Evaluation of reflective writing in a first year Engineering course

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Structured abstract

BACKGROUND
A new first year second semester course, ENGG1200 "Engineering Modelling & Problem Solving" was implemented at the University of Queensland, Australia in 2012. The course required students to take charge of their own learning through unique delivery of content comprising online modules, workshops, laboratories, and teamwork. Assessment included a series of reflective writing tasks with the twofold aim of developing and enhancing students' integrative writing skills while at the same time asking the individual student to explore and comment on their own progress within the course. In this study, the focus is on the last reflection (R5), which aimed to gauge student's perceptions of personal goal attainment within the course, their involvement in the course, what lessons they had learnt and what helped them during the process/course. This paper presents and discusses preliminary results obtained through semantic analysis of the reflections and comparison with other related student data. Previous studies from (Reidsema et al., 2009 and 2010; McAlpine et al., 2007) show that while the use of student's critical reflections to evaluate student learning has been on the initial evidence successful; the practice is still rare in Engineering courses.

PURPOSE
The reflective writing responses of students were analysed to determine: 1) The quantitative and qualitative measures that might indicate individual students are taking ownership of their learning, through the use of semantic analysis; 2) Specific patterns in the reflections related to student learning (Vermunt, 2004) and 3) Determine the degree to which students' reflections correlate (Ericsson & Simon, 1985) with their actual performance within the course, by comparing it with other student data.

DESIGN/METHOD
Students' reflective writing answers (N=824) were transferred to a database that also contained individual student data relating to performance and team peer assessment. The individual answers were then exported as a simple text file for semantic analysis using a proprietary text traversal tool to extract the frequency of key words or phrases and their contextual use. The analytic approach was to focus on the use of the first person in the student responses, particularly when used in conjunction with words or phrases associated with learning or phrases related to "ownership of learning".

RESULTS
Current preliminary results indicate that: 1) Ownership of learning has been achieved by most students in the course; 2) The majority of students believe that they have reached their learning goals during the course; 3) Students are heavily reliant on course tutors and this may be an obstacle to the development of ownership of learning and 4) Teamwork was the most mentioned help during the course amongst students.

CONCLUSIONS
The continuous use of reflection as a learning tool within ENGG1200 appears to help student engagement, design thinking and ownership of learning. R5 data will also support course improvements based on students' feedback and help staff during teaching. Using semantic analysis to assess the reflections proved to be good and useful, being recommended for research on future student writing assessments. However, it is very important to make the stimulus questions as neutral as possible when using reflective writing. This way the students are not "coached" in their response and won't necessarily tend to use keywords that are also expected during the analysis. The more neutral are the questions, the more accurate the semantic analysis will be.

KEYWORDS
Engineering education; reflective writing; ownership of learning.

Introduction

Throughout the global university sector, and most particularly within the discipline of engineering, there has been an increasing trend towards achieving high quality outcomes based educational goals. This trend has developed with the revision of accreditation standards that encourage the improvement in developing graduate attributes. Several recent reports funded by the Australian Council of Engineering Deans (King, 2008) and the Royal Academy of Engineering (Graham, 2012) point towards a number of critical issues that are shared by universities in Australia. Some of these issues are: the demand for engineers continues to exceed graduate supply; decreasing financial resources for teaching and laboratories in engineering schools; worsening student-staff ratios; high levels of student attrition; uneven exposure of engineering students to contemporary practice; difficulties in appointing experienced engineering practitioners; and the balance of subjects within current engineering curricula, which is not adequately matched to graduates' and industry's current and future needs.

On top of these issues, there is also the challenge to increase student engagement during the engineering program; their capacity for design thinking and also for ownership of their learning. Addressing all these problems will require significant innovation and improvements to curriculum design and delivery. It's also necessary to have a greater emphasis on the use of online technologies and authentic active learning models, allowing for the transfer of fundamental engineering theoretical knowledge to industry relevant practical and abilities based knowledge and skills. One approach to solve these issues is reflected in the development of blended learning environments. These environments need to combine online technologies with intense active learning, that support students engaged in semester or yearlong team-based design projects. This approach allows students to learn the required engineering fundamental concepts in an applied and authentic environment, without increasing research-focused teaching resources. At the University of Queensland (UQ), Australia, a major innovative learning project that exemplifies this approach is underway throughout a new first year course called ENGG1200 "Engineering Modelling & Problem Solving". This course was implemented at UQ in the second semester of 2012.

