Exploring the Impact of in Class Writing Exercises in an Engineering Course

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***Abstract*—Employers of engineers expect from their new graduates to be not only technically proficient but, also demonstrating good communication skills at the workplace. Despite these high expectations, no special measures are taken by most engineering faculties and engineering educators for fostering such attributes. Writing has long been seen as a tool to develop communication skills. The introduction of short writing exercises in class not only can improve writing skills of students but may also help in fostering 21st century skills. This introductory study explores the impact of in-class writing activities in a third-year engineering course with a view to improve written communication skills and promote critical thinking through real-world problem-based learning. The writing exercises were peer-reviewed by the students. The data was collected through a paper-based questionnaire containing closed as well as open-ended questions. The survey findings showed that these activities were perceived positively by students and improved their writing skills. It also stimulated students to learn, and apply their knowledge to solve real-world problems and provide constructive feedback on peers' work. The initial findings provide enough encouragement to further explore the implementation of teaching and learning activities based on writing as a strategy to foster written communication skills.**

Keywords—writing practice, engineering education, peer assessment, communication skills, and teaching/learning strategies.

I. INTRODUCTION

Communication skills are important attributes for today's engineering graduates [1] which is one of key outcomes required by an undergraduate engineering programme under the ABET Engineering Criteria 2000 [2] and Washington Accord accreditation standards for Engineers [3]. Engineers spend at least 60% of their work in technical collaboration [4]. They not only produce technical designs but also communicate these designs in written form to diverse audiences ranging from the general public to their technical peers. Formally, these writings take on many forms such as proposals, design requirements, project progress reports, memos, and emails. Poor communication is said to be the reason behind some of the most catastrophic engineering failures such as the Space Shuttle Challenger disaster (1986) and loss of the NASA Mars Climate Orbiter (1999). Lack of written communication skills at the workplace can also have negative effects on stress levels, deadlines, morale, and health, which in turn can lead to misinterpretations adversely affecting the problem resolution capability resulting in time wastage and inefficiency at work.

Despite the fact that engineering employers expect graduates to possess a high level of written communication skills, no special measures are taken by many engineering faculties and engineering educators to foster such attributes and as a result, students often fall short of the expected communication skills [5]. There is sufficient evidence that engineering graduates do not meet the standard of communication required by the industry which is a regular feature of any engineering job [6], [7]. Therefore, there is continuous demand from industry for improving the communication skills which is regarded as crucial for making progress in this career. A study conducted by a Polish educationist showed that students find it more difficult to communicate in written form than orally [8]. Interestingly, writing is seen as part of engineering job but not as part of engineering [9]. This is further complicated by the fact that many teachers in engineering faculties believe that it is the responsibility of the students to develop their communication skills [10].

The engineering curriculum emphasizes mainly the acquisition of technical and disciplinary knowledge which leaves an impression on the students that writing is not an important skill for engineers. Though our engineering curriculum includes some writing instruction, those are mainly done in groups which are certainly not enough to gauge students' competency at essential communication skills in particular writing skills due to inequity of the contribution. This is further endorsed by the lack of questions related to communication skills in the examination [11]. The process of learning is often entirely based on performance (marks) and lacks constructive feedback on writing due to the high cost associated with it. To provide detailed writing feedback would allow for a learning process based on the experience of presenting by reflecting on the comments from assessors and their marks. The downfall of this approach is that any large increase in student numbers places a logistical strain to provide sufficient feedback to aid learning [12].

In order to be relevant in today's world, universities need to respond to the demands of industry by developing graduate competencies beyond the disciplinary demands such as good communication skills. It is hard to incorporate new courses into an already crowded engineering curriculum for this additional

competence. One way to achieve these skills is to integrate them with subject modules. We envisage that incorporating relevant and well implemented activities can improve communication skills. This research explores the impact of in-class writing activities in engineering with a view to improve written communication skills and promote critical thinking through real-world problem-based learning. The exercises are designed so that it does not compete with the otherwise depleted resources of teaching and marking time thus making them viable for implementation in a Year III engineering course, Digital System Design I. The finding of this study will encourage other practitioners to include such exercises in their course design to improve written communication skills and develop other graduate attributes towards employability.

