Engineering Curriculum Design - Understanding motivational variables and their influence on self-directed learners when using 1:1 mobile devices.

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Abstract

Engineering curriculum design and delivery within the framework of budget restraints, learning outcome policies and industry standards, is a complex task that understandably universities and the engineering industry invest significant resources. It would be expected that what is actually occurring within the engineering learning space is a reflection of the constraints upon the industry, producing graduates, and products and services that provide a return on investment through intellectual capital. Firstly, the literature review will contextualise and explain the engineering student's motivational variables to actively engage in their learning spaces, and how this may be applied by curriculum designers to improve the quality and delivery of courses. In particular, what are the intrinsic and extrinsic motivational variables and associated values that student's desire during their engineering learning experience. Secondly, the research study will explore how motivational theory can be applied to the stages of 'active learning' when integrating 1:1 mobile devices for engineering learning. 1:1 mobile devices include iPad, mobile phones, Surface Tablets or handheld Wi-Fi or Internet accessible device used for learning purposes. It is not fully understood how to influence 'active learning using existing teaching and learning strategies. How to influence an engineering undergraduate student to prioritise the use of 1:1 mobile devices as a means to source prescribed and unprescribed curriculum resources to improve learning outcomes. Is it unreasonable to expect engineering students to be constrained to the learning resources supplied by the engineering course facilitated, or should engineering students be encouraged to use their own initiative and find their own supporting information?

Keywords: 1:1 mobile device, Engineering education, learners, active learning, self-regulated

1.0 Introduction

'The most important attitude that can be formed is that of desire to go on learning.'
 John Dewey – (Dewey, 1963)

Engineering curriculum design and delivery within the framework of budget restraints, learning outcome policies and industry standards, is a complex task that understandably universities and the engineering industry invest significant resources. It would be expected that what is actually occurring within the engineering learning space is a reflection of the constraints upon the industry, producing graduates, and products and services that provide a return on investment through intellectual capital. Firstly, the literature review will contextualise and explain the engineering student's motivational variables to actively engage in their learning spaces, and how this may be applied by curriculum designers to improve the quality and delivery of courses. In particular, what are the intrinsic and extrinsic motivational variables and associated values that student's desire during their engineering learning experience. Secondly, the research study will explore how historical motivational theory can be applied to understand the stages of 'active learning' when integrating 1:1 mobile devices for engineering learning. 1:1 mobile devices include iPad, mobile phones, Surface Tablets or similar handheld Wi-Fi or Internet accessible device used for learning purposes. It is not fully understood how to influence 'active learning using existing teaching and learning strategies. How to influence an engineering undergraduate student to prioritise the use of 1:1 mobile devices as a means to source prescribed and unprescribed curriculum resources to improve learning outcomes. Is it unreasonable to expect engineering students to be constrained to the learning resources supplied by the engineering course facilitated, or should engineering students be encouraged to use their own initiative and find their own supporting information?

This research study is within the theoretical framework of 'self-regulated learning' and 'Active Learning' principles.   In this study, academic views are presented from the literature to contextualise motivational theories during a time when mobile technologies did not exist and contrast these with current developments to highlight learning motivations influencing the use of 1:1 mobile devices.

2.0 Methodology

In consultation with the research authors, a library search protocol was developed prior to the literature search commencing. A mixed search strategy via accessing electronic databases and drawing on library held hard copy resources was undertaken between 2016-17. The following electronic resources were accessed in the literature search:
• EBSCO (http://search.ebscohost.com/),
• IEEE Digital Library (http://ieeexplore.ieee.org/), and
• Google Scholar (http://scholar.google.co.uk/).

Keywords were used to facilitated searches: active learning, self-regulated learning, learning motivation, learning theory, mobile technology, tablet, iPad; 1:1 mobile device, instruction, instructional, learning, and engineering learning. Studies were included in the literature review if they were peer reviewed and contributed to explaining the historical development of learning theories to contextualize or explain the emergence and motivation of learners' use of mobile technology (e.g., WiFi accessible mobile devices such as iPhones, iPads and Android mobile devices); and were written in English. Studies were excluded

if they were not reporting on adult learning behaviour, or could not demonstrate empirical evidence.
The guiding questions for the literature review included:

1. How does the learning process use 1:1 mobile devices to support 'surface and deep' learning?
2. How can 'intrinsic and extrinsic' values be developed in engineering students as thinking while using 1:1 mobile devices for active learning?
3. Can an engineering curriculum design influence the way an engineering course is designed to cater for students who have already adopted the use of 1:1 mobile devices to improve their learning outcomes and assessment results?
4. How can 1:1 mobile devices support students during problem solving activities and produce innovative results (intellectual capital)?
5. How can mobile devices assist engineering students to manage the learning process by organising modules of information that will lead to higher learning and problem solving skills?

