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Research paper

CDIO and the Engineering of Personalised Learning Environment: An Exploration

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Abstract

One of the fourteen grand challenges for engineering in this century, as identified by the National Academy of Engineers (USA) in 2008, is the advancement of personalised learning. The relevance of creating personalised learning in the context of Malaysian higher education can be inferred among the ten shifts stated in the Malaysian Education Blueprint 2015–2025 (Higher Education), which feature key elements towards spurring excellence in the nation's higher education. This research investigates the spaces and opportunities available in a Personalized Learning Environment (PLE) for enhancing learners' soft skills beyond course content. How is this policy transferred into practice? Specifically, how can educators use technology to engineer a holistic personalised learning experience? In the context of 21st century education, how can we ensure that learners' soft skills are given due attention in the PLE? Using key concepts in engineering education, primarily Conceive-Develop-Implement-Operate (CDIO), and the fundamentals of disruptive innovation, this study illustrates the engineering process adopted to design and implement a PLE in the humanities. As findings illustrate, comprehensive PLE management creates opportunities for enhanced learner autonomy and leadership development while ensuring that the educator's roles continue to be relevant and evident.

Keywords: *active learning, CDIO; disruptive innovation, meaningful learning, Personalized Learning Environment (PLE).*

1. Introduction

One of the fourteen grand challenges for engineering in this century, as identified by the National Academy of Engineers (USA) in 2008, is the advancement of personalised learning [1]. This challenge aims to address the issue of learner and learning diversity in the age of information. Yet, in the current technologically advanced age of digital literacy and hyper-connectivity, is developing personalised learning still relevant? Has this challenge not been addressed thus far?

Personalised Learning Environment (thereafter, PLE) is synonymous with 21st century learning, where cutting-edge technology meets self-directed learning seamlessly to provide a space for individuals to develop knowledge and skills at a customised pace and rate. As the role of teachers continuously oscillate in this fluid environment from knowledge provider to content curator, the focus on the learner and learning continues to drive a successful PLE. Nonetheless, another area of concern that PLE needs to address is the development of human skills to help individuals match the singularity of machine advancement in the 21st century [2]. The true potential of 21st century learners is about not what they know and how much they understand of any given topic so much as how well they can relate and connect with other learners to promote human skills such as social sensitivity, empathy and social relations [2]. This work investigates the spaces and opportunities available in a PLE to enhance these soft skills.

In the context of Malaysian higher education, the relevance of developing personalised learning can be inferred amongst the ten shifts identified in the Malaysian Education Blueprint 2015–2025 (Higher Education), which feature key elements towards spurring excellence in the nation's higher education. From exploring a globalised online ecosystem to establishing the National e-Learning Centre, which is meant to 'spearhead the e-content development, coordination, monitoring as well as strengthening international linkages', the National Education Blueprint prioritises the learner and the learning process in the current global digital landscape [3].

Yet, as much as engineers are challenged with the advancement of personalised learning and the National Education Blueprint champions the importance of technology in higher education, educators and learners, irrespective of field of study, remain the key players in the learning process. How do educators use technology to engineer a personalised learning experience? How can we ensure that learners' soft skills are given due attention in the development of PLE? To facilitate this discussion, we used key concepts of the engineering edu-

cation framework, primarily Conceive-Develop-Implement-Operate (CDIO), as discussed by engineering educators and scholars, to illustrate the engineering process implemented in developing a PLE in the humanities.

2. Engineering and the Learning Process

Engineering, as a profession, according to engineering educators, aims to create a systematic application of 'the principles of science and mathematics to Conceive, Design, Implement and Operate (CDIO) products, service, technologies, systems and solutions that improve the quality of life' [4]. The CDIO initiative, which was established in 2000 by the Massachusetts Institute of Technology, Chalmers University of Technology, Linköping University and KTH Royal Institute of Technology, created the necessary vision, goal and pedagogy of engineering education [5]. As a framework for critical thinking, CDIO is systematic and holistic in addressing the predicted effects or consequences of a proposed system while working towards possible solutions.