II. Impact of Writing Exercises

Universities are ready to embrace a new class of students who are born and raised in the twenty-first century which has seen a tremendous growth in communications and information technology. As a result, digital gadgets and technologies have become indispensable components of their lives which have also significantly changed the way students are educated. Consequently, traditional methods of university teaching need to be replaced by the new ones which are increasingly based on this technology [13]. Wilson [14] notes that old-style instruction methods are no longer good enough in a society that has undergone "a paradigm shift from emphasizing teaching to emphasizing learning" (p.119). The students are no longer fascinated by the transmission mode of teaching and prefer an active classroom environment where they are engaged more and more [15]. The lecture method is considered a relatively poor pedagogical technique as it does not help students maintain their attention which begins to decline after 10-15 minutes [16]. Short attention spans are characteristics of the current student generation, also termed as the restless generation [17]. Writing activities can be seen as an instruction method to overcome this issue as they are regarded as a more active learning method. Therefore, such activities can be used to engage students in the classroom.

Higher education institutions in New Zealand attract many eager students from all over the world resulting in a massive influx of international students. This together with other recent immigrants who do not have English as their first language, constitute a significant chunk of engineering classes in New Zealand, a trend that is observable in other Western tertiary education providers worldwide. Lack of proficiency in English results in communication barriers which restricts students' class participation. Since they are not confident in speaking English, a reluctance to speak and participate in discussions in class can pose a major learning barrier. This can impact academic progress as students' learning due to reduced class participation and deserves some serious attention by educators. As an instruction method, embedded writing activities can be an effective technique to engage students who are shy and less active in class. It provides them with an alternative way to communicate with the class.

The problem solving, critical, and creative thinking skills are regarded as crucial competencies required for future engineers to be able to successfully deal with the technological challenges. It is also considered as one of the most important indicators of student learning quality which was also evident from a recent AACU [2], indicating that 93% of higher education faculty perceives analytical and critical thinking to be an essential learning outcome [18]. It is well established that good critical thinking skills benefits students in achieving well academically as it is linked to good grades. It also helps them make good decisions in life in general through reasoning. In short, critical thinking skills are one of the most valued outcomes of a quality education. Writing is an instructional method, which has long been perceived as a way to enhance critical thinking and problem-solving skills [19]. Therefore, short writing exercises can be used as a tool to foster critical thinking and help engineering students deepen their understanding of complex engineering concepts [20].

The main purpose of engineering education is to prepare its graduates for solving complex engineering problems. Therefore, exposure to real-world situations during their studies assists in acquiring the skills which are fundamental to the practice of the profession. This not only helps students obtain a profound knowledge of the design skills, but also trains them to link the theories to solving practical problems that occur in real-life [21]. We believe that there is a strong need to develop instructional activities in engineering education which will develop their skills to deal with real-world situations.

Writing is fundamental for improving students' learning. Learning happens through an instant generation of ideas (forward search) whilst reviewing writing helps the writer to transform her ideas through interaction between the rhetorical goals and content (backward search) as described by Flower [22]. Flower considers writing as a thinking process directed towards solving a problem. When students write with a view to solve a problem, they have to analyse a situation, link with past experiences, and come up with a strategy to solve the problem. In terms of socio-cultural theories, writing is expected to promote learning as it is socially constructed and collaborative [23].

The literature suggests that writing activities as instruction method can enhance motivation to learn, critical thinking, and retention of knowledge, leading to a deeper understanding and appreciation of the subject being taught [24], [25]. Despite the fact that writing activities not only help learning but also address the above mentioned issues, these are scarcely used in engineering courses. This paper describes the results of a research undertaken by the authors to develop a teaching methodology in the form of embedded writing exercises to develop attributes such as writing skills and critical thinking considered absolutely necessary for emerging engineers.

