Fostering Ownership of Learning in Engineering Education

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Structured Abstract

BACKGROUND
Engineering education is purposefully incorporating more active and online learning, with the Flipped Classroom becoming more prevalent (Bishop & Verleger, 2013; Reidsema et al., 2014). The interpersonal and thinking skills required from students to succeed in this new environment often require development, particularly in terms of improving their ability to learn and of taking more responsibility for their learning (Milner-Bolotin, 2001). These elements can be grouped in a broader concept, called Ownership of Learning (Wiley, 2009). Fostering Ownership of Learning (OL) across the curriculum appears to promote epistemological, ontological and practical benefits to student engagement (Barnett & Coate, 2005; Stevens et al., 2008). However, more information about the concept of OL became necessary, leading to an investigation to acquire further evidence of OL from engineering courses at the University of Queensland (UQ) that use the Flipped Classroom model.

PURPOSE
This paper explores the concept of OL in further detail, aiming to support engineering students operating in the Flipped Classroom environment. This concept is being used as a model to explain the phenomenon of students changing their way of engaging with their learning, due to the learning challenges of the ill-structured Flipped Classroom model implemented at UQ from 2012. In particular, the research presented in this paper will elaborate on why: 1) Developing OL is important for engineering students to build their professional identity and 2) Understanding OL is important for educators to design Flipped Classrooms in engineering education.

DESIGN/METHOD
Approaches to OL used in other disciplines were examined, critiqued and evaluated with respect to their applicability within the context of engineering education (Clark, 1991; Dudley-Marling & Searle, 1995; Wiley, 2009). This evaluation resulted in a tailored definition of student OL, which allowed the development of a framework for its investigation and future use in engineering courses at UQ.

RESULTS
Preliminary results indicate that OL is a process, which is stimulated by triggering events (Clark, 1991; Wiley, 2009). These findings have led to the development of a framework for identification of some stages (categories) of the OL process, with the establishment of its respective indicators. These stages involve students having beliefs over the value of what they are learning, feeling responsibility for their learning and performing actions to take control of their learning, allowing for the development of self-efficacy along the pathway to own their learning (Clark, 1991; Bandura, 1997; Shroff et al., 2013). An underlying principle for OL involves students being able to organize their own learning, over the curriculum, and to recruit teaching and guidance for themselves (Lave & Wenger, 1991).

CONCLUSIONS
Findings of this study suggest that fostering OL is an important pedagogical goal when designing courses and curriculum in engineering education. Evidence acquired from engineering courses at UQ indicate that OL is important for achieving higher order cognitive/affective skills, corroborating previous results from literature. Therefore, further data will be collected, to support and refine the OL theoretical framework being developed. This framework is expected to facilitate comprehension of why some students seem to do well in complex active learning courses while others do not, as well as enable a better understanding on why some courses appear to be more effective than others in developing OL.

KEYWORDS
Engineering Education; Ownership of Learning; Flipped Classroom.

Introduction

The engineering education sector is currently facing challenges that should be solved. Students entering engineering are lacking Ownership of Learning (OL) and an orientation towards mastery, with traditional lecture-based instruction methods contributing to this problem (Digital Promise, 2014 – p. 8). On top of this challenge, engineering education is purposefully incorporating more active and online learning, with the Flipped Classroom (FC) becoming more prevalent (Bishop & Verleger, 2013; Reidsema et al., 2014). This new scenario is requiring students to organize their own learning, and to recruit teaching and guidance for themselves (Lave & Wenger, 1991), posing additional challenges for students to cope with, and for the engineering education sector to solve (Quental, 2013 – p.9).

The motivation for this research lies in finding ways to help address these challenges, by investigating how students develop OL, and making a contribution for the uptake of OL across the engineering curriculum through adequate course/curriculum design, so we can help students to maximize their learning. An additional motivation for doing this research on the concept of OL was due to the implementation of two compulsory courses in the first year engineering program at the University of Queensland (UQ). These courses are called "Engineering Design – ENGG1100" (E1), offered in the first semester, and "Engineering Modelling and Problem Solving – ENGG1200" (E2), offered in the second semester.