The literature review was narrowed to sixty-three research studies from a total of 228 potential database or library sources, which were then categorised pre (1976-2008) and post (2009- 2017). As mobile technology became apparent in educational settings for learning, it became apparent further research would be needed. The following discussion includes the learning motivation theories and empirical studies that historically contextualise and attempt to understand the motivational variables and their influence on self-directed learners when using 1:1 mobile devices. This literature review is limited to acknowledging that early learning motivational theorist and empirical studies were reporting without the knowledge of the future influence mobile technology would have on learning, and the suppositions about the influence of mobile technology on learners' motivations are limited to the interpretation of the authors.

3.0 Self-regulated and Active Learning

There is diversity of academic thinking around what constitutes student 'self-regulated' or 'active' learning and learners can be influenced to improve teaching and learning outcomes. However, further research is required to understand how 'active learning' principles can be applied to the use of 1:1 mobile devices for learning within engineering learning spaces.

Inter-disciplinary teaching and learning can be broadly categorised into (1) cognitive psychology, (2) motivation psychology, and (3) educational sciences (Gijbels, et al. (2014). The following research traditions have been identified from the literature, including;

(1) Deep or Surface Learning (Marton and Saljo, 1976, 1997) – where students who adopted a 'deep' learning approach' began with an intention to understand meaning from texts, could question an author's arguments, and relate them to past knowledge and personal experience. In contrast, 'surface' learning occurs when students began with an intention of memorizing facts, however, without understanding its context;

(2) Learning conceptions or beliefs about learning and teaching (Saljo, 1979),

(3) Learning Styles. (Kolb, 1984);

(4) Metacognition variables of learning (Flavell, 1987);

(5) Biggs (1987, 1979 and 2003) categorized learning as 'utilizing, internalizing and achieving' study orientations. Entwistle and McCune (2004), focused on learner motivations and processing strategies via a study 'orientations' instrument tilted, 'The Approaches to Studying Inventory (ASI)'; a categorization of student responses as either 'deep, surface and strategic' (Entwistle, N., 1988).

(6) Motivational aspects (Entwistle, 1988) (Boekaerts, 2006);

(7) Cognitive aspects of learning (Sadler-Smith, 1996), (Moskvina and Kozhevnikov, 2011);

(8) Aspects of self-regulation towards learning (Boekaerts, 1997);

(9) Vermunt and Vermetten (2004) used the term 'Learning patterns' to describe students' habitual ways of learning, how students cognitively process information and the metacognitive, motivational, and affective strategies applied;

(10) Study Orientations (Nieminen et al., 2004); (Richardson (1997), and

(11) Intellectual Styles. (Zhang and Sternberg, 2005);

(12) Mayer, et al. (2010) argue the 'quality' of a student could be determined by their ability to use cognitive operations to organise and review meaningful learning into packets of knowledge to support higher cognitive learning.

Post the year, 2009, with the advancement of technology, the engineering education literature has considered 1:1 mobile devices as primarily a communications tool, or as a means to access online information, however, not as a learning and motivation tool to facilitate higher order thinking. This presents a unique opportunity for the engineering educational sector to discuss the validity of curriculum design that supports engineering students' use of 1:1 mobile devices within engineering learning spaces.

4.0 Student approaches towards learning

Traditionally, how a student approaches their learning is viewed as being influenced by factors within the learning environment, students' perceptions of these factors and student characteristics (see Figure 1 – General Model of the Student Approaches to Learning).
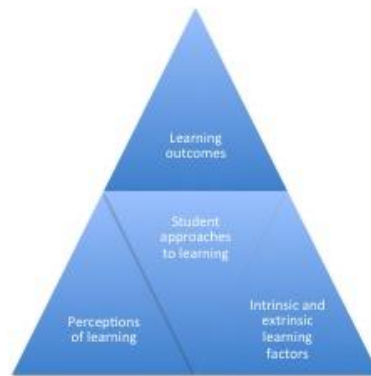
Figure 1 – General Model of the Student Approaches to Learning.
Gijbels, D., Donche, V., Richardson, T., and Vermunt, J., (2014) - Learning Patterns in Higher
Education- Dimensions and research perspectives. Routledge – Taylor and Francis Group
London and New York. p.28

However, a generalist theoretical view does not explain what is occurring in a student's thought processes during formal and informal learning. Schunk (1986) argues that students are active in cognitive processes while completing learning activities, and therefore curriculum design needs to ensure problem-solving is occurring rather than relying on direct instructional models of learning. Performance and development criteria for engineering curriculum delivery will need to show how the learning sequence will motivate and achieve higher order thinking amongst engineering students when active learning is applied while using 1:1 mobile devices technologies.

5.0 What is self-regulated and active learning?

Schunk and Zimmerman (2008) define self-regulated learning as a process by which learners personally activate and sustain cognitions, affects, and behaviours that are systematically orientated towards the attainment of learning goals. In contrast, 'Active Learning' is a broad term to describe students who are engaged in learning activities in the engineering learning space (Koch et al., 2014). Problem and project-based learning are specific forms of active learning where a problem is the starting point of interdisciplinary, student-centred learning in groups (De Graff, and Kolmos, 2003). The benefits of active learning allow students to develop skills including teamwork, collaboration and conflict management, problem-solving skills, self-regulation skills and professional skills (Palmer and Hall, 2011). To achieve active learning, students need to be supported with a curriculum design and the technology tools (1:1 mobile device) to instil confidence to develop higher order thinking skills. The discipline of studying students' 'Self-regulated Learning (SRL)' came from research showing that learner' skills and abilities did not fully explain student achievement, but maybe influenced by self-regulation and motivational factors (Schunk and Zimmerman, 2008).