III. Writing Activities

This teaching methodology was incorporated into a third-year of computer systems engineering course in the form of six in class simple writing exercises which had been perceived well by the previous year students.

A. *Writing Activities*

The writing activities are designed based on Keller's [26] model which considers motivation as an important factor for

learning whereby attention is a pre-requisite and forms an important element of motivation for learning. Keller's ARCS (attention, relevance, confidence, and satisfiability) model focuses on classroom activities that enhance student engagement. The writings activities used in this research are designed in a way to foster an engaging learning environment related to the real-life application of their learning, motivate them through an intellectual challenge, the peer review fills them with confidence, and they get satisfaction through reward in the form of marks. Also, the satisfaction is directly linked to the level of motivation and positive consequences in the form of praise (through feedback) or award (marks) were used to motivate the student.

We used the Analysis-Design-Development-Implementation-Evaluation (ADDIE) model for designing these writing activities for engineers. In the first step, students analyse the engineering problem to be solved for the benefit of the community. In the next step, they devise a solution to the problem. Finally, they give the possible implementation of their solution to be evaluated by the peers. Receiving feedback on their own writing and providing them with a chance to improve it, was one of the highlights of these exercises. In most of the courses, the student submits the project report and feedback is available in the form of marks. Even if a written feedback is provided, it is not effective as students have already submitted their final work for grading and they do not bother to look deep into the feedback provided and rectify the weakness pointed out in the feedback. These writing activities are designed in a way to encourage students to carefully consider the feedback and respond to it by incorporating the suggestions into their writing and resubmit the updated version for another peer review.

The objectives of these exercises were to:

- Engage the students in class
- Develop insightful, critical, and creative thinking
- Learn how to formulate and communicate constructive feedback on peers' work
- Learn how to gather and respond to feedback on their own work
- Provide a connection with social contexts and real-world community issues.

There were a total of six short writing exercises as described below:

- ***Writing Exercise 1A***: Think of a real-world digital system which could be used to solve an existing problem in the community. You are required to identify the problem, suggest a title for the project and describe how it may benefit the community. Your description should be between 100 – 200 words, strictly. This activity will be peer-reviewed and marked by at least two other students.

- ***Writing Exercise 2A:*** Consider the real-world digital system proposed by you in writing exercise 1 and give an accurate and thorough description of it so that a designer is able to design a system based on the description provided by you.

- ***Writing Exercise 3A:*** Give a description of how you would implement the system proposed in Writing Exercise 2A using Field Programmable Gate Array (FPGA). What are the pros and cons of your implementation? What resources are used? Compare an FPGA based implementation with a micro-controller based implementation.

- ***Writing Exercise 1B, 2B and 3B***: Incorporate the feedback provided by your peers into your writing and re-submit your improved version. This activity will be peer-reviewed again. You should post both the old and new writings.

The students were meant to complete the writing exercises during the lecture time. To ensure equitable access to learning activities and respecting students' time commitments with other engagements, students were allowed to complete the activities after the lecture. These writing exercises were synchronized with the lecture contents, lab work, and the mini-project. As a requirement of the course, it was not compulsory for students to complete the activities but it did carry some very low percentage of marks as a reward for motivating them.

B. Peer Review of Writing Activities

One of the issues with the writing exercises is that they very time consuming for teachers and teaching assistants already constrained by other academic and teaching commitments. If teachers have to spend excessive time to conduct exhaustive activities then this effort overshadows the benefits of the practice. These drawbacks were avoided by sharing the responsibilities with students making this practice cost-effective. The responsibilities of assessing a large number of students' writing exercises are assigned to students and teacher took the role of managing these activities [27]. Since this was a summative assessment, problems associated with peer grading, for example, inaccurate marking, must be considered as students have a tendency to under mark [28]. Two measures were adopted to counter these potential problems. Firstly, the peer assessments were a double blind-review process with clear instructions and, secondly, it was moderated by the lecturer with a view to improving the accuracy [28].