E1 and E2 were designed with the concept of OL in mind, aiming for students to demonstrate OL, especially in terms of encouraging them to take responsibility for their own learning. The courses are deliberately scaffolded and make use of a FC model developed at UQ to assist on the goal of developing student OL. Course content is delivered via online modules, workshops and laboratories. Reflective writing is used as part of the assessment activities, encouraging students to develop OL by doing a meta-level review of their own performance over the course through writing (Quental, 2013; Reidsema et al., 2014 – p. 6)

It has been observed in both E1 and E2 that some students are changing their behaviour during the course, in a positive way. Evidence from analysis of student reflections in E2 (Quental, 2013 – p. 8), and anecdotal evidence acquired from E1 and E2 through interviews with course staff and class observations, indicate that these same students appear to become more proactive during these courses. These students are taking more responsibility for their learning through time, perceiving more value in what they learn and also becoming more motivated to learn engineering. In addition to that, coding of reflections from E2 indicate that students have developed the following types of skills:

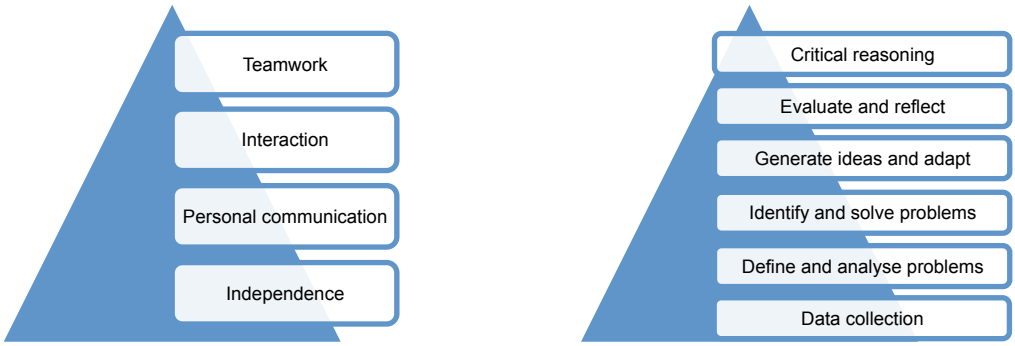

Figure 1: Interpersonal (left) and "Thinking" (right) skills developed by E2 students. Source: Reidsema et al. (2013)

However, another part of the cohort in E1/E2 still appears to be very critical to the FC model, not adapting well to it, being quite the opposite of the other group of students. These students still want to be "spoon fed" with knowledge, showing low motivation to learn, which also impacts on their final marks in E1/E2. As a consequence of this distinction between students that change their attitude towards learning and students that do not change it, the concept of OL is being used as a model to further understand this phenomena in more detail.

Moreover, particularly in E2, the concept of OL had two main roles: firstly, it was used as a Curriculum Objective (CO), especially through use of reflective writing. Secondly, it was also important for the FC model to work up to its full potential. The amount of content covered in E2 was too extensive to be given through a traditional lecture while at the same time meeting another CO: the integration of theory with practice to drive deeper conceptual understanding of engineering fundamentals (Reidsema et al., 2014 – p. 2). In order to help solve this problem, the content on engineering fundamentals was moved online, and split in several modules, requiring students to watch them in advance, and show up to classes prepared.

Students were also reminded by Course Coordinators and tutors that they needed to develop OL, especially in terms of being responsible for watching the online lectures prior to classes and engaging in the activities/workshops planned for the course. Otherwise, if not taking the responsibility of watching the online content and being engaged, students would not show up prepared to perform the problem solving activities and practical work that are also part of the course and, consequently, would not get full advantage of the course structure

Therefore, considering the increasing use of the FC, from the context of Engineering Education in general and from the UQ context in particular, it is important to encourage students to develop OL, as it draws attention to the role of students in their own learning (Dudley-Marling & Searle, 1995). Although fostering OL appears to promote epistemological, ontological and practical benefits to engage students in the curriculum (Barnett & Coate, 2005, Stevens et al., 2008), a better understanding of the concept of OL became necessary. Particularly, to comprehend why/how some engineering students seem to be better prepared to own their learning than others, and also why/how some engineering courses appear to be more effective than others in fostering OL.

