If I don't have a language to discuss and think about it then it's not part of my reality

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STRUCTURED ABSTRACT

CONTEXT
Learning is socially and culturally constructed by the learner. However, a social construction requires a language to allow students to think about, evaluate and discuss their learning. We propose that students often fail to recognise their own learning shortcomings because their available learning literacy limits their capacity to understand, evaluate and address issues with their learning.

PURPOSE
To investigate how engineering students behave and respond to being introduced to learning theories, dispositions and affective processes to provide them with a vocabulary to understand, evaluate, discuss and address issues with their learning.

APPROACH
How students behaved and responded to these activities was investigated through exploring the evidence from a number of different studies conducted in the 1st, 2nd and 3rd year subjects. In the first-year subject a student survey, tutorial observation study and content analysis of students' portfolios was conducted (the content analysis identified references to learning dispositions, affective processes and learning frameworks). In the second-year subject a small number of students agreed to undertake a semi structured interview while in the third-year subject a student survey was used to explore the impact of the learning activities on student learning and professional development. Elements of these three different studies are reported here.

RESULTS
These preliminary findings indicate the benefits of developing student's language to facilitate their ability to understand, evaluate, discuss and mindfully reflect on their learning and learning dispositions.

CONCLUSIONS
The evidence suggests that having a language about learning improves both student's feelings of competence and their learning motivation. We also recommend introducing these activities in a first year of university for the benefits to accumulate and to embed sustainable changes in student's learning culture and their learning trajectory across their whole degree.

KEYWORDS
Learning dispositions, reflection, agency, self-efficacy, affective processes, learning language

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Introduction

Goldsmith (2018) comments that the traditional delivery of engineering curriculum reflects a positivist epistemology (Radcliffe, 2006) which values propositional knowledge, i.e. knowing about things. This epistemology places emphasis on knowledge acquisition; it is generally aligned with educational beliefs that knowledge is seen to be an independent entity and focuses on the transmission of knowledge from lecturer to student (Samuelowicz & Bain, 2001). This type of pedagogy promotes learning for reproduction (Beswick & Ramsden, 1987) and learning by students as passive recipients of the knowledge transmitted by their instructors.

The higher education sector has recognised the need for improving STEM education. Much of this improvement has focused on engaging students in blended learning activities as opposed to the traditional chalk and talk approach. These activities including flipped, project, problem and/or enquiry-based learning all require students to actively engage with and take an independent and responsible approach to their learning.

While these changes have bought many benefits to STEM students they rely heavily on students being able to take much more responsibility for their own learning than in traditional lecture-based subjects (Reidsema et al, 2017). Recent studies based on interviews with engineering students at an Australian university (Willey & Gardner 2014a, b, Willey et al 2014, Gardner et al 2014, Willey & Gardner 2015) have shown that many students that perform poorly in flipped learning environments typically do not demonstrate the agency and self-efficacy necessary to take responsibility for their own learning. We found many students who struggled with these more independent approaches had become accustomed to expecting specific guidance in their learning, being told what to think, learn and do. They felt unsupported when they had to exercise their own judgement. When student's learning expectations are not met, they often blame the instructor rather than recognising the need for them to develop the associated skills.

Similar findings are reported by other researchers from a range of learning contexts such as Buckingham Shum & Deakin Crick (2012), and Thomas (2013). Deakin Crick and Goldspink (2014) refer to the link between learning dispositions, agency and identity and how students' thinking about these concepts, such as self-efficacy, frames their future learning trajectories. While engineering programmes generally address propositional knowledge, we argue that developing an ongoing learning identity trajectory is also significant for students' learning.

Learning is socially and culturally constructed by the learner (Boud,1993). However, a social construction requires a language allowing students to think about, evaluate and discuss their learning. We propose that students often fail to recognise and/or blame others for their own learning shortcomings because their available learning language limits their capacity to understand, evaluate and address issues with their learning. In this paper we investigate how engineering students behave and respond to being introduced to learning theories and affective processes to provide them with a vocabulary to understanding, evaluate, discuss and address issues with their learning.