The ENGG1200 course requires students to take charge of their own learning through unique delivery of content, comprising online modules, workshops, laboratories and teamwork. Lectures were minimized and used only to showcase best practices. The focus of this course is to partially solve some of the issues observed in the engineering curriculum. It is especially aiming to improve student engagement, their capacity for design thinking and ownership of their learning. Regarding ownership of learning (OL), we followed the definition from (Milner-Bolotin, 2001). The term is comprised of three major components of the learning process by students: finding personal value; feeling in control and taking responsibility.

One form of assessment in ENGG1200 is a series of reflective writing tasks. These tasks have a twofold aim of developing and enhancing students' integrative writing skills while at the same time asking the individual student to explore and comment on their own progress within the course. With students learning how to reflect, their technical and professional competencies could be developed through reflective writing (Reidsema, 2010). By implementing reflective practice in this course, our aim is to provide not only student benefit but also staff benefit. We can have a better idea on what students think, what are they learning and their concerns in the course. With all this information we can provide a more complete help to students during their learning process and also re-design the course whenever necessary.

The reflective writing exercises were held in an innovative environment, where a new teaching practice in Engineering was developed for the ENGG1200 course, using the flipped classroom model (Brown, 2012). Project Based Learning and Problem Based Learning pedagogies were implemented in the course. The concept of Massive Open Online Course (MOOC) was used as basis in ENGG1200. A video based learning system that runs out of

the centralized Learning Management System (Blackboard) of UQ was also designed. This online system delivers 22 videos on engineering materials that students had to watch during the first part of the course. Each week's concepts are reinforced by on campus activities, comprising of a one hour workshop, two hours of materials classes and two hours of problem solving classes per week. Therefore, the online content delivered is consolidated with active learning on campus, in order to maximize student learning. An online navigational aid, called a Learning Pathway, was also developed for this course, and it aims to help students navigate (Stevens, 2008) through such complicated theory-application type courses as it is the case of this course.

A total of five reflective writing exercises were assigned during the course to a class of 912 students and no previous training was provided for this task. In the first reflective writing exercise (R1), students were asked to declare what goals they wanted to achieve. For the last reflection (R5), students were then asked if they reached their goals declared in R1. Reflections R2, R3 and R4 had questions about specific contents of the course. In this study, the focus is on the last reflection (R5), which aimed to gauge student's perceptions of personal goal attainment within the course. In order to perform the last reflective writing exercise (R5), students were instructed to provide a written reflection of between 200 and 300 words and answer the three following questions: 1) Critically review your involvement in the course. Did you meet your goals? 2) What were the key lessons learnt? and 3) What helped you during the process?

Based on the work of (King, 2008) and (Moon, 2004), a reflective writing rubric was developed incorporating four criteria: Depth, Insight, Logic/Clarity and Feedback. This rubric was used to assess student writing in R5. Each student reflection was classified on a mark from 1 to 5 for each of the four criteria. A mark of 1 means a poor reflection, 2 a mixed reflection, 3 an average, 4 a good and 5 an excellent reflection. So, the maximum mark a student could achieve for R5 was 20, which means he would have gotten a mark of 5 in all 4 criteria. This paper presents and discusses preliminary results obtained through semantic analysis of the reflections and presents other relevant student data found. Thematic analysis will be performed at a later stage of this research. Previous studies from (Reidsema et al., 2009 and 2010; McAlpine et al., 2007) show that while the use of student's critical reflections to evaluate student learning has been on the initial evidence successful; the practice is still rare in STEM (Science, Technology, Engineering and Mathematics) courses.

Goals and hypothesis

The primary aim of the research was to understand what might be the quantitative and qualitative measures that indicate individual students are taking ownership of their learning. This will be achieved by performing a semantic analysis of the reflective writing exercises. Therefore, the first research goal was to verify what kind of information can be extracted from the student data in terms of students' perceptions of achievement and the factors underpinning the observed continuum of ownership of learning.