Early self-regulation research in education focused on cognitive strategies and behaviours, such as monitoring, organizing, rehearsing, managing time, and establishing a productive work environment. However, the roles of personal goals linked to a student's future (reactive outcome measures including

academic grades or standardized test performance and proactive measures, such as goal setting and choice of learning strategies), attributions, self-efficacy, outcome expectations, self-concept, self-esteem, social comparisons, emotions, values, and self-evaluations are now routinely considered (Schunk and Zimmerman, 2008).

> *'Self-regulation refers to the process, internal and/or transactional, that enable an individual to guide goal-directed activities over time and across changing circumstances (contexts). Regulation implies modulation of thought, affect, behavior, or attentive via deliberate or automated use of specific mechanisms and supportive meta-skills. The processes of self-regulation are initiated when routinized activity is impeded or when goal-directedness is otherwise made salient (e.g. the appearance of a challenge, the failure of habitual action patterns – (Karoly, 1993).'*

Zimmerman (2001) states self-regulated learning theories assume that students can (a) personally improve their ability to learn through selective use of metacognitive and motivational strategies; (b) proactively select, structure, and create advantageous learning environments; and (c) play a significant role in choosing the form and amount of instruction they need. For engineering curriculum designers and educators, this implies the importance to place a priority on student learning motivations, as a matrix of considerations when designing and an engineering curriculum. Also, it may imply that priority should be given to enable engineering students to chose their own technologies such as 1:1 mobile devices to support them within their engineering learning spaces.

6.0 Self-regulation motivational variables

Self-regulated motivational variables are explained as thought processes an engineering learner uses during active learning. Zimmerman and Risemberg, (1997) conducted research using a fourteen (14) self-regulation learning strategy inventory to guide research around student trends in student motivations. The inventory included the following variables;

1. Self-evaluation
2. Organizing and transforming (rearranging and restructuring instructional materials)
3. Goal setting and planning
4. Seeking information (from non-social sources such as a book)
5. Keeping records and monitoring
6. Environmental restructuring (rearranging the physical setting to make learning easier.)
7. Self-consequating (arranging for rewards or punishment for success or failure)
8. Rehearsing and memorizing.
9 to 11. Seeking assistance from peers, teachers, and adults.
12 to 14. Reviewing test, notes and texts.

Schunk and Zimmerman (2008) identified cognitive, affective, and behavioural processes that influence

students to 'activate and sustain' self-regulated learning (Boekaerts, Pintrich and Zeidner, 2000). Note, this early research did not consider the benefits of using 1:1 mobile devices as a motivational tool.

Keppell et al. (2006) argue peer learning, sharing ideas, interacting to encourage interdependence motivates students to interact beyond the learning space, which provides opportunities for 'deep learning' and improved academic performance. Peer learning extends to using social media APPS (Facebook, Twitter, Messaging services, shared learning spaces like Blackboard, Edmodo, Desire) on their 1:1 mobile device, where students can interact using messaging services, access and create online quiz and tests and use and create expert peer discussion groups to encourage curiosity, sharing of resources and ideas, and encourage critical thinking and problem solving skills (Tlhoaele, M., Suhre, C., and Hofman, A., (2016). Is it possible to consider in the near future a trend where traditional learning spaces will become virtual reality spaces as an integrated platform for learning (e.g. Second-Life). It would seem innately logical to realise the importance of 1:1 mobile devices as an unexplored learning space and motivational tool for learning that needs to be 'normalised' as an essential component of any engineering curriculum design?

7.0 Structured v's unstructured classroom learning

Challenging the notion of what constitutes a learning space is critical to understanding what challenges and motivates engineering students to become higher order thinkers and innovators within the discipline of engineering and more broadly. Schunk and Zimmerman (2008) argue that within a controlled classroom environment, students could be influenced by the teacher to recognise their poor self-regulation and replace this with effective learning goals and strategies, to encourage self-monitoring and self-assessment of an individual student's progress. Replacing these with attributes of a productive learning environment including been encouraged to seek assistance and to be encouraged to demonstrate flexibility, by redefining their current goals and or set with new ones (Boekaert and Niemivirta, 2000).

Schunk and Zimmerman (2008) acknowledged that where a less-structured environment existed, it could not achieve the same learning cognitive, affective, and behavioural processes, and hence, the researchers recognised there must be other underlying unidentified student self-perceptions influencing student motivation to engage with their learning; such as goal orientation, personal competence causality regarding personal outcomes (attributions) Whilst, self-monitoring is a cognitive process, where a student remains motivationally inattentive to feedback, this monitoring is unlikely to be sustained and/or enhance learning outcomes. (Boekaerts and Niemivirt, 2000). This observation implies that when integrating 1:1 mobile devices for student learning as an integral tool within a curriculum design, it will require monitoring of its use with the learning space.