Scope of this paper

In this paper, we explore the concept of OL in further detail, discussing how OL can be defined. Preliminary ways to identify and measure OL in engineering courses are also presented. A discussion on the development of OL across the curriculum is performed, showing initial recommendations for the design of course and curriculum to properly foster OL in engineering education. Preliminary results on what has been already found at the UQ context were also used as reference for the recommendations.

Our research involves two main hypotheses. The first involves investigating if FC courses that make use of Project-Based Learning (PjBL), heavily based on engineering design/build and teamwork, like E1 and E2, have particular elements within their course design that help students to develop OL more effectively than traditional courses. Then, we will identify what are these elements. The second hypothesis consists of assessing if some students that attend engineering at UQ are better prepared to own their learning than others, and then map the patterns that emerge from the analysis of student attributes/factors found in students that demonstrate OL. These attributes/factors might involve age considerations, gender, financial support, family background etc.

Study

This study on OL is being done at UQ, and is a work in progress. The focus of the study is on the courses E1 and E2, and the students involved in them. In order to determine how OL can be identified and measured, firstly a literature review on the concept of OL, as defined by several authors, was performed. After this review, a tailored definition of OL was developed. Based on this new definition, the instruments to assess OL in engineering courses were created. These instruments are based on a mixed methods approach to collect objective evidence of OL in engineering courses, and mainly consist of a survey and a set of semi-structured interview questions that are being conducted with engineering students.

As part of a pilot study on OL, an open call for volunteer students of E2 to join the research was made in 2014, forming a focus group. The survey, called Ownership of Learning Survey

Tool (OLST), is being applied to this group. The OLST will be administrated three times over E2, to assess how OL changes over time and for the purposes of validation of the instrument. In 2015, with the instrument fully validated, the OLST will be applied to E1 students as well, which will be then monitored in a longitudinal study to fully assess OL across the curriculum and over time.

With the purpose to complement the data from the OLST, the interviews will be performed with selected students from the focus group, and also with high performing senior students that show a set of desirable characteristics, such as resilience, proactivity, time management skills, etc. So far, only one senior student has been interviewed, and some data from the interview were used as basis for the recommendations to foster OL across the curriculum presented in this paper.

Exploring Ownership of Learning

What is Ownership of Learning?

The concept of OL is defined in different ways by different authors, especially due to distinct conceptualizations of the term Ownership (Wiley, 2009 – p. 10). A critical review of the literature related to OL was performed, which mainly involved analysing the works from Bandura (1977); Clark (1991); Dudley-Marling & Searle (1995); Bratman (1999); Milner-Bolotin (2001); Barnett & Coate (2005); Stevens et al. (2008) and Wiley (2009). Although different, these diverse views on OL have certain elements in common, which are summarized in Table 1:

Table 1: Summary of references to build OL framework, in light of current definition