The second goal was to identify specific patterns in student learning (Vermunt, 2004) within students' R5 responses. Some patterns we want to check are, for example, if the average impression of students over the course had a specific comment/subject in common or if they had a similar critique about a particular aspect of the course or if a particular lesson learnt was always mentioned by them. So, by identifying these specific patterns in students' reflections, we want to assess if was there a common event that helped or hindered their learning. With deeper understanding of patterns like these, new learning methods may be implemented and eventual changes in the course could be done. After a preliminary analysis of students' R5 answers, four hypotheses were defined to be tested in search for some of these patterns: 1) Most students thought they had met their goals for the course; 2) Tutors were the source of help during the course/process mentioned by the majority of students; 3) Learn how to use *Creo* (design software) was the most mentioned lesson learnt by students; 4) Time management was the biggest constraint during the course among students.

The third and last goal of this study is to determine the degree to which student's reflections correlate (Ericsson & Simon, 1985) with their actual performance within the course, by comparing it with other student performance data from individual and group assessments, such as marks, GPA etc. We want to check the accuracy of the reflections in representing a true measure of student ownership of learning through this comparison. By confirming this accuracy, it will be able to support the assessment proposed in our first goal with respect to ownership of leaning during ENGG1200. We also plan to make a comparison between students' declared goals presented in the first reflection (R1) with their statements in R5 (first question) about completion of these goals in ENGG1200 and assess its relation to ownership of learning during the course.

Methods

The steps of the research are summarised in the workflow shown below:

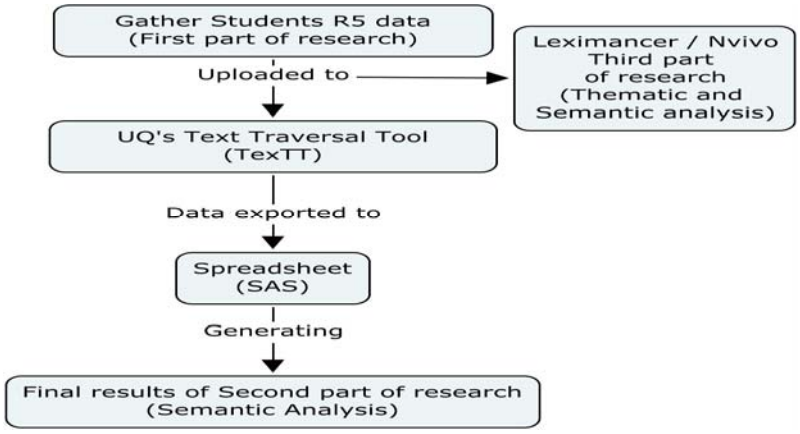

Figure 1: Research workflow.

In the first part of the research, students' reflective writing answers (R5) were organized in a student database, together with additional individual student data related to performance and team peer assessment. The R5 answers were also manually split according to the three respective questions related to R5. This way, four different files were raised: one for each R5 question and one comprising all R5 questions. This was done in order to seek additional patterns in the reflections, as we aspect each of those files to show distinct patterns, since the questions were different.

The second part of our research comprised the analysis of all R5 data by performing semantic analysis on the four R5 files. These files were uploaded into UQ's proprietary software called Text Traversal Tool (TexTT). This step of the research is still in its initial phase, as only one R5 file (R5 answers to all questions) was analyzed with TexTT. The aim with TexTT was to extract the frequency of keywords or phrases and their contextual use in a sentence. Within this software we could: select the number of word phrases (WP) to be searched together as a group in the R5 data; visualize the respective list of the most frequent groups of WP for a selected number of WP; and also the frequency for each one of the WP (WP count). After selecting in the software a particular group of WP from the WP frequency list, we could read all sentences in the R5 data that contained that particular group of WP and also its frequency (sentence count). The third and last part of the research will be to perform similar work as in the second part, but doing deeper research in semantic/thematic analysis using more powerful softwares such as *Leximancer* or *Nvivo*.

