Introduction

A developing international engineering industry is dependent on competition and innovation, creating a market for highly skilled graduates from respected overseas and Australian Engineering universities. To remain internationally competitive, Australian universities are continually evaluating and sourcing feedback about their educational culture and teaching practice to ensure it is meeting the expectations of students. (Oxley, 2000) Successful transition planning by Australian course designers is at the forefront of pedagogy research within a framework of industry consultation. The delivery of engineering teaching and learning via blended face-to-face, problem based, research focused and online collaborative learning will continue to be the foundation of future engineering education, however, it will be those institutions who can reshape its learning spaces within a culture of innovation using 1:1 devices that will continue to attract the brightest minds. Investing in educational research that explores the preferred learning styles of learners and matching this to specifically designed 1:1 personalized web applications may be the 'value add' to improve student engagement. Embedding extrinsic values into course content and delivered through managed online educational systems may lead the future of engineering research and learning. (Australian Federal Member for Aston, Feb. 2013) It is proposed to explore the learning needs of individual learners by hypothesizing and conducting field research to attempt to predict possible outcomes derived from constructivist personalized 1:1 online engineering course delivery that is adaptive, promotes a culture of innovation and intrinsically 'adds value' to Australian University's Engineering intellectual property.

Old World Perspective

In 2001, Dr. Brian Lloyd reflecting on his 30 years within the Engineering Industry, prepared a comprehensive report titled, 'Engineering the Future – Preparing professional engineers for the 21st century'. In his report written in consultation with the Association of
Professional Engineers, Scientist and Managers Australia, he details the historical development of engineering education in Australia. He purports that by formalizing career pathways based on a hierarchy of formal engineering qualifications will be the main driver for change. Interestingly, 'in 1911, the University of Queensland became the first Australian University to enter the correspondence education field. (Oxley, 2000) The model of correspondence education was based on the 'Old World' British model where the main clients were itinerant or remotely based school-teachers and civil servants working towards bachelor degrees. Many of these bachelor degree courses were overseen by corporate membership examinations of the professional engineering institutions. (Lloyd, Rice, Ferguson, & Palmer, 2001) Lloyd makes an interesting
observation when he states, '…distance education in all its various forms is set internationally to become the dominant mode of higher education delivery of the 21st Century.' (Lloyd et al., 2001) He reflects on the main reason for his observation been the
advantages for students of engineering including '…the flexibility of time and place of study. Study material can be delivered by mail or online to anywhere in the world and can be studied when and where is most convenient for the student.' (Lloyd et al., 2001) Lloyd makes a further observation and states, 'Commercially, distance education provides an easier mechanism into international higher education markets, and as government funding on universities diminishes, overseas markets become a critical income source.'(Lloyd et al., 2001) Lloyd astutely identifies, "Students must feel that they are part of a learning community and derive motivation to engage in the study

material from the lecturer." (Lloyd et al., 2001) He explains that to maintain student motivation there is a cost difference between proximity and distance education via online delivery services. To maintain motivation, smaller student ratios are required for online communities in comparison to proximal teaching and learning. At the time of Lloyd's writing, he did not anticipate the impact web technologies would play in the distribution and access of engineering education.

In the United States of America, a trend towards Open Online Delivery has exponentially given access to a new market of online learners. Whilst a very small segment of higher education institutions are experimenting with Massive Open Online Courses (MOOC), the majority of institutions remain cautious about its impact on higher education enrolments. (Allen & Seaman, 2013 p. 15)

"It is reported that 2.6 percent of higher education institutions currently have a MOOC, another 9.4 percent report MOOCs are in the planning stages. The majority of institutions (55.4%) report they are still undecided about MOOCs, while under one-third (32.7%) say they have no plans for a MOOC. Academic leaders remain unconvinced that MOOCs represent a sustainable method for offering online courses, but do believe they provide an important means for institutions to learn about online pedagogy. Academic leaders are not concerned about MOOC instruction being accepted in the workplace, but do have concerns that credentials for MOOC completion will cause confusion about the value of higher education degrees. Students considering MOOC delivery mode have a real perception that higher education institutions are more likely to be in a position to deliver innovative courses." (Allen & Seaman, 2013 p. 15)