Context: integrated engineering program

The integrated engineering program is a series of subjects that form part of the core requirements of undergraduate engineering courses at the University of Sydney. The multidisciplinary subjects (one at each year level) are designed to develop and apply technical engineering and professional skills to authentic sustainable real world projects and workplace practices.

The aim of the program is to build an understanding of the nature of engineering and what it means to think and practice as an engineer. The four units were conceived to move student's through the following four stages:

- understand and analyse the concepts that underpin engineering;
- think like an engineer in undertaking design of technologies;
- act as an engineer to solve problems through creating systems;
- lead engineering innovation in solving societies challenges.

In addition to developing specific technical and professional skills (such as teamwork, communication, and an understanding of ethical and professional practice) the subjects develop core fundamental skills –such as an ability to analyse one's own capabilities, plan their development and manage their own learning. In this paper we report the impact of activities designed to develop student's capacity to cultivate these fundamental skills. In particular, we focus on the activities developed to provide students with a language to allow them to think about, evaluate, identify, discuss and address issues with their development and learning.

First year: Integrated Engineering 1

In a large (600 students) multidisciplinary first year integrated engineering class students are introduced to learning theories (constructionism), metacognition and affective processes including self-efficacy and agency. Students were given pre-work activities to research and investigate these terms and student personas to use to provide context to evaluate and explain the perceived development. In tutorial classes the results of these pre-work activities were discussed after which additional personas and role-plays were used for students to develop a language and have discussions about different behaviours and responses to learning. In subsequent activities students reflected on their own learning and developed plans to take action to address any identified areas of development. The prework and discussion within the activities are deliberately designed for students to develop a language to reflect on, evaluate, understand and improve their learning, learning dispositions and processes.

We used what became known as the 'pirate method' which had students continually assessing their performance against the 4 R's (reflection (metacognition), resilience (self-efficacy) resourcefulness (agency) relatedness (social aspects of learning including collaboration). In the second iteration of this subject the Crick Learning for Resilient Agency (CLARA) framework (Learningemergence, 2015, Deakin Crick et al 2015) was also introduced. It provided another layer to help students identify and construct their understanding of their learning dispositions and extend their language to think about and evaluate their learning (Gardner et al 2017).

As part of their assessment students had to undertake a group design project. The narrative used to scaffold the design project had student working as teams of interns for a fictitious company. At the end of the semester students had to apply for a part time design engineer position with the company. This required them to write a cover letter and respond to two of the selection criteria. The selection criteria were taken from actual advertisements for engineering positions and were chosen to reflect the professional development required by the discipline and recognised in accordance with Engineers Australia level 1 competencies (Engineers Australia 2013). To assist them in preparing their application students were required to maintain a portfolio within which they planned, monitored and evaluated their development of the skills listed in the selection criteria using the reflective framework previously described.

Second year: Integrated Engineering 2

In the second year subject, which is again a large (600 students) multidisciplinary flipped engineering class, the concepts introduced in first year are reinforced and students are expected to apply them at a higher cognitive level in their learning within their group project and maintain an assessed reflective portfolio that includes planning, monitoring and reflective evaluation phases

Third year: Integrated Engineering 3

In the third-year multidisciplinary class (320 students) again there is a focus on using language and reflective portfolios for students to evaluate, plan and assess improvement in regard to their learning profiles. In particular, in this unit the results of the first year studies (Gardner et al 2017) are used to highlight engineering students' relatively lower developed creativity and mindful agency and the importance of these attributes and curiosity in regard to finding innovative solutions in engineering contexts. This is a flipped class with workshops/tutorials, but no lectures, so students are expected to take responsibility for their independent learning in this subject. Students engage in a series of pre-work, workshop and reflective activities. In the first workshop they use the CLARA questions and typical behaviours of people with each attribute to assess their current development. They then apply a number of strategies including those outlined in CLARA to further develop their learning dispositions. The results of these activities are assessed through self and peer review of contribution within a group project and a reflective portfolio.