As an approach, the CDIO process is not sacrosanct to the field of engineering. As Alatabi asserts, CDIO is geared at harnessing a habitual mindset that is critical and organised [4]. Assuming the stance by Crawley et al. of seeing CDIO as the context and not the content of knowledge development [5], the current discussion utilises CDIO to contextualise the discussion of PLE development in a non-engineering course.

The last few years have seen a tremendous transformation in all areas of teaching in higher institutions, including in the field of humanities. Two case studies were conducted between 2013 and 2016 to experiment with the changing ecosystem of learning in humanities. The first case study was conducted in 2013 for an understanding of the transforming needs of the 21st century learners and their learning process in a humanities context [6]. In the case study, the teaching approach was designed around a flipped classroom methodology to blend face-to-face classroom engagement with online learner participation by making the course input and tutorial tasks available prior to class time on the learning management system (thereafter, LMS) [6]. The approach was meant to disrupt the conventional learning process beyond the norms of the 3-hour-per-week class time and the four-walled classroom. In 2015, a second case study was conducted to incorporate a third learning space to the available face-to-face session and online platform [7]. In this case study, learner engagement occurred pre- and post-classroom time using a mobile platform. This approach was implemented to complement the existing flipped classroom approach applied during the 2013 case study [7]. In 2016, another dimension of the LMS was incorporated into the teaching approach using an open online learning platform that made the humanities course available on www.openlearning.com. These case studies illustrate the continuous experimentation with the use of technology to establish learning spaces that can promote active and meaningful learning amongst 21st century learners.

At every juncture of the experiential approaches taken from 2013 to 2016, the primary focus was to incorporate 'disruptive innovation' in 21st century education. Disruptive innovation requires us to reevaluate two fundamentals of higher education, namely, 1) 'to rethink many of the age-old assumptions about higher education – its processes, where it happens and what its goals are' and 2) to 'escape from policies that focus on credit hours and seat time to one that ties progression to competency and mastery' [8]. With disruptive innovation as focus, educators need to rethink the conventional process and focus of teaching at higher education institutions and begin to conceive, design, implement and operate a personalised learning experience for learners using available and relevant technologies. This study explores the disruptive innovation adopted in the two case studies of 2013 and 2015 through the lens of CDIO.

2.1 Conception of a new learning process: Why do we need it?

The core component of disruptive innovation in designing 21st century learners' learning experience is akin to Alatabi's description of engineers' drive for innovation and technological advancement, which is motivated by the desire to better a current condition while bringing to reality a vision of the future [4]. In the two humanities case studies conducted in 2013 and 2015, the focus was to improve the learning experience and facilitate greater opportunity for learner diversity through pedagogical innovations that emphasize 'an intentional action that aims to improve university students' learning in a sustainable manner' [9].

At the conception level of the PLE for the two case studies, the emphasis was the two vital components of conceiving, namely, customer needs and technological possibilities [4]. In the former, the 'customer' represents learners of a generation who, as studies have indicated, exhibit a high level of being technologically driven, socially connected and cognitively self-empowered. As Mohamed Amin Embi stated, Generation Z, i.e. those born after 1996, are defined by their ability to use technology for social change and self-empowerment [10]. These learners are driven to reach their true potential using their digital know-how and social connectivity. Figure 1 shows a hybrid PLE that merges face-to-face, online and mobile learning spaces.