Locke and Latham, (2002) found students who are highly motivated and who are given the opportunity to choose their own learning tasks linked to higher order thinking goals, are more likely to show a greater perseverance to complete the set task successfully. For example, a student who is motivated towards a career in maths, practises in their spare time to gain mastery of the maths language and regularly receives

positive feedback from maths tests, is more likely to experience success than a less motivated student who has no interest in the subject but has the ability (Schunk and Hanson, 1985). A second example, research shows that self-regulatory reading strategies can be mastered with practise, however, a passive reader will not willingly engage with the reading interventions and therefore, not achieve the expected learning outcomes compared to others (Schunk and Pajare, 2005). In contrast, a student who is encouraged by the curriculum design to actively use a 1:1 mobile device for learning purposes, may derive an educational advantage over a student who uses the same device to socialise and listen to music, may be distracted from engaging with the learning within the same learning space.

8.0 What is motivational conflict?

Imagine an active and vibrant learning space where engineering students are encouraged to bring and use a 1:1 mobile device, to collaboratively identify a real-world problem, research background information, discover possible solutions, link up with experts online and demonstrate higher order thinking skills, however, half of the class could not afford a 1:1 mobile device and was unmotivated to use technology. Whilst, the intention of the curriculum design had facilitated learning by using 1:1 mobile devices, a conflict has arisen between the curriculum design for learning and student motivations within a self-regulatory process. Instead half of the class are inactive, creating a need for the educator to run alternative activities to appeal and motivate students who have formed a perception that aspects of the learning are boring and repetitive (Schunk and Zimmerman, 2008).

Similar concern has been expressed about using tangible rewards or prizes to motivate student learning, where, if the reward is insufficient (infrequent, or too frequently given) then the student may become unwilling to engage in the task (Figure 2 – Freyer and Elliot, 2008) - Achievement Goal Endorsement) (Deci and Ryan, 1987). Where autonomy is allowed for student to pick their own task, 'Cherry picking' may occur where students choose 'superficially fun' activities (playing strategy games on a 1:1 mobile device during learning time) but do not develop important depth of understanding to demonstrate expected competencies (Schunk and Zimmerman, 2008).

Figure 2 – Achievement Goal Endorsement – Ref. Freyer, J., and Elliot, A., (2008) –
Stability and change in achievement goals. Journal of Educational Psychology. In,
Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning –
Theory, research and applications. Taylor and Francis Group LLC. p. 60

Elliot and Harackiewicz (1996) described those students who are either 'approach-performance' or 'avoidance-performance'. Students who are performance goal orientated will try to outperform other students and demonstrate in a public way competence and superiority, whereas, the 'avoidance-performers' will set themselves the goal of avoiding failure by looking incompetent. Unintentionally, engineering students with a spectrum of undiagnosed autism and/or other known learning disability may be at higher risk of performance issues. Vlachou and Drigas (2017) stated an autistic student can appear to be closed off in their own world, a world in which normal social skills are impaired, and is resistant to collaborative external interaction and communication.   Werry and Dautenhahn (1999) states an autistic person does not attempt to get attention unless it is to fulfill a need, which would therefore need to be provided by another person. In particular, where the curriculum design is intentionally encouraging students to use 1:1 mobile devices for collaborative learning, the device can become a source of 'escapism' from realising personal responsibility for their own learning.

9.0 Setting motivational learning goals

1:1 mobile device can be a motivator for learning, however, a clear discussion about how and when the device is to be used is essential. Midgley, Kaplan, and Middleton (2001) states that students with a learning approach that is goal orientated, report more self-monitoring and more use of deep processing strategies during learning than students with a learning-avoidance goal orientation (Pintrich and De Groot, 1990).

Vygotsky (1978) states goals must be meaningful, personalized and specific to the individual; activities that are within the individual's Zone of Proximal Development (ZPD). Students who can personalize their learning goals are more likely to develop intrinsic values towards been self-motivated and sustain this over time. This means that to sustain student motivation when using 1:1 mobile devices for learning, engineering educators need to model how to set personalized learning goals and provide regular feedback to demonstrate to students how to effectively use their 1:1 mobile device for learning and set a 1:1 mobile

device personal learning goal.

