructor interaction; evidenced that students score higher in face-to-face-classrooms and e-learning environments with high instructor interactions; indirectly indicating a strong affiliation between LS and LOs. Lu et al. (2007) assessed the role of Kolb's LS Inventory (KLSI) on (1) endured time-on-e-learning behaviour (ELB), (2) KLSI on LO and (3) LO and ELB by experimenting with forty undergrad students, revealing: (1) no significance between KLSI and ELB, (2) no significant between LS and LO and (3) significance between LO and ELB. Ogundokun, (2011) also assessed the role of LS, school environment, and test anxiety, on LOs by surveying 300 senior secondary school students, revealing all significant relations.

Further, Liew et al. (2015) assessed LS on LO by (1) identifying LS of preclinical undergrads and (2) assessed the role of learning preference (LSs and learning approaches) on performance (LOs) via 419 international preclinical undergrad surveyed participants from a Kuala Lumpur university. This study revealed that majority of learners preferred unimodal LS, and minority-preferred multimodal LS. It also found no relation between LS and LOs. The best definition of LS, driven from Kappe et al. (2009) and Charlesworth (2008), categorizes LS in four categories: theorist, activist, reflector and pragmatist LS. Students with activist LS enjoy challenges while enjoying new experiences. Such socially inclined students enjoy experiences, though bored when implementing them. Students with reflector LS act slowly, since they observe processes and predict outcomes while learning. Pragmatists are deliberate and analytic since they are practical and down to earth; enjoy dissecting/reassembling problems though disliking deep learning. Although Charlesworth reported that Chinese students were more inclined towards the theorist LS, the quantitative analysis on Indonesian, Chinese and French students expressed significance of theorist LS. This confirms that theorist dimension deserves no recognition in this research. Additionally, Charlesworth's LS instrument needs empirical retesting to reassess its influence on LOs in HE multicultural-classrooms context since scholars reflect contradicting effects of LS on LO with minimal understanding of the role of LS on LO. Accordingly, the three propositions, P3, P4, and P5: (Figure 1) are:

· P3: Activist students LS plays a positively significant role on LOs.
· P4: Reflector students LS plays a positively significant role on LOs.
· P5: Pragmatic Students LS plays a positively significant role on LOs.

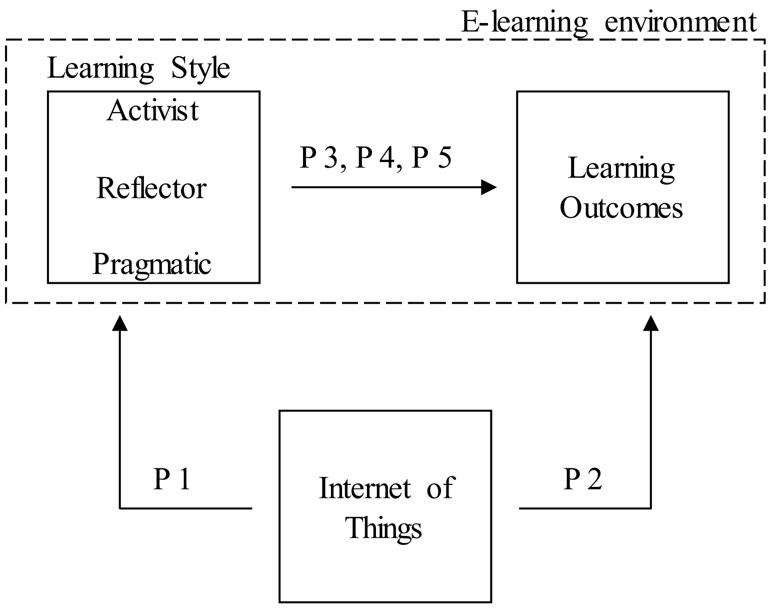

Figure 1. Research Model

As depicted in Figure 1's conceptual model with five propositions, the holistic integration of IoT, LSs and LOs is inspired through the e-learning initiatives undertaken by the private and public HEIs of the Kingdom of Bahrain. Instructors aligned T&L with students' IoT realize they receive higher scores in student evaluations.

Discussion and Conclusion

The aim of this literature review study is to comprehend what perceived benefits could IoT pose on an e-learning environment so that instructors and learners will be aided for improving their LSs to better achieve their LOs. There is a theoretical implication pertaining to this research. As shoen in Figure 1, holistic integration of IoT, LSs and LOs deepens the under-researched understanding of LOs for solving the declining HEI T&L quality. Hence it addresses the lack of consensus and contradictions amongst researchers pertaining to factors affecting LOs and HEI T&L quality and an uncertain and inconclusive knowledge (Huang et al. 2018). Our research adds value to knowledge towards the education sector since this sector was reported as slow at adopting ICT (Sultana & Haque, 2018; Huang et al. 2018; Reich et al. 2016; Canfield et al. 2015; Tong et al. 2015; Caspersen et al. 2017; Hill, 2012) and scant research understood the extent to which IoT affects LOs and hence T&L quality through LOs. This research studies the relation between students' perceived use of IoT and its effect on LS and Los. It was motivated to address the empirically unassessed claim of past scholarly stating that LOs do not account for LS (Čolaković & Hadžialićb, 2018; Jesus, 2018; Mircea et al., 2017; Miraz et al., 2015) and should require empirical evidencing. This scarcity is also felt across mature and emergent technologies supporting LS and LOs such as cloud computing, where the focus is mainly on the research of the application of cloud computing in e-learning environments (El Mhouti et al., 2018).

Furthermore, there is a practical implication of the Figure 1 model. If this model is empirically assessed, within a HEI context, instructors will have a motivating confirmation of how important IoT is when it comes to facilitating LS and LOs. Instructors will be able to comfortably adopt IoT to enhance their curricula which in turn will be more individualized to learners than simply being customized to the whole course. The same advantage also goes for LOs which will not only be centered to a course but individually to each learner. The main limitation that we discovered was from our thorough literature review. There is scant literature which even discusses the effect of IoT on e-learning environment, let alone the effect of IoT on LS and LOs. Future research could empirically assess the Figure 1 model cross-sectionally and longitudinally, and the target population should be learners and instructors to attain a holistic comprehension of how this model can facilitate the improvement of the T&L quality.

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