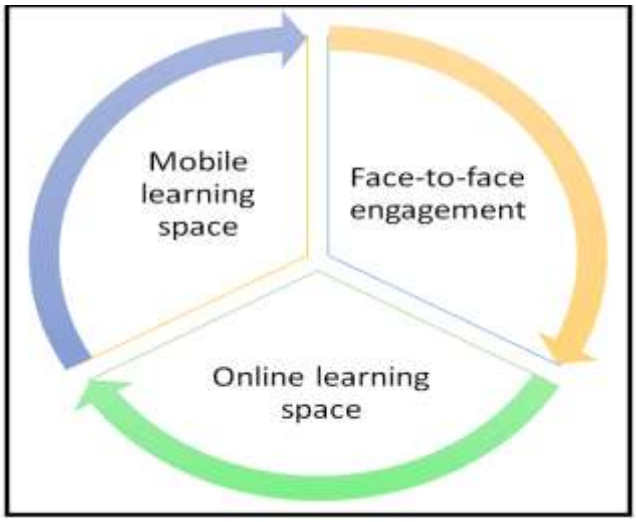

Fig 1: Hybrid PLE

The second component of conceiving, i.e. 'technological possibilities', utilises various technological advancements in the e-learning field [4]. From online and mobile learning platforms to Open Educational Resources (OER) and massive open online courses, technology, as we see it today, continues to lead 21st century learning into a new and exciting dimension. This 'brave new world' sets the stage for anyone to learn anything they want anywhere in the world that has been reached by the technological advancement. As a grand challenge for engineering identified by the National Engineering Association (USA), creating this possibility for the world at large will continue to drive the profession of engineering in this century [1].

On the basis of the available technologies that the learners and teachers were exposed to in the two case studies, a collective learning space was engineered to incorporate the open learning platform and the mobile learning space while retaining the face-to-face classroom engagement. According to the two case studies, a conclusion was drawn that this hybrid PLE allows the educator to begin learner engagement from any of the three available spaces. A more 'disruptive' method would be to begin ice-breaking sessions with learners using either the mobile or online platform. Once engagement begins, the educator may follow up the learning process by considering the other available learning spaces. The continuous design of the learning experience allows for engagement in class, online and on-the-go (See Figure 1.).

2.1 Designing a new learning experience: How should we begin?

Experience gives educators a hindsight perspective of how best to design and structure lessons to ensure the best results beyond the intended learning outcomes. However, the need of educators to remain within their comfort zone sometimes prevents them from exploring uncharted territories, including the use of new technology in the learning process. For example, the convention of teaching and learning has been lecture followed by seminar or tutorial sessions, and this convention has produced results for a long time. Hence, stepping away from this mode and disrupting the learning process with technologies and innovation which educators may not be familiar with become a challenge. These are real and major challenges for 21st century educators trained with 20th century pedagogy and mindset. Assuming an engineering perspective, which sees failure as part of the learning process [4], the two case studies aimed to redesign the students' learning space by making them collaborators in the learning process. Figure 2 shows how educators can promote learner collaboration in PLE.

At the core of the design stage of the PLE, as experimented in the two case studies in 2013 and 2015, is meaningful and active learning. The former is characterised by the leaners' ability to connect new knowledge with relevant existing knowledge [11]. The latter, active learning, emphasizes a student-centric pedagogy that promotes high-order thinking skills in learners as they work towards solving problems connected to the topic being discussed [12]. To create a personalised learning space that promotes meaningful and active learning, the design of the PLE considers three fundamentals. Firstly, every space (including mobile, online and face-to-face spaces) can be utilised to promote intrapersonal and interpersonal engagement and learning. Secondly, every learner plays a dual role of active engagement with course content and tasks and becomes an active member of the class, facilitating interpersonal communication and collaboration. Thirdly, every engagement holds the promise of being meaningful beyond the fulfilment of course objectives as the engagement (between learners, and between learners and the teacher) develops the space for promoting the soft skills of learners (See Figure 2.).