Schunk and Zimmerman (2008) in Figure 3 – attempts to contextualize Vygotsky (1978) ZPD as Self-Entity verses Incremental motivational variables. This attempts to explain how students see themselves within the learning space.
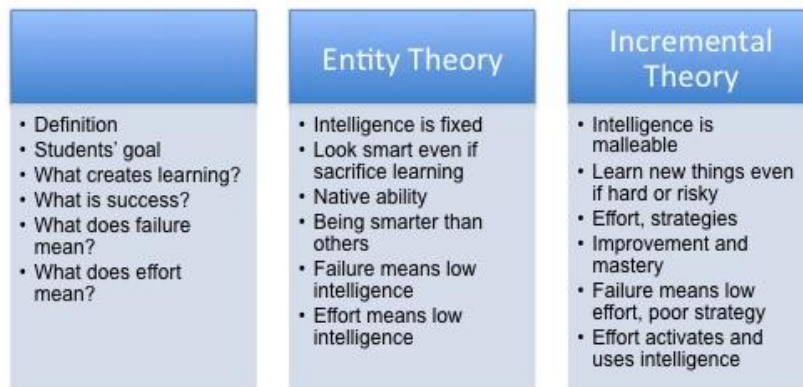

Figure 3 – Self-Theories – Entity Theory v's Incremental Theory]
(Ref: Schunk, D., and Zimmerman, B. (2008) - Motivation and self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p. 33)

Using a 1:1 mobile device can be perceived as an extrinsic reward. Kamil et all (2008) argue providing extrinsic rewards to students may increase students' initial motivation to participate and explore the world. Earning tangible rewards, such as toys, food, and prizes, and avoiding punishments were found to have more detrimental effects than receiving verbal rewards. Kamil et al. (2008) argue verbal rewards or praises for student educational performance can be categorized by focus: ability or effort. Praising students for being smart, fast, or knowledgeable can lead to students' perception that their achievement is an indicator of their intelligence or ability. Kamil et al (2008) states students who have an ego-centric view are likely to develop performance goals for example, the goal of achieving good grades. When faced with failure, students with performance goals might infer that they do not have the required ability and seek only those opportunities that make them look smart. On the other hand, students praised for their effort might view ability as an expandable entity that depends on their effort. These students are likely to develop learning goals for example, the goal of enjoying explorations and challenges or acquiring new skills and knowledge. They might interpret failure as an indicator of their lack of effort rather than lack of ability.

Kamil et al. (2008) argues that when an educator leader stresses performance outcomes, students develop performance goals. Likewise, when an educator puts more emphasis on the learning process and provide a supportive environment where mistakes are viewed as growth opportunities instead of failures, students are more likely to develop learning goals. Students who have learning goals are more motivated and engaged and have better test scores than students who have performance goals (Kamil et al., 2008). Setting an expectation for engineering students to use 1:1 mobile devices to set, access and monitor personal performance goals is a way to enable students to achieve personal growth. Learning goals can be set weekly

to align with the engineering curriculum design, and provide intervals for feedback to be monitored and accessible via the 1:1 mobile device learning space.

10.0 Engineering career motivational factors

Personal career goals are a key motivator for students and 1:1 mobile devices can be used to encourage students to source career information and monitor employment trends. Bandurra (1997) states students' career expectancies are linked to course choices. A student who is highly motivated with a high self-efficacious about their maths and writing skills may not seek a higher education because of its high cost and the low perceived benefits on graduating with a degree that will not return an appropriate career path or financial reward. Ensuring appropriate career information is freely available will minimise post-dissonance following a course enrolment decision.   Encouraging students to regularly update the careers goals will motivate students to persevere in the chosen course, minimising perceptions of personal failure.

Setting individual performance goal orientations as a supportive self-directed learning strategy fosters positive judgements of personal competence, and this leads to self-sustained motivation towards learning. Schunk and Zimmerman (2008) acknowledge the challenge for educators is to promote a culture of self-improvement rather than favourable social comparisons with others. Integrating career pathway information, off-site industry visits and/or guest speakers from relevant engineering industry groups may support intrinsic values and sustained learning motivation.

11.0 Social orientation supports motivation

Newman (1990) states, students who rely on a social context for their self-directed learning strategies are dependent on their level of self-efficacy. The decision to seek help can be daunting for a student because such requests can lead to increased anxiety, a feeling of rejection or ridicule rather than assistance and praise. Newman (1990) suggests students need a high level of self-esteem to admit their limitations to others and it is the responsibility of the educator to provide a supportive environment where students perceive the benefits to seek help outweigh the embarrassment of not seeking help.

At the time, Newman (1990) did not identify 1:1 mobile devices as a tool to support the learning process, particularly to aid communications between lecturers and students in the form of ongoing feedback during informal and formal assessment.

'Incremental learning' occurs where a student accepts responsibility for their learning goals, and seeks out support mechanisms to achieve an outcome. 1:1 mobile devices that are perceived to 'add value' through software tools, become an important partner when undertaking difficult course material and needing to understand cultural differences quickly. Hong et al. (1999) demonstrated that students could be motivated even though there may not be an academic improvement in course outcomes. For example, University of Hong Kong, an elite university who only offered courses and examinations in English, offered to all

enrolled students English tutorials with the motivation that it will improve their learning outcomes. The study identified two groups of students; those who valued learning (Incremental learning theory) accepted the offer, and those who had a higher self-entity perspective of their learning (already had a grasp on the language barrier).   (See Figure 4 – Schunk, 2008) - Practices that promote an incremental versus Entity Theoretical Approach of Learning). Those with a high self-entity were less likely to enrol in the English tutorials than those students who valued 'incremental learning'. The study implied that students who perceived they had the ability did not need to make any additional effort. 'If you are good at something, you shouldn't have to work hard at it.' However, self-entity motivated students were less likely to seek out learning strategies to improve the learning outcomes on not been successful, rather would consider cheating on future tests to justify their lack of willingness to adopt 'incremental learning' strategies (Hong, et al., 1999).