Although TexTT was the main tool used for the ongoing second part of the research, additional manual analysis on the data output from TexTT was performed using a MS Excel Spreadsheet (SAS). After uploading the R5 file to TexTT, the outputs were copied to the SAS, in order to finish the semantic analysis. To achieve the first and second goals of the research, the 20 most frequent expressions with four WP listed by TexTT were copied to the

SAS, as well as the WP count numbers and Sentence count numbers. All sentences for each of the four WP groups listed were copied too. Within the SAS, we've defined for each WP group if they were applicable to assess ownership of learning (goal 1), possible learning patterns (goal 2), or both, based on requirements mentioned below. Then, each sentence was classified as either "Positive", "Neutral", "Negative" or "N/A", according to individual analysis and depending on the subject (goal 1 or 2), which is also described below.

We established two WP requirements (WPR) before considering a WP group suitable for assessment in terms of ownership of learning (goal 1). The first WPR was that a WP group needed to present or indicate at least one writing structure using "Subject + Object + Verb" and at least one first person pronoun, such as "I", "me", "mine", "my", "we" and/or "us". That would be a first indication of personal engagement with the situation described by the student and also reflection capability, as the students were supposed to develop their own story when writing the reflections. The second WPR was that a WP group also needed to have at least one verb that showed independent thinking by students, such as "feel", "believe", "think", "find", "will", "can", "learn" and "know". In case the above requirements were not met in a particular WP group, we could still consider it suitable for assessment in terms of ownership of learning. However, it was necessary to check if most sentences within this WP group fulfilled those WP requirements.

After selected the WP groups suitable for assessment in terms of ownership of learning (OL), two sentence requirements (SR) were established for the sentences within these WP groups, before considering OL as "positive". The first SR was that at least one of the following keywords (or related words/subjects) would necessarily need to be present in a sentence: "Materials", "Problem solving", "Modelling", "*Matlab*", "Design", "*Creo*", "Manufacturing", "Communication" and "Teamwork/Team". These keywords were established since they are directly related to the eight Learning Objectives of ENGG1200, mentioned in its Course Profile. The second SR was that a sentence needed to show at least two out of the three characteristics that define OL, which were mentioned in the introduction. Having only one characteristic of OL is not enough to state there was OL, and at least two traits are required (Milner-Bolotin, 2001 – p. 41). If only one of the SR was met, we classified a sentence as "neutral", and left it for further manual analysis (i.e. manually read the reflection). If none of the SR were met, the sentence was classified as "negative". If the sentence was out of scope compared to what was being evaluated, we classified it as "N/A".

To consider a WP group suitable for assessment in terms of learning patterns (goal 2), the only WP requirement was that it needed to present something meaningful that could indicate a pattern in student learning or related to the course. The keywords mentioned in the first SR of goal 1 were a good indication of possible patterns. Then, it was verified what sentiment was expressed by the students in each sentence within the selected WP groups. Sentences were classified on either "positive" or "negative" according to sentiment analysis. If a sentence didn't show either positive or negative sentiment, it was marked as "neutral". If the sentence was out of scope compared to what was being evaluated, we classified it as "N/A". In order to assess hypotheses 1 and 2 of this second goal we've used a different approach, since there was no sentiment involved in the questions to be answered. We've picked a sample of 424 students randomly selected from the database and did a manual reading (straight from the database), in order to check if the hypotheses were correct.

Results

From a class originally of 939 students that registered for ENGG1200, it was noticed that 912 finished the course, receiving final grades. The remaining 27 students withdrew the course (dropout rate of 2.9%). From the 912 students that finished the course, it was noticed that 824 students had done Reflection 5 (824 entries, i.e. 9.6% of students haven't done R5). From these 824 responses to R5, the answers were also split according to the 3 questions related to R5, which led to the following numbers: 822 students answered question 1 (99.8%); 797 students answered question 2 (96.7%) and 716 students answered question 3

(86.9%). The fact that question 3 was considerably more "ignored" by students than the others may indicate something, but this still needs to be investigated.

The current research results for goals one and two are summarised in Table 1 below:

Table 1: Analysis of the 20 most frequent four word phrase expressions from TexTT.