References	Ownership of Learning Process				
	Triggering Event / Experience (Learning Triggers)	**Beliefs on learning (Convictional Dimension)**	**Desires & Goals to learn, (Psychological Dimension)**	**Actions & Plans to Learn (Behavioral Dimension)**	**Outcomes of OL Process**
Dudley-Marling & Searle (1995)	No.	Yes. Choice, based on beliefs over value of learning.	Yes. Autonomy, by exercising responsibility.	Yes. Control. Behaviours to take control of learning process.	No.
Milner-Bolotin (2001)	No.	Yes. Students find personal value in learning.	Yes. Feel responsibility for their learning.	Yes. Take control of learning process.	Yes. High Cognitive/ Affective Outcomes. Feel in control.
Wiley (2009)	Yes. Catalysing experience/personal calling.	Yes. Ownership as identifying with.	Yes. Ownership as right and responsibility.	Yes. Ownership as "buy-in".	Yes. Attitudinal reorientation leads to Lifelong learning.
Bandura (1977)	No.	No.	No.	No.	Yes. Self-efficacy beliefs.
Stevens et al. (2008)	No.	Yes. Identification Dimension.	Yes. Navigation Dimension.	Yes. Accountable Disciplinary Knowledge Dimension.	No.
Barnett & Coate (2005)	No.	Yes. Knowing Dimension. Epistemological aspects.	Yes. Being Dimension. Ontological aspects.	Yes. Acting Dimension. Practical aspects.	No.
Bratman (1999)	Yes. Events trigger a reaction, influencing beliefs & goals.	Yes. Beliefs, related to the informational state of the student, his beliefs about learning.	Yes. Desires, related to the motivational state of the student. Develop Goals.	Yes. Intentions, related to the deliberative state of the student. Develop Plans to achieve intentions. Perform Actions.	No.
Clark (1991); Mezirow (1991)	Yes. Disorienting dilemma/Integrating circumstances.	Yes. Convictional Dimension: changes of own beliefs.	Yes. Psychological Dimension: changes of understanding of self.	Yes. Behavioral Dimension: changes in lifestyle.	Yes. Transformative Learning.
Lave & Wenger (1991)	No.	No.	No.	Organise own learning, recruiting teaching/guidance.	Yes. Situated Learning.

During the review of the literature, a consistent pattern within the previous definitions of OL was noticed, which led to the development of a tailored definition. This pattern indicated that previous definitions proposed for OL were usually focusing either on cognitive (beliefs/convictions), affective (psychological) or behavioural aspects, which would be a limitation for applying them to the context of engineering education. We've also noticed OL was usually viewed as a "thing" instead of a process. Since OL was not viewed as a process, discussions about triggers and outcomes within a process were rarely mentioned.

In order to develop a more comprehensive definition of OL, it was necessary to: 1) Cover most previous literature and 2) Be more realistic in mimicking human experience so that OL could be properly assessed in the context of engineering education. As we know that a change of attitude involves changes of cognitive, affective and behavioural nature (ABC

modes of attitude, see Stangor, 2014), we propose OL to be viewed as a process, involving students changing their attitude towards learning - in terms of cognition, affection and behaviour - and that this change would happen over time. A view of OL as a process involving a change of attitude is also in line with what Wiley (2009) says about OL being "an *attitudinal reorientation* towards a personal learning quest" (Wiley, 2009 – p. iii and p. 52).

Based on the work of Clark (1991 – p. 146), we consider that the change of attitude that happens within the OL process over course and curriculum, involves: students reviewing their system of beliefs (Convictional Dimension), changing how they understand themselves (Psychological Dimension) and also modifying their behaviours & lifestyle (Behavioural Dimension). As a consequence of this change as a person, students develop high order cognitive & affective attributes, such as critical thinking and self-efficacy, which are outcomes of the OL process (Bandura, 1997; Milner-Bolotin, 2001 – p. 141).

The OL process appears to be influenced by trigger events (learning triggers) that happen within course and curriculum, which help the OL process to develop (Bandura, 1997 – p. 3; Bratman, 1999; Clark, 1991 – p. 149; Mezirow, 1991 – p. 168; Sim & Duffy, 2004 – p. 4; Wiley, 2009 – p. 42). These triggers appear to be either from an extrinsic nature, such as the imminence of failure, or of an intrinsic nature, like when realizing a personal talent (Clark, 1991 – p. 149; Wiley, 2009 – p. 42). A view of OL being “triggered” is also in line with what Wiley (2009) says about OL starting after "a *catalysing* experience or in the awakening of personal calling" (Wiley, 2009 – p. iii and p. 52).

In a university environment, the OL process appears to mainly unfold in two different levels of depth. The first level would be within a course, and involves students changing their attitudes towards learning, but this change would not be as deep as within the second level of depth. The second level would happen across the curriculum, with students going through a deeper change as a person. This change as a person is also aligned with the highest conception of learning proposed by Marton et al. (1993 – p. 284).