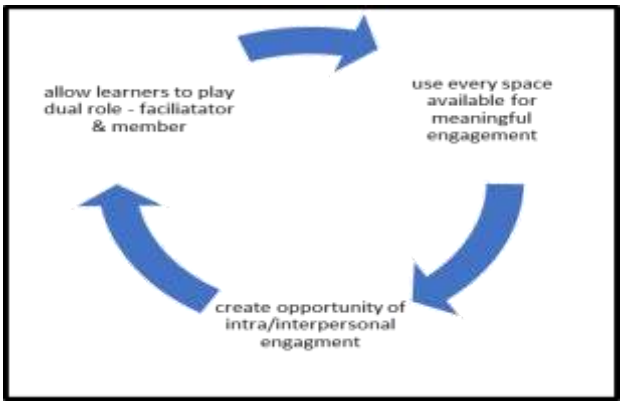

Fig 2: Fundamentals of learner collaboration in PLE design

By making the learners the focus of the design process, the two case studies addressed two issues at once. The first was promoting learning anytime and anywhere, and the second was advancing improved learner well-being to ensure that learning is enjoyable and meaningful while meeting course objectives. Well-being in the learning context appropriates Konu and Rimpela's 'The School Well-being Model'. Meanwhile, the two components of the framework appropriated into the present study are social relationships or interpersonal relationships and means for self-fulfilment or intrapersonal relationships [13]. In designing a PLE, educators need to be mindful in addressing implicit course outcomes (beyond those identified by programs), which concern the development of learners' soft skills, namely, intrapersonal and interpersonal communication skills. These concepts are used as the yardstick in the current work for evaluating learners' well-being upon their experience of a new PLE.

2.3. Implementing and operating a new learning experience: What role do we play?

The third and fourth stages of the CDIO process are implementation and operation, respectively. The former oversees the execution of the design, whereas the latter monitors the functionality and maintenance of the design. Both stages require the management of resources, including learners, time and learning materials. In the implementation and operation of a new learning space, the aspect of management considers a few given components, which include learners' willingness and openness to try the newly designed learning space, and the teacher's role of engaging and encouraging the students' continued participation. Figure 3 shows how the ever-changing roles played by educators and learners are conceptualised.

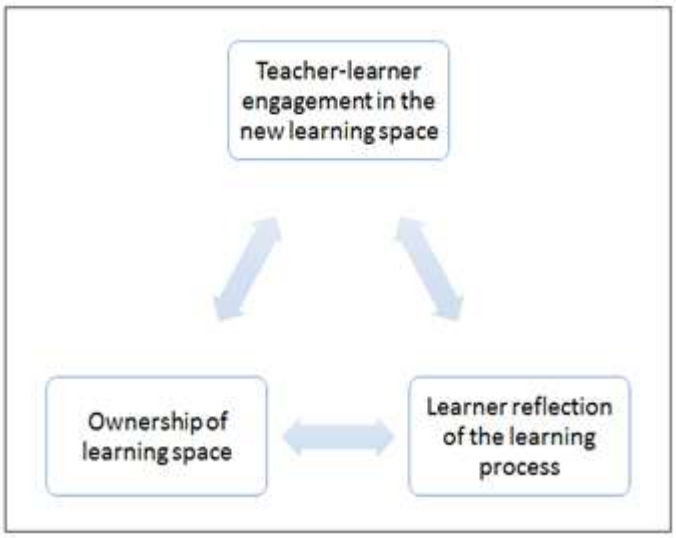

Fig 3: Evolving roles and responsibilities of 21st century learner

According to the two previous case studies of the use of blended learning in generating learner engagement, students are generally highly motivated and inquisitive to learn [7]. They have the passion to explore new ideas and are ready for challenges posed by lecturers, provided that these tests are pitched at a level suited to their interests and abilities. However, one of the conclusions drawn from the two case studies is that as much as technology is a wonderful invention, it does not guarantee meaningful and active learning. Learners still require encouragement to embrace the new learning style of embedding technology into the conventional teaching methodology.

Hence, a key feature of the operation stage is the feedback from learners. As John Dewey famously said, 'We do not learn from experience. We learn from reflecting on experience'. The value of learner reflection in the implementation stage is crucial for the success of the design. Since the two experiential studies about the use of a technology in developing learner engagement were conducted in 2013, numerous insights into how learners perceive learning and social engagement have been reached [7]. These reflections assist educators in understanding how learners view face-to-face interaction and online/mobile engagement.