Method

How students behaved and responded to these activities was investigated through exploring the evidence from a number of different studies conducted in the first, second and third year subjects. In the first-year subject data was collected from a student survey, tutorial observation study and content analysis of students' portfolios (the content analysis identified references to learning dispositions, affective processes and the 4R's). The tutorial observations were all undertaken by one of the authors who was from another university and hence not involved in any subject assessment. This provided consistency across observations and aligned with requirements of the ethics approval for this study. In the second-year subject a small number of students agreed to undertake a semi structured interview while in the third-year subject a student survey was used to explore the impact of the learning activities on student learning and professional development. Elements of these three different studies are reported here.

Discussion

First year subject

Students reported the previously described activities gave them a better understanding of how they learn and empowered them to think differently and respond to any learning difficulties they may encounter. In the first year unit the students found the personas and role-plays as effective means for them to safely engage, discuss and understand the learning theories, affective processes and learning dispositions before using them to evaluate and plan improvement in their own development. In observed tutorials students were able to explain the learning dispositions of the persona their group was working with – for example "We rated her high on belonging because…." and "He shows low creativity here where it says…".

Students were comfortable to openly discuss and provide feedback on the personas even when in the large 600 student class. One particularly engaged student commented that she got a high rating for 'belonging' in her CLARA profile – she said she interpreted this as showing that she "belongs" in this class and this gave her the confidence to participate (answering questions, showing a diagram on the document camera etc in the large lecture theatre).

The content analysis of student reflective portfolios showed many students reflected on their individual CLARA profile using the results to plan their continued development as a learner as evidenced in the following quotes. We have also included an indication of the student's overall final subject result, their gender and whether they are domestic or international students:

> *Currently, my learning profile does not differ very much as to how I see myself as a learner. It accurately reflects me with high learning dimensions of curiosity, hope and optimism and sense making, whilst also reflecting my weaknesses in low collaboration and mindful agency. (Credit, male, domestic student)*
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> *At first, I have thought it was completely wrong. However, after a while, I have agreed more with CLARA outcome. The reason for this is I may lose or lack in creativity due to heavily depending on team members…. Since I was bit shy/afraid to give different opinions, this may have reduced my creativity. To solve this issue, recently, I am working hard to plan my time and manage it more efficient way. After doing 'CLARA' self-reflection, it feels like that I have better sense of myself, and found the way that I should be directing myself to... (Pass, male, international student)*
>
> *Belonging has resulted as my second weakest learning dimension… I see myself as independent and someone who can find support when needed but as shown in the learning profile, the belonging dimension expresses my inability to seek assistance from people when I need it the most. This has made me realise that I have remained so independent that even when I find difficulty in understanding or when I get stuck in any situation, I keep my problems to myself and hope that somewhere along the way I will find a solution or solutions to all the questions that I am keeping to myself. (Distinction, male, domestic student)*

> *The least parts of the graph in the learning profile are the Collaboration and Belonging. I got to admit that I have trouble with this two areas in my life. I felt like these are the two things I should focus and improve most. I need to balance out the way how I rely and ask people for help and opinions. Even though I treasure my alone time very much, having to ask people for help is healthy as it opens me up to the things that I could have never thought before. Thus, I will try to improve myself by going out there with my own pace. (Pass, female, international student)*

The instructors noticed that the activities assisted students to be able to think about and more clearly articulate their learning needs, resulting in them taking more responsibility for their learning and their learning journey. Further evidence of this was found in correspondence with the coordinating academic where students sent emails using the terminology "I am using my agency", "after reflecting on this I have demonstrated my resilience". This further demonstrates that even in first year the use of these terms was becoming part of the student's language in both describing and thinking about how they undertake and evaluate their learning.