Based on data from Table 1, the adapted definition of OL that underpins the aims of this research involves five dimensions of the OL process, which are: Trigger Events; Beliefs on learning (Convictional Dimension); Desires & Goals to learn (Psychological Dimension); Actions & Plans to Learn (Behavioral Dimension) and Outcomes of the OL process. A graphical representation of the OL process is shown in Figure 2:

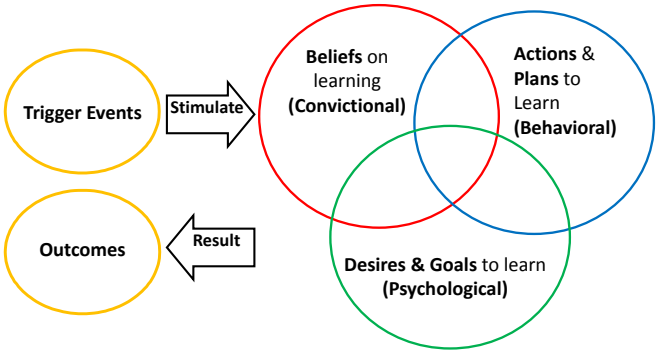

Figure 2: Framework of the OL process developed for this research.

OL is a variable related to human attitude, and therefore involving cognitive, affective and behavioural aspects (Stangor, 2014). Consequently, it is a continuous variable that can be measured using an interval scale (Milner-Bolotin, 2001 – p. 41; Shroff et al, 2013). This interval scale can be measured from Low OL to High OL, where Low OL would involve not fully developing all dimensions of the OL process highlighted in the framework of Figure 2, while High OL would involve developing all of them. Similarities within the literature reviewed in Table 1 appear to allow a correlation between levels of OL and other related concepts in learning theories, as they share similarities in terms of cognitive/affective attributes. This correlation is proposed in Table 2:

Table 2: Correlation between levels of OL and other related terms in learning theories

Ownership of Learning	Low OL	High OL
Approaches to learning (Biggs & Tang, 2007)	Surface Approach	Deep Approach
Achievement Goal Orientation (Middleton & Midgley, 1997)	Performance Goal Orientation	Mastery Goal Orientation with/without Performance Goal Orientation
Conceptual Change (Biggs & Tang, 2007)	N/A	Conceptual Change
Self-efficacy (Bandura, 1977)	N/A	Self-efficacy
Transformative Learning (Mezirow, 1991)	N/A	Transformative Learning
Situated Learning (Lave & Wenger, 1991)	N/A	Situated Learning

How can Ownership of Learning be measured?

The framework of the OL process shown in Figure 2 will be the basis to identify students that demonstrate OL within engineering courses at UQ. Based on this framework, the OLST was developed to measure OL. Data from the OLST will then be crosschecked with other evidence of OL acquired from courses at UQ, through interviews and class observations.

The OLST is divided in two parts. The first part of the OLST measures five Categories of OL, through a total of 37 questions on a Likert scale, while the second part has a set of reflexive questions. The Categories are the five OL dimensions, and, under each Category, respective Indicators were developed. The proposed indicators were mostly based on previous literature (listed in Table 1), to identify OL in further detail. The partial list of indicators for the OLST (questions 1 to 18) is shown in Table 3. Additional indicators of the OLST to specifically assess goal orientation (questions 19 to 37) are described later in the paper:

Table 3: Research keys for the first part of the OLST (measurement of OL)

Category	Indicators	Question
Triggering Event/Experience (Learning Triggers)	Drastic change towards learning - Rapid increase in motivation.	1
	Forced to learn subject - Avoid failure (extrinsic driver - performance goal orientated).	2
	Find new areas of interest (extrinsic driver - mastery goal orientated).	3
	Discover a natural talent (intrinsic driver - mastery goal oriented).	4
Beliefs on learning (Convictional Dimension)	Personal convictions on the value of learning.	5
	Believe it can connect prior with current knowledge - Connection with prior knowledge.	6
	Think skills are useful for the future/other courses - Connection with future knowledge.	7
Actions & Plans to learn (Behavioral Dimension)	Aim to take control of their learning - Perform actions to increase learning.	8
	Act as a Proactive learner.	9
	Plans for learning.	10
	Have ways of controlling their learning - Make decisions and choices within course/curriculum.	11
Desires & Goals to learn (Psychological Dimension)	Responsibility for activities during the couse - Outwards/Collective/Social responsibility.	12
	Responsibility for learning - Inwards/Individual/Personal responsibility.	13
	Goals for learning.	14
	Self reflection over own learning - Understanding of the self.	15
Outcomes of Ownership of Learning Process	Sense of ownership towards course activities - OL outwards.	16
	Sense of ownership towards own learning - OL inwards.	17
	Self-efficacy: believe is prepared for an assessment.	18