Expressions from TexTT		Answers to all three Questions ("AllQ.csv" file)						
Word phrase group (WP group)	Item	Applicable for goals?	WP count	Sentence count	Positive sentences	Neutral sentences	Negative sentences	N/A sente.
my involvement in the	1	1 and 2	100	90	42	40	8	0
the problem solving sessions	2	2	94	68	45	13	5	5
materials and problem solving	3	2	92	89	53	12	3	21
i believe that i	4	1	90	77	36	40	1	0
i feel that i	5	1	86	68	30	37	1	0
the beginning of the	6	2	83	62	N/A	N/A	N/A	N/A
of the course i	7	1 and 2	82	33	21	12	0	0
at the beginning of	8	2	102	98	N/A	N/A	N/A	N/A
at the start of	9	2	86	88	N/A	N/A	N/A	N/A
involvement in the course	10	1 and 2	95	96	33	61	1	1
that i have learnt	11	1	74	66	55	11	0	0
i was able to	12	1	71	41	40	1	0	0
the start of the	13	2	68	55	N/A	N/A	N/A	N/A
involvement in this course	14	1 and 2	65	63	15	45	3	0
believe that i have	15	1	64	64	27	36	1	0
and problem solving sessions	16	2	63	53	31	22	0	0
i believe i have	17	1	63	50	23	27	0	0
i feel as though	18	1	62	52	29	23	0	0
as much as i	19	1	59	47	22	25	0	0
to be able to	20	1	58	40	31	8	1	0

Semantic analysis was performed on the 20 most frequent WP groups using four word-phrases, within the R5 file with answers to all three questions. For the first goal, WP groups related to items (second column, from left to right) 1, 4, 5, 7, 10, 11, 12, 14, 15, 17, 18, 19 and 20 provided perceptions of achievement in terms of ownership of learning. Most sentences within these WP groups fulfilled our requirements for OL (classified as "positive"), which indicates that most students in the course have managed to own their learning.

For the second goal, several possibilities for patterns in student learning were found. From items 1, 10 and 14 we found indications that the involvement of students in the course was positive. For the seven remaining items that are shown in Table 1, additional information was also extracted. Items 2, 3 and 16 indicated a positive sentiment with respect to Problem Solving sessions. Particularly for item 3, it was indicated a positive sentiment with respect to Materials sessions as well. Items 6, 7, 8, 9 and 13 are being considered for further research on students' performance by comparing it in the beginning of the course (items 6, 8, 9 and 13) and in the end of the course (item 7). It was noticed that item 7 is usually used in the sentence "...at the **end** of the course I...". However, further investigation is necessary. We intend to do future assessments on other possible learning patterns, as well as checking hypotheses 3 and 4 of our second goal, which are currently under investigation. The idea behind assessing these patterns is also to conclude if there was a common event that helped or hindered learning.

During the classification of the sentences, we've noticed some challenges. For example, TexTT only shows the sentence where the highlighted WP group is inserted but not the remaining sentences related to that particular sentence before and after it. So, in case a particular sentence did not fulfill our classification requirements, it is still possible that this could have been fulfilled by a sentence before or after it. However, we were unable to know that based on the output from TexTT and therefore the assessment was limited on some sentences. TexTT was very useful as a first filter of R5 WP groups and its sentences, leaving

fewer entries to be assessed manually and thus saving research time. The other challenge noticed is that sentences from TexTT are not discriminated between students. In other terms, we cannot know in advance to which student a sentence refers to. Additionally, for a particular WP group, two or more sentences shown in TexTT could be from the same student. This would be a problem when checking the percentage of students that thought they'd met their goals for example. In other words, for a particular expression that could confirm hypotheses 1 ("Students thought they had met their goals"), such as "I met my goals" (4 word phrase expression), two or more entries could be from the same student, distorting the actual real situation/percentage of students that thought they actually had met their goals. That is why we preferred to do a manual reading of the reflections in cases like this, where this situation was possible. Using the word-phrase and sentence counters of TexTT instead of thinking in terms of number of students may overcome this flaw but this still needs to be confirmed. We can also manually crosscheck each sentence from TexTT to match a student in the database, but takes much more research time, especially in the case of word phrase groups of +1000 sentences.