Second year subject

In the second year subject students were expected to use the concepts taught in first year to plan, monitor and evaluate their learning and professional development in a reflective portfolio while undertaking a group work project. Online resources were provided to support students to reflect on and discuss their learning. In line with our ethics approval only students who were currently not undertaking an Integrated Engineering unit were invited to be interviewed. Of these, four students agreed to participate in the semi structured interviews to explore the impact of the social construction and language activities on their learning and professional development. When asked what they didn't like about the Integrated Engineering subjects, student A commented that some of this material (learning theories and affective processes) was common sense and although highlighting her learning needs, she believed this would have occurred naturally without intervention. Further discussions with student A revealed she valued the technical knowledge of engineering over the professional practice attributes. It should be noted that student A was an engineering/music double degree student and hence her skill set, experience and attributes are quite different from the majority of the remaining cohort. Conversely, students B and C (both male) felt the activities gave them a valuable new way to think about and evaluate their learning and development. In addition, student B commented that he could see the value of being better informed and that having an improved capacity to reflect on his learning and development would be beneficial in his future professional career. These initial results indicate the variation in both perceived value and benefit to students of developing their learning language. What was clear from the four interviews is that students who valued these type of learning activities were able to use the language to reveal something about themselves and their approaches to learning and they thought that this awareness would benefit them in their professional engineering career.

Third year subject

Eighteen students agreed to complete a voluntary survey (cohort 320) exploring their approaches to learning and learning dispositions. The results show a clear difference in the reported impact of the learning activities between those students who had undertaken the previously described first year subject and those that had undertaken an earlier version of the subject in which the learning dispositions and learning language were not introduced.

Students who had been introduced to the concepts in first year reported being comfortable in using them and the associated language to describe and assess their learning. Respondents overwhelmingly reported that the activities were both beneficial and valuable helping them to plan actions to further improve their learning and their learning dispositions. They also helped them to infer how their peers learn enabling them to better collaborate with them:

> *The "workshop activity helped me think about how I need to change my behaviours and approaches to improve my learning".*

> *"The activity helped to gain a perspective on my fellow classmates and their learning experiences"*

In contrast, for students who did not undertake the first-year unit, that is, they were encountering these terms/theories for the first time, only a small minority of respondents indicated that the online resources and activities provided significant benefit, approximately a third reported they had some benefit, while nearly half found they were unable to recognise the value. Their free response answers suggest that many students were unsure about how to use and/or engage with these activities seeing them as disconnected or were unable to find the relevance to their learning.

> *"The topic is not related to my field at all".*
>
> *"Vague and confusing"*

Findings and Recommendations

While these initial findings are not definitive they do indicate the potential benefits of developing student's language to understand, evaluate, discuss and mindfully reflect on their learning and learning dispositions. The following comment illustrates the benefit for students in being able to understand and evaluate their approaches to learning:

> *I got between 'Open Readiness' and 'Fragile Dependence', a little more towards open readiness, but I think I have a tendency of feeling unmotivated and have an inclination of giving up on things that are difficult, especially after spending a long time on it and seeing minimal/no progress so* ***I didn't know there was a phrase that describes this****. (Distinction, female, domestic student).*

We would suggest that this language also contributes to improving student's feelings of competence (or reduces feeling of incompetence that result from not be able to describe or understand what one is experiencing) and their learning motivation.

The results also suggest the importance of introducing these activities in students' first year of university where arguably there is less resistance and more openness to change. We expect that this will also facilitate deeper engagement, allow students to accumulate more benefit and to embed sustainable changes in their learning culture and their learning trajectory.

We advocate that this approach would also benefit other disciplines similar to engineering such as business, science and medicine where, unlike the social sciences, students may not be introduced, nor have the opportunities in their studies to apply, discuss and reflect on learning theories, affective processes and dimensions of learning.

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