As it can be seen from Figure 2 and Tables 1 and 3, the Psychological Dimension of the OL process involves students feeling responsibility for their own learning and developing Desires and Goals to learn. It is also known within Goal Theories that setting Goals is linked to task psychological motivation, which guides behaviour (Middleton & Midgley, 1997 – p. 715).

One of the many existing Goal Theories is Achievement Goal Orientation theory (AGO). This theory involves the idea of being psychologically motivated to achieve learning goals. According to Middleton & Midgley (1997 – p. 710), this motivation can be driven by either a Mastery Goal Orientation (MGO) and/or a Performance Goal Orientation (PGO).

Coincidently, OL has already been considered related to motivation and AGO (Biggs & Tang, 2007 – p. 33; Milner-Bolotin, 2001 – p. 141). OL and AGO were also found to have some correlation along the timeframe of a course. As shown in Table 2, High OL has been found to correlate with MGO and, to a lesser extent, to inversely correlate with PGO, in terms of outperformance of peers (Milner-Bolotin, 2001 – p. 50 and 112).

Therefore, based on AGO theory, we can assume that the Goals developed by Students that demonstrate OL are driven by Mastery and/or Performance, and since OL and AGO are related, we have embedded AGO as part of the OL process and not something separate as

in previous works. In our approach, we propose AGO to be specific sub-categories within the Psychological Dimension of the OL process. The purpose of these sub-categories is mainly to assess what types of learning goals students develop and what is the psychological motivation behind them, which will guide their behaviour (Middleton & Midgley, 1997). Our new approach is shown in Figure 3, and the sub-categories with respective Indicators of AGO used in the OLST (questions 19 to 37) are listed in Table 3:

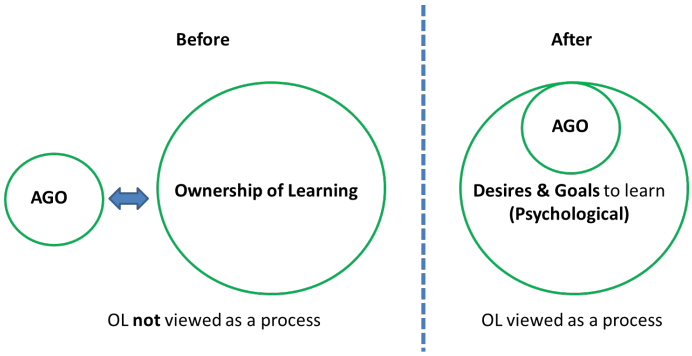

Figure 3: Approach of embedding AGO as part of the OL process.

Table 3: Research keys for sub-categories of AGO to assess goal orientation

Psychological Dimension AGO sub-categories	Indicators	Question
Mastery Goal Orientation (MGO)	Psychological Resilience.	19 & 20
	Want to learn new things.	21
	Enjoy thinking like an engineer (think on how own learning can be applied in real world situations).	22
	Seek to master the content of courses.	23
	Engagement on course gives motivation.	24
Performance Goal Orientation 1 (PGO1 - will to outperform peers: Performance-approach goals)	See as important to have better grades than peers.	25
	Aspire to be the only one in class able to answer questions.	26
	Aim to show to instructor that they are the smartest students.	27
	Seek to have better results on tasks than others.	28
	Aim to show to peers that they are the most intelligent.	29
Performance Goal Orientation 2 (PGO2 - fear of showing lack of competence to peers: Performance-avoid goals)	Seek to not perform lower than peers.	30
	Afraid of peers thinking they are unintelligent.	31
	Think their performance indicates their level of intelligence to peers.	32
Performance Goal Orientation 3 (PGO3 - fear of showing lack of competence to instructors: Performance-avoid goals)	Engagement in course to show to instructors that do not know less than peers.	33
	Afraid of instructor thinking they are unintelligent.	34
	Think their performance indicate their level of intelligence to instructor.	35
Performance Goal Orientation 4 (PGO4 - fear of showing lack of performance to self: Performance-avoid goals)	Fear of failure in the course.	36
	Fear of failure in the engineering program/curriculum.	37