C. Peer Review Instructions

- Peer comments should focus primarily on the quality of idea and the arguments that support the idea
- Be polite when giving comments, do not use harsh words
- Appreciate a good idea, use positive words and sentences.
- Give your suggestion on the title
- Point out if something is ambiguous.
- Ask an open-ended question if something is not clear to you. Write longer but fewer comments.

IV. METHODOLOGY

A. Background

The study was conducted in the third-year engineering course consisting of computer systems engineering students. The main aim of this research was to assess the usefulness of the writing activities towards students' understanding of the Digital System Design course. It is a 15-point medium/advanced course in digital system design intended at Year 3 students of a four-year undergraduate program at the Electrical and Computer Engineering Department. It builds upon the knowledge and skills acquired in Fundamentals of Computer Engineering; a prerequisite of this course taught in the second-year. The objective of this course is to give the students the theoretical basis and practical skills in the design of medium size modern digital systems using Field Programmable Gate Arrays (FPGAs). Topics covered in this course include digital systems implementation technologies; abstraction levels; hardware description languages; structural, architectural and behavioral modelling; register-transfer level design; data-path and control units; fixed and microprogrammed control units; ASM charts; synthesis from ASM charts, digital computation; verification; design of a simple processor; using FPGAs as the prototyping technology. All these topics are presented with the theoretical part directly relating to a number of design examples and problems tackled in the tutorials, laboratories, and also a design project. The students who pass this course should have sufficient design skills to work on projects in the area of digital system design. This is an important course as it is a prerequisite for three other advanced level courses. This course is taught using team teaching technique [29] to broaden lecture overage and reduce workload. It uses the sequential motif of teaching [30], two of the academic staff equally share the responsibilities. It has two major components comprising Hardware Description Language which is used to implement the digital system and the digital system design flow. Each lecturer teaches a part of the course while, logically related, have clearly marked boundaries. This is also the general practice at the university. The course is designed predominantly using Traditional/Discipline-Based and Cognitive Approach [31]. The course learning outcomes (CO) provided in Table I are mapped to program outcomes (PO) in Table II. The mapping is provided in Table III which shows a misalignment of PO5 which is not matched to any CO explicitly. Also, there is no topic covering the written communication.

TABLE I. COURSE LEARNING OUTCOMES

	Course Outcome
CO1	Use and apply principles and techniques of modern digital systems design which ranges from medium to large scale digital systems
CO2	Use modern design methodology based on a hardware description language (VHDL) to design complex digital systems
CO3	Design and synthesize digital systems using register transfer level (RTL) methodology clearly distinguishing between data processing and control part of systems
CO4	Apply the systematic design flow from the digital system design specification to the implementation, where the target technology will be field-programmable gate arrays (FPGAs)
CO5	Verify digital systems functionality using simulation and test-benches before real implementation and understand basics of simple processing and memory systems.
CO6	Prototype medium scale digital systems based on FPGA technology

B. Sample

Sixty undergraduate students from a large metropolitan university in New Zealand participated in the study (15 females; 45 males; average age 21 years). All participants were enrolled in a Year 3 Digital System Design I course and received no course credit for participating in the experiment. Participants represented an undergraduate discipline of Electrical and Computer Engineering. There was no obligation on students to participate in the research and provide the feedback. Students gave informed consent to take part in the current research which was completely voluntary. Thirty-six students responded to the paper-based questionnaire, which was included in the final quantitative data analysis.

C. Methods

This is an exploratory study investigating students' perceptions on whether embedded writing exercises enhanced their conceptual understanding of real-word problems through writing and peer review. A cross-sectional questionnaire consisted of six closed questions (Likert type scale) and also included three open-ended questions. The quantitative data was summarised using descriptive statistics whilst the text responses were analysed in NVivo v 11 software (QSR) using a general inductive approach for analysing qualitative open-ended response data [32]. An open coding scheme was followed by thematic categorisation, during which similar conceptual categories were merged in order to create larger concepts.