It is reported that in 2012, less than one-half of higher education institutions reported that online education was critical to their long-term strategy. In 2012, that number is now close to seventy percent. (Allen & Seaman, 2013 p. 4) The proportion of chief academic leaders that say online learning is critical to their long-term strategy is now at 69.1 percent – the highest it has been for this ten-year period. (Allen & Seaman, 2013 p. 2)

Observations suggest that MOOC's are perceived amongst higher education institutions as a 'try before you buy', it assists students to determine if online delivery suits them and can assist students to select courses that meet their needs, therefore reducing the level of course drop out. (Allen & Seaman, 2013 p. 12)

Has Engineering Pedagogy Changed?

Pedagogy is defined in the Oxford Dictionary (2014) as the scientific method and practice of teaching. Russ Edgerton (2001) has attempted to add to this definition and used the term 'pedagogies of engagement' referring to the methods used within engineering education by educators to engage students for learning. (Smith, Sheppard, Johnson, & Johnson, 2005) It is Edgerton's (2001) definition that premises this literature review with the intention to identify specific learning styles and cultural factors to understand the effectiveness of online learning using 1:1 mobile web based devices.

A newly enrolled engineering student who is about to embark on their chosen course of study, needs to be informed about how they will be expected to respond and what the learning outcomes and assessment criteria will be used to successfully complete the course. It may also be useful when designing engineering courses to consider how institutions develop and communicate their own expected social behaviours and values throughout the learning structures to integrate students into the engineering faculty's culture. It may be 'what is not said' that may reveal why some students 'drop out' and/or highlight their inability to adapt to a preferred teaching style of

the lecturer(s) and or designed pedagogies of engagement. Considering the cost to attract and secure enrolments and the ‘flow on’ effect of lost intellectual capital, it would seem only logical to

ensure students are well supported through effective communications and course design.

Course designers, who have in-depth knowledge about the premise from where the instruction is to be constructed, will have a higher likelihood of setting achievable learning outcomes and higher levels of engagement when the focus is on student centered instruction. These same premises are applicable to 'face-to-face' and 'on-line delivery' modes within a blended learning environment. There are three broad learning premises that currently shaping the 'world view' of engineering education; behaviourism, cognitivism and constructivism.

Skinner (1957) demonstrated behaviours that result in desirable consequences would likely recur; those that result in undesirable consequences will be less likely to reoccur. (Ferster, 1957 p. 2) The behavioral theorists believe the lecturer's job is to establish situations, which reinforce desired behaviour from their students. The behaviourist expects the teacher to predetermine all the skills they believe are necessary for the students to learn and then present them to the group in a sequenced manner. 'Positive Reinforcement' is used to strengthen behaviour and ensure the behaviour is repeated successfully. (Bedelan, 1989 p. 410)

Reinforcement theory specifically interests educationalist because it helps to explain why learners who experience 'uncertainty' while engaging in learning, tend to have a higher need to achieve a greater reward. (Fiorillo, Tobler, & Schultz, 2003) Educational psychologists attempt to explain 'Uncertainty and reward' leads to increasing the type of brain dopaminergic response that has been linked to motivation. (Berridge & Robinson, 1998 p. 313) The 'uncertain reward' effect may explain why humans are more likely to get a greater satisfaction from games of chance (in contrast to games of skill), such as online games that are stressing 'uncertainty' and 'reward' and/or even leading the gamer to develop gambling habits. (Shizgal & Arvanitogiannis, 2003 p. 1857) The connection between these two concepts has become blended by academic discussion and the idea of 'Uncertain Reward' (in contrast to two separate concepts 'Uncertainty' and 'Reward').