Fostering Ownership of Learning across Course & Curriculum

Our initial data acquired indicate that active learning pedagogies, especially PjBL, help students to better develop OL when compared to traditional lecture-based methods. Based on the data acquired so far, the main reasons appear to be that PjBL pedagogies give students more opportunities to take responsibility for their learning and to find personal value over what they learn, as they are able to learn by doing practical activities and enjoy that experience.

Since the introduction of the FC requires the use of active learning pedagogies, which in engineering might specifically involve the adoption of PjBL, it is important for educators to better understand the OL process when planning to flip their engineering courses and properly develop high order cognitive and affective attributes in students, which are linked to outcomes of the OL process. In addition to that, OL may also be an important concept to enforce as a CO and for the FC model to work up to its full potential, as it was experienced in the UQ context, where students had to take responsibility for their learning in watching the online resources in advance to get the most out of the course structure.

In Figure 1, independence/autonomy was the most interpersonal skill demonstrated by E2 students. Since autonomy is developed by exercising responsibility, and thus related to OL (Table 1), it might be an indication that the E2 FC model played a vital role in developing OL.

Students that demonstrate OL have a strong sense of individual responsibility within a course (Milner-Bolotin, 2001) and also collectively across the curriculum (Barnett & Coate, 2005. This might indicate that if students constantly exercise individual responsibility across the curriculum, they expand it to a collective level, feeling more responsible for others as well. These are the two main types of responsibility in Social Psychology (Gouveia et al., 2003).

Therefore, since responsibility appears to be developed and expanded across the curriculum, engineering educators might need to consider this phenomenon when designing course and curriculum, thinking in advance on the best ways to help students to fully develop OL in terms of responsibility, for example, by implementing activities that involve teamwork.

In our current understanding of the OL process, one of the main aspects of the Convictional Dimension involves students developing strong beliefs (convictions) about the knowledge they learn. Students are able to extract personal meaning from this knowledge, finding it relevant (Milner-Bolotin, 2001 – p. 42; Shroff et al., 2013). Although further investigation is necessary, preliminary evidence indicates that the main elements that form the professional identity of students are these convictions over what they learn, acquired over time across the engineering curriculum, as learning and identity are inseparable (Lave & Wenger, 1991).

On the other hand, identity also involves elements that would fit more within the Psychological Dimension of the OL process, such as how they understand themselves (Stevens et al., 2008 – p. 357). This way, it is important for students to fully develop OL, encompassing these two dimensions, in order to fully build their professional identity. So, in order to help students fully develop their engineering identity, educators should design course/curriculum with the goal of allowing students to extract personal value over what they learn, within course and across the curriculum. This appears to be possible through the implementation of more practical activities and PjBL. Thus, the values students acquire over time will build up well and then will be integrated into their professional identity, as engineers.

Conclusions

Although fostering OL appears to be a relevant pedagogical goal, further research is necessary to understand this process in more detail. The adoption of the concept of OL as a CO appears to be helping students to properly engage in the FC model and supporting them to organize their own learning over course and curriculum (Lave & Wenger, 1991).

Encouraging students to develop OL appears to be assisting them to engage with the engineering curriculum in terms of Knowing, Acting and Being, i.e. it is allowing them to situate their learning, figuring out what they need to know, what they need to do and what does it mean to them as a person (Barnett & Coate, 2005 – p. 3; Lave & Wenger, 1991; Marton et al., 1993 – p. 284). This way, through the results of our research, we hope to help not only students, improving their performance, but also all staff involved in the design of engineering courses and curriculum.

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