TABLE II. PROGRAM OUTCOMES

	Program Outcome
PO1	Fundamental knowledge in computer systems
PO2	Practical skills in hardware and software design
PO3	General problem-solving skills required in the design and building of the systems
PO4	Project work
PO5	Verbal and written communication
PO6	Exposure to a variety of existing and leading-edge electronic, hardware and software technologies

TABLE III. PROGRAM AND COURSE LEARNING OUTCOMES MAPPING

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
PO1	√	√	√			
PO2				√	√	√
PO3					√	√
PO4	√	√	√	√	√	√
PO5						
PO6			√	√	√	√

D. Evaluation

In order to explore the impact and effectiveness of the writing activities, we asked students to complete a questionnaire. The questionnaire included different measures such as engagement in the class, motivation to attend lectures, achieving learning outcomes, intellectual stimulation, fostering of critical thinking, evaluation of peers' work and peer feedback. The students were asked to evaluate items with 1 for strongly disagree, 3 for neutral, and 5 strongly agree. A higher value indicated a higher level of effectiveness. The means and standard deviations (SD) of the returned Likert responses are reported for each question in the results section. In addition, students wrote written comments in response to open-ended questions. The responses to the questionnaires were received and entered into an excel sheet for further thematic analysis as described above.

E. Measure

Since this was an intervention study, it required the approval of an ethics committee. This study has received ethical approval from the Human Participants Ethics Committee from the University of Auckland (Reference No.: 018848). During the first lecture, the principal investigators explained to all students about the writing exercises and addressed their concerns. A facilitator was appointed to record the findings by conducting a paper-based survey and also to avoid the conflict of interest as the lecturer himself is the principal investigator. The survey was conducted by a female teaching assistant who was involved in this course helping with the labs and was well known to students. An email announcement containing the participation information sheet was sent to the class explaining the research and its outcomes. Only those students who signed the consent form were invited to participate in the survey.

V. Results and Discussion

A. Background of the Students Participated in the Survey

A survey was distributed to the class whereby 75% (N=27) of the survey participants were male and 26%female (N=9). Of the 36 survey respondents, almost a third (N=13) had English as an additional language. Of all the students who participated in the survey, 23% attended all twelve lectures, 65% attended 6 to 9 lectures, and 12 % attended less than half of the lectures.

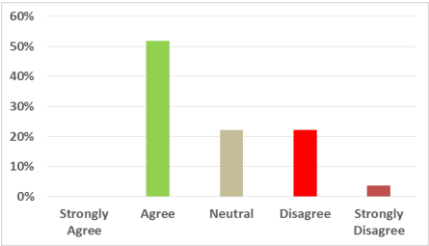
B. Impact of Writing Exercises on Engagement and Motivation

Fig. 1 (a) shows the students' response to the question of whether writing exercises engaged them in the class or not. Around 52% of students thought that the writing exercises did engage them in the class, 26% did not agree and 22 % were neutral (Mean 3.25 ± SD 0.90, range 1 - 4). The reason for not agreeing might be due to allowing them to complete writing exercises out of the lecture time. Responses could be different if the word "class" was not used in the question. The high completion (84%) rate of the exercises is proof of the fact that writing exercise did engage students. A cross tab analysis revealed that all those students who attended all the lectures agreed that writing exercises engaged them in the class and of those who attended less than half of the lectures, were neutral or disagreed with this statement. Of those who attended 6 to 9 lectures, 50% agreed, 25% were neutral, and the remainder disagreed and strongly disagreed. This is indicative that students who are habitual of attending lectures are more likely to be engaged in the lectures.

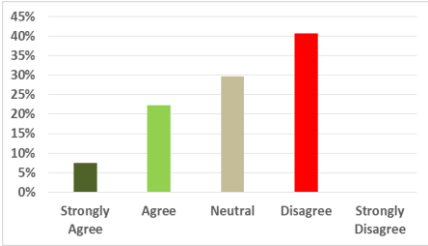
Although students reported higher engagement in the lectures due to the writing exercises, this was not enough to motivate them to attend the lectures. Figure 1(b) shows around 60% of the students tended to disagree with this statement (Mean=2.89, SD=0.91). Interestingly, 75% of those who attended more than half of the lectures said they were not motivated by the exercises but were attend lectures anyway. An unusual high attendance was observed during the first writing exercise but a significant drop was observed when students learnt that these could also be submitted online, outside the lecture hours. Online submission outside lecture hour was to accommodate the working students or students with other commitments to participate, irrespective of attendance not. In other words, writing exercises and attendance of the lecture were not coupled, another reason why it is not a stimulus for attendance. The reason for not attending the lectures are therefore varied, for example, heavy involvement of the student with assignments as some were due in the middle and especially towards the end of the semester when these writings were conducted.