Constructivism in the classroom: (1) Cognitive or individual constructivism depending on Piaget's theory, and (2) Social constructivism depending on Vygotsky social theory. (J Piaget, 1936) (Powell & Kalina, 2009 p. 241) In cognitive constructivism, ideas are constructed in individuals through a personal process; as opposed to social constructivism where ideas are constructed through interaction with the teacher and other students. (Powell & Kalina, 2009 p.241)

Cognitive development proposes that humans cannot be given information, which they immediately understand and use; instead, humans must construct their own knowledge. (Jean Piaget, 1953) Children, up to adulthood, will start using higher levels of thinking or abstract ideas to solve problems. (Powell & Kalina, 2009 p. 242) Observing students and comprehending their level of difficulty is paramount to this process. (Powell & Kalina, 2009 p. 243) For example, when teaching complex concepts, some students in the classroom may grasp them quickly while others can be struggling. Asking questions of students to know where they may have difficulty is part of the inquiry method to alleviate misconceptions. Understanding these stages and teaching within the ability of students to grasp concepts logically and intellectually is a main goal of all lecturers. Effective learning occurs when clarity begins.

Instructional design is becoming an emerging discipline in response to student centered learning. One of the foundations of instructional design is that it is a component of a user centered development process. It is based on knowledge of the application of learning theory to designing experiences that promote thinking for learning. (Eklund, Kay, & Lynch, 2003 p.20) There is an increasing recognition that

successful learning requires not just quality instructional content but an appropriate context that includes facilitation and an understanding of the learner. The teacher, who supervises the successful deployment and integration of the content into the teaching and learning environment, facilitates this context. The teacher's role is to find, adapt and deliver knowledge using a variety of techniques appropriate to a knowledge domain and the needs of the learner. (Eklund et al., 2003 p.20)

The rise of cognitivism as the dominant 'post-modern/post-behaviourist' learning theory and the recognition of the importance of the social context for learning is influencing curricula and teaching practice. (Straub, 2003) Effort is being directed at determining the factors that create effective electronic learning environments, and the broader factors that create successful e-learning programs. (Khan, 2002 p. 59-60) (Frydenberg, 2002)

Instructional design for E-learning in terms of a conversation between students and instructors has been based on chronological models of speech, where one has to speak one word at a time. (Frydenberg, 2002 p. 1) Few examples of e-Learning courses are non-linear. Yet, these programs, which are intended for students under the age of 30 years, are enrolling learners who are fully at ease in an avatar-and-bot world. While educators are used to controlling learning by requiring that module 1 be completed before the learner has access to module 2, many younger learners have no such predispositions. So, how do we design non-sequential instruction?' (Frydenberg, 2002 p. 1)

Vygotsky (1962) wrote in the 'Thought and Language' where he explained the idea of 'Zone of proximal development'. He states,

> *"The distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers." (Vygotsky, 1962)*

Cognitive self-organization as the constructivist view of learning suggests that the learner is participating in cultural and learning practices and this participation is the context for self-organization. (D. W. L. Hung & Nichani, 2000 p.145-146) Zone of proximal development (ZPD), cognitivism in learning focuses on achieving higher-level learning in engendering independent, self reliant learners who can employ a range of thinking strategies to construct their own knowledge. (D. Hung & Nichani, 2001 p. 41) For example, this occurs when students act first on what they can do on their own and then with assistance from the lecturer, they learn the new concept based on what they were thinking about individually. (Powell & Kalina, 2009 p. 244) Scaffolding is an assisted learning process that supports the ZPD, or getting to the next level of understanding, of each student from the assistance of teachers, peers or other adults. (Powell & Kalina, 2009 p. 244) When students master completion of projects or activities in a group, the internalization of knowledge occurs for each individual at a different rate according to their own experience. Vygotsky believed that 'internalization' occurs more effectively when there is social interaction. (Powell & Kalina, 2009 p. 244)

Instructional design uses Vygotsky ZPD scaffold sequencing of material, limiting the number of concepts for students to embrace, however, non-linear learning presents a challenge to course designers as a deeper understanding about how learners like to engage and contribute to the body of information as part of their learning process.