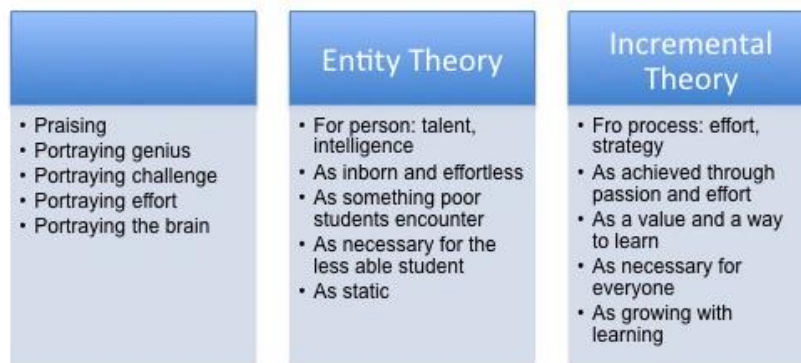|	Entity Theory	Incremental Theory
• Praising • Portraying genius • Portraying challenge • Portraying effort • Portraying the brain	• For person: talent, intelligence • As inborn and effortless • As something poor students encounter • As necessary for the less able student • As static	• Fro process: effort, strategy • As achieved through passion and effort • As a value and a way to learn • As necessary for everyone • As growing with learning

Figure 4 - Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p. 41

12.0 Gender stereotypes

1:1 mobile devices can be personalised to appeal to an individual's interests and motivations. Madon et al. (1998) states avoiding gender stereotypes is critical when making judgements about students' interests and competencies. Engineering educators need to not over estimate girls' efforts in mathematics, which may lead girls to attribute their successes more to effort than to ability. Weinstein (1989) argues that students of all ages are quite skilled at interpreting messages they receive from teachers about their abilities. Seeking feedback from students about how they are finding the course delivery is essential, particularly concerning how students are prioritising their learning tasks. Normalising the use of 1:1 mobile device as non-gender specific tool will ensure its safe and collaborative use. Modelling appropriate values when using a 1:1 mobile device needs to be considered to align with student motivations.

13.0 Teacher Role Models as Motivators

Weinstein and McKown (1998) states educators have a unique role to play in fostering self-concepts of ability, motivation, and academic performance for all students. This means teachers need to form accurate perceptions of their student's abilities based on the student's behaviour and performance in the classroom

rather than preconceived ideas about male and female abilities (Schunk and Zimmerman, 2008).

Schunk and Zimmerman (2008) developed a research model that attempted to quantify self-regulatory sources (variables) of motivation. (See Figure 5 and 6 – Schunk and Zimmerman (2008) - Sources of Motivation and their Role in Self-regulatory Learning (SRL).) These are shown and are identifiable by the following variables;

Self Regulatory Role			
Source of motivation	Precursor	Mediator	Concomitant or exclusive outcomes
Goal orientation	X	X	X
Interests	X	X	X
Self-efficacy	X	X	X
Outcome expectancy	X		
Future time perspectives	X		
Task values	X	X	X
Volition	X	X	X
Intrinsic motivation	X	X	X
Causal attributions	X	X	X
Goal setting and self-reactions	X	X	X
Social motivation	X	X	
Gender identity	X		
Cultural identity	X		

Figure 5 – Sources of Motivation and their Role in Self-regulatory Learning (SRL). (Ref: Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p.7)

< LESS Emphasis	MORE Emphasis >
Competing for grades	Improving and understanding subject matter content
Teaching curriculum	Teaching students
Teacher control	Supporting students as independent learners
Teacher lectures	Student discourse
End of unit/chapter tests	Frequent assessments and feedback
Passive learning	Active, cooperative, and inquiry learning
Teacher as dispenser of knowledge	Facilitating and encouraging students directed learning
One instructional strategy	Various instructional models
Memorisation and ROTE learning	Goal setting, self-monitoring, reflection and other metacognitive strategies
Correct answers	Effort, persistence, and thinking processes related to the correct answer

Figure 6 – Changing Instructional Approaches for Self-regulated Learning (Ref - Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research, and applications. Taylor and Francis Group LLC. p.356)

14.0 Pre-conditioning motivation in students using 1:1 devices

Malone and Lepper (1987), motivation is a necessary precondition for student involvement in any type of learning activity; what and how effectively students learn may be influenced by their level of motivation. Vogel and Kwok (2009) claimed that students' motivation plays a significant role in engaging and sustaining students to use 1:1 mobile devices for learning purposes.