Fig. 1(c) shows that 63% (Mean=3.47, SD=0.87) of students at least agreed that these writing activities helped them in learning and achieving learning outcomes. Again, 75% of the students who attended more than half lecture agreed. This was also reflected in the writings submitted by them. As mentioned earlier, the main aim of this course was to make student capable of designing a digital system. Students appear to have achieved this objective as they were able to think about a real-world digital system and provide a solution for it. In other words, students attending the lectures are more likely to relate the exercises with learning outcomes. A small percentage of students, 19%, though did not agree that activities helped them to achieve learning outcomes.

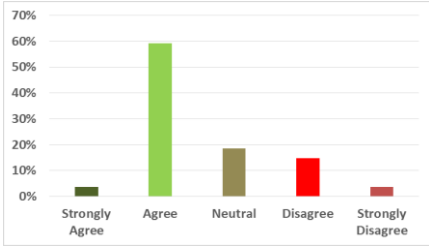
The majority of students (85%) agreed (Mean=4.14, SD=0.79) that the writing exercises were intellectually stimulating and engaged them in critical thinking as illustrated in Fig 1 (d). One of the reasons might be the openness of these activities as generally, in an undergraduate writing assignment, students are provided with strict guidelines leaving minimal or no room for creativity or critical thinking. In contrast, students had the freedom to choose a problem to their liking for solving. The writing exercises were designed in a way to empower student from the conception of an idea to implementation, thus shifting the responsibility to the student and making them an independent learner. It means that if they come across any ambiguous situation, they had to make the decision by themselves. Dealing with ambiguity is an essential and productive part of the critical thinking process [33] as they have to come up with a reason for making a decision. Students were also able to perform more active and critical thinking as they continuously received feedback on their ideas and writing from other students. Also, every student was required to analyse and assess the writings of two other students. Their task



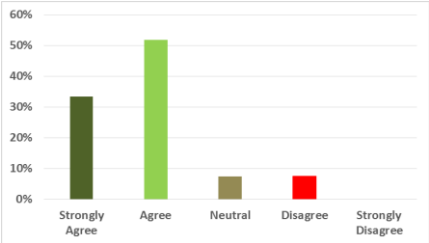
(a) The writing exercises engaged me in the class



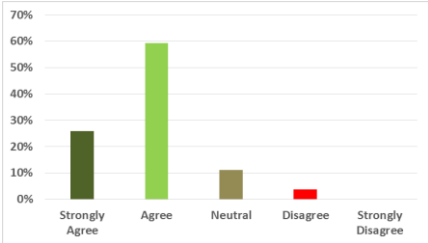
(b) The writing exercises motivated me to attend the lectures



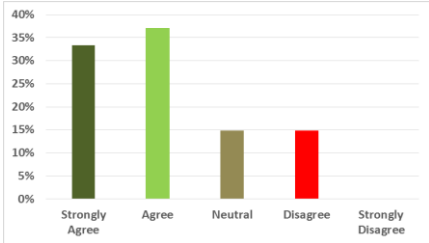
(c) The writing exercises help me in achieving the course learning outcomes



(d) The writing exercises were intellectually stimulating and engaged me in critical thinking



(e) Evaluating the work of peers was a useful exercise



(f) The peer feedback helped me in improving the quality of writing

Fig. 1. Impact of writing exercises

was to identify the point of view, look for missing information, and wrong interpretation of the facts. Since students were aware that their writing would be assessed by the peers, they

needed to provide good reasons to defend their ideas. In short, students were intellectually challenged through different ways which made it an enjoyable experience. Going through the process of peer assessment is a useful exercise and has many potential benefits for students. The same is perceived by students as shown in Fig 1(e) which indicates that 85% of the students were in agreement (Mean=4.11, SD=0.71) on the usefulness of exercises. It not only provided students with a chance to develop a skill to evaluate and justify their own work but also helped them in self-assessment and insight into others work. It also provided them with the opportunity to share their ideas as well as understand different perspectives on the writing process.