E-Games has exploded due to the ability for the E-Game environment to adjust its challenges through improvisation, generating a non-linear learning environment. (Jasinski, 2001) For some users, a game that compels the player to deal with

constant change, nothing remains stable for very long, because everything is alive and changing around the player. (Kanter, 1990 p. 19) The key to improvisation is to play with the rules, not by the rules – or to create new ones. (Jasinski, 2001 p. 2) This model of game design creates an environment where the user is forced to learn and adapt using problem solving skills. Modern virtual reality game modeling has drawn on improvisation and provides instructional designers with a researched and documented post-modern constructionist platform.

Howard Gardner (1983) an educational theorist in his book titled, Frames of Mind: The theory of multiple intelligences stated,

> *"In the heyday of the psychometric and behaviorist eras, it was generally believed that intelligence was a single entity that was inherited; and that human beings—initially a blank slate—could be trained to learn anything, provided that it was presented in an appropriate way. If individuals differ in their intellectual profiles, it makes sense to take this fact into account in devising an educational system for individuals, groups, or even nations."* (Gardner, 1983 p. 21)

Increasing number of researchers believe precisely the opposite: that there exists a multitude of intelligences, quite independent of each other; that each intelligence has its own strengths and constraints; that the mind is far from unencumbered at birth.

Seven intelligences, including; the linguistic and logical-mathematical intelligences; musical intelligence; spatial intelligence; bodily-kinesthetic intelligence; and two forms of personal intelligence, one directed toward other persons, one directed toward oneself. (Gardner, 1983 p. 11) In his descriptions of intelligences he implies that it is insufficient to assume that intelligence can be confined within the space of an individual's capacity to think, rather is a contribution of broader social experiences. (Gardner, 1983 p. 15)

The importance between learning and assessment must be unrestrictive yet constructive to quantify the level of engagement and retention of knowledge. (Gardner, 1983 p. 19) Educational institutions who reward learners in the mastery of a specific learning domain devise success criteria to demonstrate competency, however, may prove to be culturally driven rather than a measure of intelligence. (Gardner, 1983 p. 20)

Course designers must therefore ask the question, 'Where does creativity come from?'

Creativity does not only begin in the brain, the mind, or the personality of a single individual, instead stems from interactions between the individual's own competences and values; the domains available for study and mastery within a culture. (Gardner, 1983 p.
20) Innovation is judged institutionally through derived culture, values, domains and competencies; therefore, innovation is measured by the degree of expressed creativity. (Gardner, 1983 p. 20) The creative individual is one who regularly solves problems or fashions products in a domain, and whose work is considered both novel and acceptable by knowledgeable members of a field. (Gardner, 1983 p. 20)

Choosing the source of information with the highest expected reward, and, as the experience of the outcome of the choice, learners will attempt to adjust the information about the source in relation to their prediction or how the expected outcome exceeds the expected outcome. What this means for educators is learners may not necessarily rely solely on information (the reward) that is available to them at the time, but will seek out alternative sources of information to satisfy a need. Students may turn to the Internet and their wider research to meet their learning needs.

The Future of Engineering Learning

Mobile Learning (mLearning) via the Internet is challenging the traditional classroom setting, as is the pedagogical focus that is shifting away from the lecturer to a constructivist learning approach focusing on the individual learner. Mobile devices include mobile phones, smartphones, personal digital assistants (PDAs), netbooks, tablets, iPad, e-readers, digital cameras, portable media players, and gaming devices. Course designers are very aware of the barriers; the lack of industry standards across devices and software platforms, and the need to develop applications for multiple operating systems to support constructivist-learning environments. (Mockus et al., 2011 p. 6)\The questions, 'To what extent will an individual's cognitive structure change once access to information sources take place, almost in real time? Learner's can now create his or her own self-identity that is, constructing one's own knowledge base from information available. (Parker, 1997) Therefore, course designers need to consider how learning will facilitate a learner's attempt to analyze, deconstruct and distinguish the differences while learning; so that the learner can begin the process of constructing their own identity as a desired learning outcome. (Parker, 1997)