Regarding the first hypothesis of our second goal, the following results are shown in Figure 2. For the students that have not presented a clear answer whether they had met their goals or not (4.48%), further analysis will be necessary.

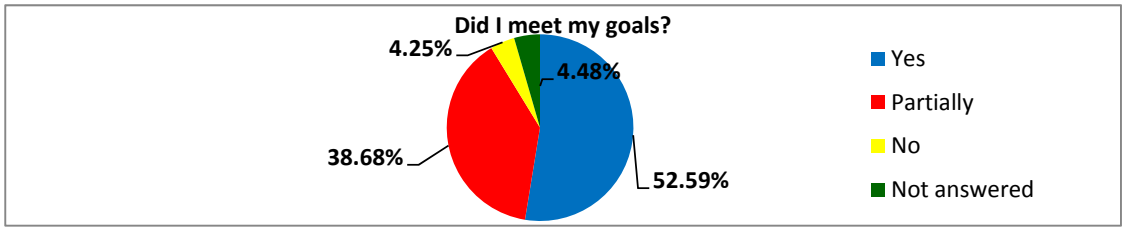

Figure 2: Percentage of students' answers whether they think they met their goals.

It was also noticed that some students weren't able to clearly communicate what their goals were at the beginning of the course in R1 and therefore some R5 data was impacted by this. Consequently, in these cases, R5 can only really be evidence of whether students "felt" that they had achieved their learning goals. We identified what students stated to be their goals in R1 and will compare this data to the R5 answers whether they were met or not. We will also compare this with the standard goals expected in the ENGG1200 course as well. Figure 3 below shows the results with respect to hypothesis 2 of our second goal:

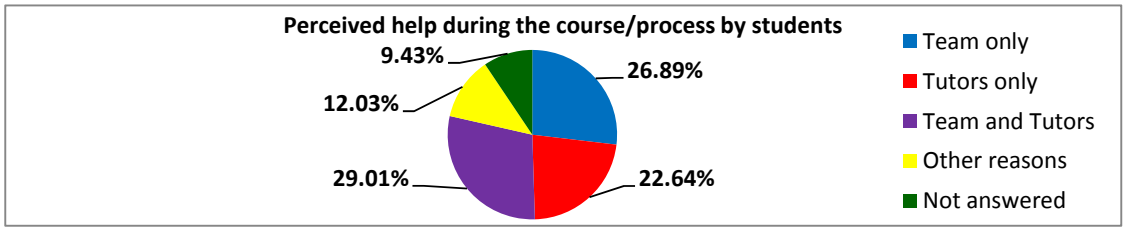

Figure 3: Percentage of students' answers on help perceived during the course/process.

Again, for the students that have not presented a clear answer of what helped them during the process/course (9.43%), further analysis will be necessary. A number of 10.4% of students that stated a clear aspect that helped them during the course/process, also said Peers (friends from other teams) helped them too. Hypotheses 3 and 4 of our second goal are still under investigation.

Overall, six common patterns have been found in the reflection 5 responses, so far: 1) Students' sentiment on their involvement in the course was positive; 2) Their sentiment on problem solving sessions was positive; 3) Their sentiment on materials sessions was positive; 4) Students are heavily reliant on course tutors and this may be an obstacle to the development of ownership of learning; 5) Most students believe that they reached their learning goals at the end of the course what proves our hypothesis 1 was correct. However,

this “feeling” needs further investigation by comparing with other assessments that happened during the course, as well as grades (third goal). This correlation between grades and intent/goals is still under research; 6) Most students believe that their own Team was the biggest help during the process/course with Tutors as the second most mentioned help by them. So, our hypothesis 2 was incorrect. The Team, instead of Tutors, was in fact the most mentioned help during the process according to students. These results from the analysis of patterns helped to improve the next offering of the class (Semester 2, 2013) as tutors were better briefed to the requirements for student ownership of learning, and a series of active workshops were performed to help students with the pace of content delivery.