The questionnaire results illustrate that the majority of the students were positive about the writing activities. The results in Fig 1(f) indicate that around 70% of students viewed peer feedback as a worthwhile experience (Mean=3.91, SD=1.02). This is in accordance with the findings of Tsui [19] that peer feedback motivates students as they have a sense of audience and results in improving the writing skills. Students also obtained more feedback on their writing than they could get from the teacher alone. Each student received feedback on all of its writings from twelve other students. This feedback from the diverse audience brought multiple perspectives and reaffirmed their knowledge. Most of the students who did not agree were those who had higher lecture attendance and were not satisfied with the level of feedback.

C. *Students' Perceptions of Peer Review Towards Deep Learning*

The survey included three open-ended questions asking students about their perception on how the peer review process as part of the writing exercises enhanced their learning, their likes and dislikes about the process, and further suggestions for improvement of this type of embedded learning activity. The main themes that emerged as a result of the thematic analysis surround learning gains in the metacognitive and cognitive dimension. Figure 2 illustrates the coding frequencies of the main concepts which were mentioned at least five times by the participants leading to the emergence of overarching themes that include evaluation of students' own learning processes, self-regulation through reflection on one-self and others' writing (metacognitive processes), and gaining a deeper understanding of real-life problems and how to solve those conceptually (cognitive processes).

Evidence for metacognition can be drawn from responses to the question "Indicate the aspect of the peer reviewing which contributed most to your learning" as follows:

> *"Having others critique my work is always beneficial, most of the time I am not able to see my mistake and therefore, having others spot these errors for me is hugely beneficial."*
>
> *"The thinking side of the things, forcing me to apply what I think/have learnt."*

Students usually think that giving feedback entails giving negative and corrective comments. One of the objectives of the writing exercises was to teach students how to give constructive feedback on peer's work. The idea was to get inside the learner's mind and understand the way he/she is thinking and ask questions which would help to learn deeper. It seems that students received this message very well as it was evident from two comments:

> "*Learnt how to give constructive criticism without being too harsh."*
>
> *"Feedback does not mean criticism"*

Most students commented on the benefits of the activities fostering what is generally known as cognitive skills which include in our scenario case analysis and evaluation of designs, arguments leading to new ways of thinking about a problem

and synthesis of new ideas. This is evidenced by the following comments:

> *"Seeing what my peers wrote and how they approached the question helped in thinking about the problem from a different perspective".*

> *"Being able to look at someone else's work, as well as receive comments on my own work was super valuable as I was able to reflect my work and improvement. It also gave me a much better understanding of how to relate course content to real-world devices, and why what I am learning is significant".*

Whilst most students commented positively on the usefulness of the writing activities, just as many students pointed to three main dislikes which included the time consuming nature, the sometimes poor quality of feedback received, and scepticism around the accuracy because it was provided by peers and not the teacher.

> *"The time constraint of when writing and receiving can be annoying".*

> *"Sometimes the peer reviews won't come on time to improve my writing".*

Moreover, others commented that they disliked the word limit for the review, suggesting that students were generally enthusiastic about the peer review. It also highlighted that students were desperate to receive feedback on their own writing, something that is seldom done in content heavy engineering classes. Rethinking the learning design in engineering to foster such important skills is therefore necessary and strongly endorsed by our research findings. However, improvements are required to optimise these activities to fully exploit the intended learning outcomes. The following suggestions were made by students on how to improve the writing exercises:

> *"Having a proper marking rubric for peer review. Also having a deadline for peer review".*

> *"Some professional feedback from lecturer for the final exercises and reduce the number of exercise".*

Overall, students most appreciated the exercises for improving critical thinking, providing intellectual stimulation and being able to deal with a real-life problem.