A trend toward the desire for personalized learning, students want to decide where, when, and how they interact with the content and the learning experience. In order to meet these learner-centric demands, education will need to be accessible through a wide range of technologies and devices. (Mockus et al., 2011 p. 24) Learning is also becoming more personalized, and the learners want to be able to choose their preferred devices with the expectation that the materials will be accessible. Educators and designers need to work towards increasing motivation by utilizing the strength and power of personalized learning that mobile delivery provides. (Mockus et al., 2011 p. 24)

Where to now?

Research has demonstrated inconclusive evidence that learning can be compartmentalized and delivered effectively to meet every individual student's need with improved assessment outcomes. Identifying learning styles has proven to show that similarities exist in the preferred mode of learning amongst specified student groups, however matching pedagogy to improving any specific learning style group's motivation and performance is inconsistent. It is accepted that further research is required to build on the existing literature with an emphasis on constructivist learning as a premise to understand a students need to identify with industry and specific university cultures to become a self expression of innovation and creativity to drive engineering learning in the future.

A discussion around the role of 1:1 mobile devices and technologies to facilitate the learning and engagement of engineering students will require careful consideration due to its likely impact on the way future course design is to be implemented.

In 2015, Deakin University, Engineering Faculty is currently transitioning to a 'Problem Orientated Design Based Learning (PODBL) model, where students will be required to solve real world problems in project teams.

Principles of project based learning in common are as follows:

- Student's work together in groups and collaborate on project activities.
- A real world problem that affects the life of the student's is presented for investigation.
- Student's discuss findings and consult the teacher for guidance, input, and feedback.
- The maturity level of student's skills determines the degree of guidance

provided by the teacher.

- Final products resulting from project-based learning can be shared with the learning community-at-large, thus fostering ownership and responsible citizenship in addressing real world problems.

Chandrasken states,

> "Learning through projects has a positive effect on student content knowledge and the development of skills such as collaboration, critical thinking, and problem solving which increases their motivation and engagement." (Chandraskekaran, 2012)

Changes in educational pedagogy design such as PODBL will rely on engineering tudents' ability to access online information. Students will turn to their 1:1 mobile devices, using their online research skills to derive an educational advantage to the design process.

Therefore, it is necessary to conduct ongoing research within an ethics framework to test constructivist theory approaches for teaching and learning; such as the perceptions of students towards the effectiveness of 1:1 mobile devices for learning. Identifying the factors that contribute to improving the effectiveness of learning through enhanced student engagement and motivation is of interest to researchers, course designers, lecturers, students and the wider engineering industry.

The following questions have arisen;

- What education teaching and learning strategies best facilitate the use of 1:1 devices for online teaching and learning?
- What are the factors within a university engineering faculty that may hinder and/or support the use of 1:1 devices for online teaching and learning?
- To what extent do 1:1 devices assist engineering educators and students to foster a culture of innovation?

The survey of the literature has suggested a hypothesis, a need for fieldwork and analysis may clarify the questions to assist the engineering education industry. E.g. Course designers, lecturers and students to better understand how to motivate engineering learners towards a culture of innovation.

Deakin University Engineering Faculty researchers are currently engaged in a longitude study to test the hypothesis; If, 1:1 mobile devices are used to access online learning, then will there be an improved perception of student engagement in the unit of study? If, a measured perception of student engagement does exist, then, will this lead to a measured learning growth?

The methodology for the study utilizes 'Vermunt's Inventory of Learning Perceptions', include, (1) meaning directed - deep processing strategies, self-regulation and learning viewed as a personal construction; (2) reproduction directed - surface processing strategies, dependence on external regulation, learning viewed as intake of knowledge, and desire to demonstrate ability; (3) undirected - poor self-regulation, ambivalence in learning orientation, and value given to external sources of help; and (4) application directed - strong vocational orientation to learning and a belief that learning is the use of knowledge. (Vermunt 1998) The data collected will be used as evidence to indicate any changes to prove or disprove Hypothesis 1.