Furthermore, the value of the new learning space is enhanced when learners take ownership of the process of learning. Albeit designed by the teacher, the learning space belongs to the learners and thus becomes a space in which they actively discover and explore issues raised in their field of study. As studies indicate, successful learning environments are built on the theory that the space 'should support the learner's ownership of the learning process and outcome' [15]. Therefore, the true success of the implementation and operation stages of the design process lies in the continued engagement between the teacher and the learners and in the learners' ability to reflect on the learning process while taking ownership of their learning space.

3. Conclusion

This study discusses the fundamentals of redesigning the learning space at higher education institutes in line with the National Education Blueprint, which emphasizes the importance of technology and global online learning for learner diversity. On the basis of two case studies conducted in 2013 and 2015, this research explores how the CDIO process provides the necessary tools of engagement to engineer the PLE for 21st century learners. As digital natives, our learners are equipped with technological know-how that allows them to explore and discover knowledge beyond the expectations of course objectives. The role of educators is to conceive, design, implement and operate a learning experience that ignites in learners the passion to explore subjects in online and mobile landscapes and during face-to-face sessions in class. Yet, as much as technology is a welcome innovation in the 21st century classroom, the true success of learner engagement and learner well-being is generated through, and not by, technology. With adequate support from lecturers, technology can truly be a means of promoting disruptive innovation. When successfully conceived, designed and implemented, PLE creates opportunities for improved learner autonomy and self-direction while ensuring that the educator's role continues to be relevant and evident.

Acknowledgement

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References

[1] *Blueprint 2015-2025* (Higher Education). Ministry of Education Malaysia. 2015.
[2] Alatabi M (2008). *Think like an Engineer*. Subang Jaya, Selangor, Malaysia. 2014. *Grand Challenges for Engineering.* National Academy of Engineering.
[3] Colvin & Geoff (2015), *Humans are underrated*. New York: Penguin.
[4] *Malaysian Education*
[5] Crawley EF, Malmqvist JS, Ostlund DR, Brodeur & K Edstorm. *Rethinking Engineering Education.* Switzeland: Springer. 2014.
[6] Raihanah MM, Flipped classroom and meaningful learning among UKM graduate students: A Teacher's Reflection pp. 277-295 In *Blended & Flipped Learning: Case Studies in Malaysian HEIs* edited by Mohamed Amin Embi MEIPTA. 2014.
[7] Raihanah MM, One size fits all?: SoTL and flipped learning. In E-learning and interactive lecture: SoTL Case Studies In Malaysian HEI. Edited By Mohamed Amin Embi. Bangi: PPTP, UKM. 2015
[8] Christensen CM, Horn HB, Caldera L & Soares L, *Disrupting college. How Disruptive Innovation Can Deliver Quality and Affordability to Postsecondary Education.* Innosight Institue. 2011.
[9] Walder AM (2014), The Concept of Pedagogical Innovation in Higher Education. *Education Journal*. 3, 195-202.

[10] Mohamed Amin Embi. *Pemikiran dan reka bentuk semula Pengajaran dan Pembelajaran abad ke 21*. Bangi: Penerbit Universiti Kebangsaan Malaysia. 2016.
[11] Novak JD. A theory of education: meaningful learning underlies the constructive integration of thinking, feeling, and acting leading to empowerment for commitment and responsibility. *Meaningful Learning Review*, Vol.2, (2014), pp: 1-14,
[12] Michael J (2006), Where's the evidence that active learning works? *Advances in Physiology Education* 30: 159–167.
[13] Konu A, Alanen E, Lintonen T & Rimpela, M (2002), Factor Structure Of The School Well-Being Model. Health. *Education Research*. 17(6), 732-742
[14] Malmqvist J, Hugo R & Malin K, "A Survey Of Cdio Implementation Globally – Effects On Educational Quality", *Proceedings of the 11th International CDIO Conference*, Chengdu University of Information Technology, Chengdu, Sichuan, P.R. China, June 8-11, 2015.
[15] Birenbaum M & Gazit E, The learners' Isle: A multi-user virtual environment to foster learner agency and motivation. P. 244. In. *Integrating Multi-User Virtual Environment in Modern Classrooms*. Edited by Qian, Yufang Hershey, PA: IGI Global