Regarding our third goal, it will need further research and we will need to foreground student data with the questions that were asked in the reflections. For example, if a student reported in the reflection exercise that he learned something profound and valuable but his performance in the team was poor, what does this tell us? Or, if a student reports that didn’t achieve his learning goals but did well in the assessments, what does this tell us too? We’ve already raised some data to reach this goal, which is shown below. The number of students for each mark in Reflection 5 of ENGG1200 is shown in Figure 4:

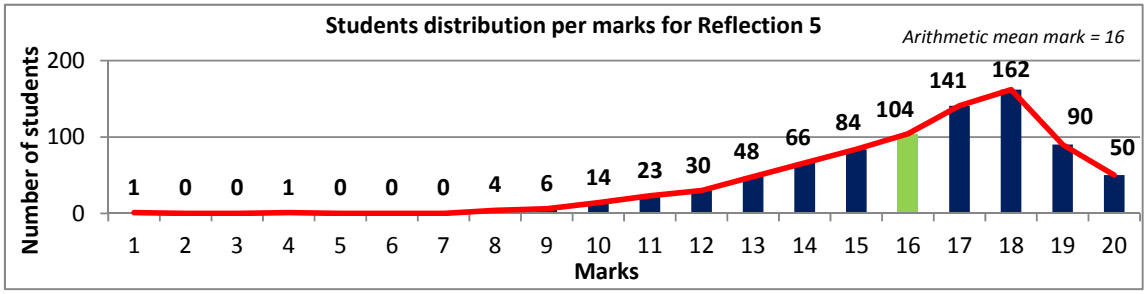

Figure 4: Number of students for each mark in Reflection 5.

The use of the reflective writing rubric highlighted that many students scored poorly both in Depth and Insight whilst only a small number of students learned something quite profound about themselves, scoring ‘Excellent’ both in Depth and Insight on their reflections. The arithmetic mean mark in R5 was 16 out of 20. Only 6% of students managed to obtain a mark of 20 (Excellent overall performance). It can be noticed a significant contrast in students performance on reflection 5, which will need further analysis to explain the reasons behind that. Several fields were included in the student database, in order to cross check with the content and grades of the reflections. To date, the following fields that can be compared with R5 have been included: PAF (Peer Assessment Factor); GPA; ENGG1200 grade; SAPA (Self Assessment to Peer Assessment Factor); Age; Project designed during the course (either A, B, C or D) and Student level at university. The third part of the research on semantic and thematic analysis using *Leximancer/Nvivo* has not been started yet, but we plan to perform deeper research on the reflections data and compare it with our current results from the second part of the research, when we used TexTT.

Conclusions

Initial results indicate that ENGG1200 was a successful experience for students and that Ownership of Learning has been demonstrated by a significant number of students during the course. This conclusion was mainly based on the analysis of the students’ last reflective writing exercise (R5). By owning their learning, it is also expected that students are able to organize themselves personally and professionally, according to the attributes established by Engineers Australia, mentioned in item 3.5 of the document (Engineers Australia, 2011). The analysis of students’ reflections has helped with course improvements, which were implemented in the offering of the class in Semester 2, 2013. The continuous use of reflection as a learning tool within ENGG1200 will help keep the course constantly up to date with students’ needs, in order to support their learning. It will also be able to help professors and tutors stay fully aware of the subjects within the course that students tend to struggle

more to own their learning. One limitation of the study on this paper is that it was done using data only from the 2012 offering of ENGG1200 (one semester). The 2013 offering of ENGG1200 is still underway and its data have not been collected yet.

The methods of data analysis using semantic analysis proved to be good and useful, being recommended for research on future student writing assessments. Another lesson learnt from this research is regarding the development of the reflective writing questions and its application to semantic and thematic analysis. It is very important to make the stimulus questions as neutral as possible. This way the students are not “coached” in their response and won’t necessarily tend to use keywords that are also expected during the analysis. The more neutral are the questions, the more accurate the semantic and thematic analysis will be. With the results of this research, two outcomes will be possible: support the ownership of learning of students and also provide directions for improvements in the course. It will be able to have a better idea of how students perceive this new Flipped Class, which presented theory and learning content online, required them to "own their learning" by being prepared for face to face activities on campus and that also engaged them in "authentic" engineering practices.

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