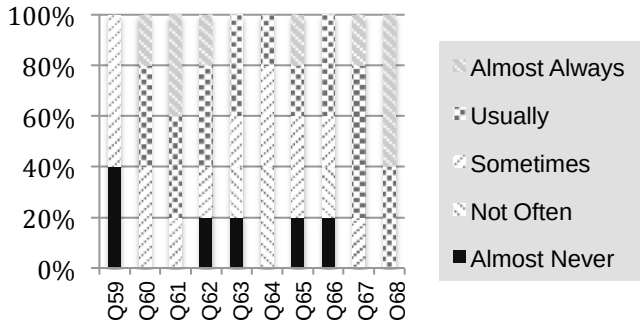
The control group responded to a series of research questions:

Q1. I compare my view of a course topic with the views of the authors of a textbook used in that course?
Q2. I analyse the separate components of a theory step-by-step?

Q3. I pay particular attention to those parts of a course that have practical utility?
Q4. To test my learning progress, I try to answer questions about the subject matter, which I make up myself.
Q5. To test my learning progress, solely by completing the questions, tasks and self-tests in the course material?
Q6. I notice that it is difficult for me to determine whether I have mastered the subject matter sufficiently.
Q7. If I have difficulty understanding a particular topic, I should consult other academic sources (Library) of my own accord?
Q8. I have a need to work together with other students in my studies?
Q9. I do these studies out of sheer interest in the topics that are dealt with?
Q10. I have chosen this subject area, because I am highly interested in the type of work for which it prepares?

Preliminary results taken from Deakin University first year engineering students study control group, as shown in **Table 1**, **Engineering Students' Perceptions**; Q1 results suggests 60 per cent of engineering students perceive textbooks as a necessity for learning, while Q7 contrastingly, shows 80 percent of students are turning to alternative academic sources to understand difficult topics. Q2 results suggest students perceive a need to analyze theory, step by step, but Q3 and Q10 demonstrates students' perceive a need to see a practical utility or career application for the learning to be meaningful. Q4 and Q5 results suggest up to 40 per cent of students are not engaging fully with their learning. Q6 results suggest the majority of students perceive they are at risk of failing the course due to misconceptions arising from the teaching and learning provided. Q8 and Q9 results suggest students perceive working with other students who share common interests beneficial. In summary, engineering students are looking for opportunities to become self-directed in their learning, beyond the traditional expectations of having to rely on textbooks, the information and expertise provided by their lecturers, local industry career pathway expectations and traditional online teaching and learning course sequences. It is not suggested these building blocks should be excluded from course design, but rather to incorporate greater flexibility for student choice to access alternative sources of course related information via 1:1 devices from across disciplines to enrich the student's ability to become innovative when engaging in engineering problem solving projects.

Table 1 - Engineering Students' Perceptions



The next phase of the study will explore whether improved student perceptions can increase motivation and assessment outcomes by enhancing the engineering curriculum using self-directed learning interventions. Further publications from the research project will discuss what is meant by self-directed learning interventions and their role to promote a culture of innovation for learning accessible via engineering student's personal 1:1 devices (iPads, smart phones, tablets and the like) and their potential influence on future engineering course design.

Conclusion

An exciting revolution is emerging as web technologies provide a platform for new ideas in engineering education. The literature survey has shown a 'gap' where there is a need to explore the connection between pedagogy, student perceptions about their learning and the effectiveness of 1:1 mobile devices to assist in establishing a culture of learning innovation. University culture and course design are essential elements considered by current and future engineering students, influencing their choice of study mode and institution. Institutions that can meet student learning needs will lead the international engineering industry in course design innovation. Competing factors, such as physical location and expertise may be enhanced by the future implementation of increased access to 1:1 devices as a preferred mode of study access by campus and off campus students.

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