15.0 Extrinsic and intrinsic motivation

Understanding the learners extrinsic and intrinsic motivations for wanting to use a 1:1 mobile device for learning and personal needs will help the curriculum designer to develop learning interventions suited to the technology platform that will be widely accepted. Deci and Ryan (1985) has noted that self-determined learner behaviour can stem from both intrinsic motivation (i.e., the learner engages in an activity because it is interesting or enjoyable) and from extrinsic motivation (i.e., the learner engages in an activity because he or she desires the outcome and wants to achieve some instrumental end such as earning a reward). Extrinsic motivators including activities performed for reward, or avoidance of feelings of guilt (Introjected regulation), activity performed because of its importance, value, or utility (Identified regulation), and activity motivated by own values system, interest and need (Integrated regulation). Marton and Siijo (2005) argues reliance on extrinsic rewards that rely on 'surface' learning result in unsatisfactory performance due to an absence of intrinsic cognitive process. Modelling appropriate strategies to show how a 1:1 mobile device can be used for learning will help learners to adopt values that are commonly shared within and outside of the learning space.

Malone and Lepper (1987) proposed that the following elements make an activity both intrinsically and

extrinsically motivating for a learner: challenge, curiosity, control, cooperation, competition and recognition. Malone and Lepper (1987) claimed that learners are more motivated when goals are clearly defined and when challenge is balanced in such a way that the learning process is neither too easy as to bore the learner, or too difficult such that success seems impossible. Malone and Lepper (1987) claim the goal is to develop learners who are self-directed and self-motivated, both because the activity is interesting in itself and because achieving the outcome is important. Where intrinsic motivation to learn is the educator's ultimate goal, extrinsic motivators such as cooperation, competition and recognition may be considered when designing learning environments or selecting instructional materials. Mupfiga et.al (2017) identified 'Flipped Learning' where students can watch videos made by their lecturers before they come into class, or record lectures as they are being done and later look at them during their study sessions. They could post them on their own blogs and have discussion with other classmates. Lecturers assume a facilitating role by proactively adopting 'flipped learning' whereby they upload more material beyond what is to be presented throughout the course, allowing students to download and study on their own using their 1:1 mobile device so that when they come into class there is more of discussing rather than presenting.

16.0 Allowing choice as a motivator

The nature and marketing of 1:1 mobile devices supports the student's perception of freedom of choice. Chou, Block, and Jesness, (2012) state the ability to adjust content to student level and allow self-paced learning may thus lend 1:1 device technologies as an ideal tool for implementing differentiated instruction in the classroom. What this suggests is there is an onus on the curriculum to differentiate the learning activities to allow for a number of entry levels that appeal to engineering students who are progressing through the course. This raises questions about the effectiveness of formative assessment to indicate a measure of learning, rather than pass or fail. Using a 'Bell Curve' of results as evidence of effective teaching may be counterproductive, if used in isolation to measure a student's motivation towards their learning performance goals.

17.0 Performance feedback motivates learning

Choice is also linked to individual learning progress. Using a 1:1 mobile device to complete tasks and receiving personal feedback via the device's messaging software. Malone and Lepper (1987) argue performance feedback and score keeping allows the individual to track progress towards desired goals. Valk, Rashid, and Elder (2010) states many 1:1 device games and apps are programmed to provide immediate feedback and thus provide continued motivation for those who are not motivated by traditional educational settings and assessment. Encouraging students to take short reward breaks during the learning by playing games on the 1:1 mobile device may not necessarily be counterproductive to the curriculum design and individual learning goals.

Malone and Lepper (1987) states cognitive curiosity occurs when learners discover that their knowledge is incomplete or inconsistent, prompting the user to explore and attain new information and competence with

the technology. Technology-enhanced environments afford individuals with almost limitless opportunities for exploration and ready access to information to support both sensory and cognitive curiosity (Malone and Lepper, 1987).

18.0 Collaboration as a motivator

1:1 mobile device technology facilitates collaborative learning. Johnson and Johnson (2003), cooperation (compared with competitive and individualistic efforts) promotes greater effort exerted to achieve and greater productivity; more 'on-task' behaviour, higher quality of relationships among participants (e.g., greater interpersonal cohesion, task-oriented and personal support) and greater psychological adjustment (e.g., greater social competencies, higher self-esteem).

Chou et al. (2012) states students can learn at their own pace, collaborate with others and offer advice to each other through various 'Apps' run on 1:1 mobile devices. Utilizing student-centred learning interventions and associated software Apps that support the curriculum design can encourage student collaboration and creativity, and a student centred, socially interactive classroom. This means making greater use of social media, like 'Facebook', Google Classroom, Edmodo and similar Apps during the learning process via a student's own 1:1 mobile device. Engineering curriculum design incorporates in-house systems that facilitate social interaction, although in many student spaces these are not compatible with a student's normalized learning environment. Niemlec and Ryan, 2009 state, consideration must be given to authentic collaborative opportunities with outside organizations to maintain student-learning motivation. The need to feel connected to other people to experience satisfaction, support and belonging in the environment where they learn is important to maintaining learning motivation.

19.0 Recognition as a motivator

Malone and Lepper (1987), states learners enjoy having their efforts and accomplishments recognized and appreciated by others. In order for an environment to engage the motivation variable for recognition, the results of the individual's activities must be visible to other people. Malone and Lepper (1987) states, this can be done in several ways: (1) the process of performing the activity may be visible, (2) the product of the activity may be visible, or (3) some other result of the activity may be visible. Using a 1:1 device as a tool to facilitate motivation for recognition seems logical. Students choosing to make a social statement about their motivation to learn through the choice of 1:1 device. Covili (2017) explains how Google are investing significant resources into shifting the fundamental understanding of what constitutes a learning space. Collaborative spaces accessible across the globe may prove appealing to motivate transnational and local students to collaborate. Engineering curriculum design to be relevant may need to incorporate a greater focus on establishing a collaborative international learning environment. Why can't classes include collaborative spaces across campuses to share knowledge and to equip students with an awareness of the importance of their contribution to the 'Bigger Picture' of engineering career and education research? Whilst the question is rhetorical, it is essential to be willing to challenge traditional understanding of what

constitute an effective learning space to appeal to what is motivating engineering students.

20.0 Environmental factors as motivators

Introducing a culture where 1:1 mobile devices can be accessed and understood as a valuable learning tool takes time, however, where it is necessary to implement structural changes to achieve learning outcomes, students and staff are able to accept change. Baeten et al. 2010; Entwistle et al. (2003); Vermunt and Vermetten (2004) have indicated that a large number of personal and environmental factors are linked to students' learning patterns. Supporting empirical studies have identified variables to explain how students cope with learning in specific learning situations. It is not solely determined by their general preferences but is the result of an interaction between their perceptions of the learning context, their disposition and other learner characteristics (Gijbels, et al., 2014).

Donche (2010), and Vermetten et al., (1999) has shown that some learning pattern characteristics are to some degree variable across course contexts and throughout time in higher education settings (In Gijbels et al., 2014). Gijbels and Dochy 2006; Vermunt and Minnaert (2003) states, inducing changes within students' learning patterns has, however, proven to be difficult in studies that took place in learning environments designed for that aim (In Gijbels et al., 2014). Donche and Gijbels (2013) state as part of the explanation for conflicting results in this latter domain of research may be generated by the conceptual base and measurement of student learning in these studies (In Gijbels et al., 2014). Recent empirical contributions in the domain of learning pattern research stress the need for further clarification of vital components of students' learning patterns. Gijbels et al. learning conceptions (Richardson, 2011) and learning strategies (Vermunt and Endedijk, 2011) and how these patterns develop in higher education in the 21st century (Vanthournout et al., 2011) (Gijbels et al., 2014).

This also brings in important questions concerning how differences and changes in student learning can be validly measured (Coertjens et al., 2013) and which future research perspectives are needed to increase our present understanding of student learning and development (Richardson, 2013) (Gijbels et al., 2014). Further research would need to be conducted to measure the impact of student and staff perceptions, should a focus be placed on using 1:1 mobile devices to improve student-learning motivations.

21.0 Discussion

Since 2009, 1:1 mobile device are an emerging technology that supports individualised learning goals, and presents as an opportunity for curriculum designers to rethink how to redesign learning interventions and spaces that will improve student motivation and learning outcomes. The premise of 'active learning' and freedom of choice are democratic values inherently included within engineering education learning spaces. Supporting these values will be how 1:1 mobile devices can be leveraged, where students can develop their curiosity and higher order thinking skills to solve problems and become part of a global learning community. Enabling an individual to engage in goal-directed activities over time and across changing circumstances

(contexts). Learners perceive the importance of equipping themselves with the ability to use cognitive operations to organize and review meaningful learning into packets of knowledge to support higher cognitive learning by using 1:1 mobile devices, is an important pathway to transitioning into a successful career pathway. In the future, traditional learning spaces will become virtual reality spaces as ongoing education and the workplace become integrated. The importance of 1:1 mobile devices as the future access point will become the norm, and will play a pivotal role in personal and professional socialisation. Unstructured learning environments will play an important role in developing perceptions of what constitutes life-long learning values. The 1:1 mobile device community is driving change and is generating a need to re-evaluate traditional teaching and learning models.

22.0 Conclusion

Motivational variables play an important role in shaping how a student perceives the engineering learning space. Importantly, its relevance to the enabling of higher education students to use 1:1 mobile device to source learning resources and identify relevant performance goals for continuous feedback. Setting learning expectations through effective role modelling, supports fostering of a culture of 'normalisation' where 1:1 mobile devices are considered an effective learning tool. Finally, encouraging a discussion amongst higher education curriculum designers and the wider engineering sector to encourage ongoing research around how to best support emerging technologies such as 1:1 mobile devices into the future and within virtual reality engineering classroom spaces. Connecting curriculum design to understandings of learner motivations and strategically placed learning interventions will improve student engagement and foster higher order thinking skills that are essential to the future success of the engineering and other sectors' intellectual capital.

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Figure 2 – Achievement Goal Endorsement – Freyer, J., and Elliot, A., (2008) – Stability and change in achievement goals. Journal of Educational Psychology. In, Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p. 60.

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Figure 6 – Changing Instructional Approaches for Self-regulated Learning (Ref - Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research, and applications. Taylor and Francis Group LLC. p.356)