> *"Critical thinking about the problem and how to solve it and coming up with system level solution".*

> *"Being able to connect content that is quite technical to the real-world and see how relevant it is".*

However, the real-life aspect was appreciated the most. Students were allowed to choose a problem of their own choice, promoting free thinking and independent learning. Participants appreciated that they had the opportunity to exploit their creative sides which was well received as was evident from the following samples of student comments:

> *"I really enjoyed getting to think about a real-life implementation of a digital system. I also liked how each time it was stepped up to make us think about it in a different way".*

> *"The open-ended questions and allowing for the formulation of a unique solution was a stimulating challenge; unlike the normal assignments with exact constraints on what to write. That coupled with peer reviews pointed out the flaws in my logic and allowed me to make appropriate changes".*

> *"Creative freedom with what we chose to design".*

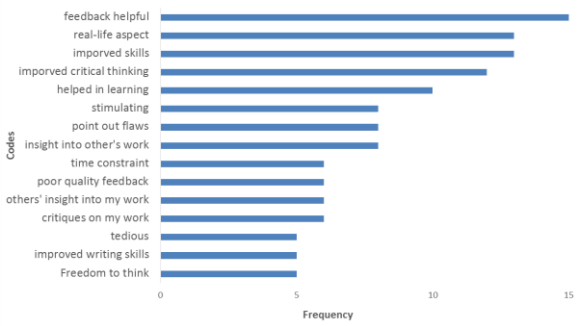


Fig. 2. Text anlysis of open-text survey responses

Due to logistic constraints, it was not possible to implement these this year. However, we intend to cut down the number of writing exercises so that it is possible to conduct those during the lecture which was a challenge. We also will assign more marks to motivate students to participate in these activities across the entire class and plan to provide the students with teacher as well as the peer feedback. Some of the students did not complete the writing exercises which can be attributed to very low marks (3%) allocated. This may also be related to the fact that writing does not come naturally to an engineer and brings them out of their comfort zone as they might not have received feedback on their writing before. Finally, we believe that short writing exercises embedded in disciplinary teaching hones in on written communication skills, an essential skill when working in a design team in industry. The gains made through the writing exercises outweigh the efforts put in implementing them thus making them a viable, effective and attractive teaching and learning strategy for other practitioners in the field.

VI. Limitations

This is a qualitative and exploratory study and forms the foundation of further initiatives and research. It only takes into account one specific course with around 65 students and out of those only a limited number of students provided their responses to a number of questions regarding the usefulness of the learning activities and suggestions for further improvements. Whilst the results are encouraging, i.e. students valued this type of activity, the relationship between active learning initiatives during the lecture and improved lecture attendance cannot be drawn. Nevertheless, the embedded writing activities can provide a vehicle for teaching other graduate competencies in engineering, such as communication skills. To be able to transfer this type of learning activity to other engineering contexts or across a program, a larger study

is necessary spanning different courses and student populations to provide more general guidelines on how to embed communication skills activities into an engineering context.

VII. Conclusion

This study investigated the impact of writing exercises on teaching and learning in an engineering course. The results of the study indicate that these writing exercises engaged the student in the lectures and intellectually stimulated them. This is further supported by the activities completion rate which was around 84%. Also, it provided constructive feedback on peer's work and using the feedback received to reaffirm their understanding and further improving the work. It also created the sense of a community practice through peer reviewed exercises. Carefully designed writing exercise can help in achieving the learning outcomes demanded by the discipline. The initial student responses provided us with enough encouragement to keep using embedded writing exercises in our course towards improving more generic engineering skills geared towards employability, such as critical thinking, self-reflection and peer review. In summary, our findings have shown that various writing exercises should be incorporated into the engineering courses as a strategy to enhance the communication skills of the students as well as their learning experience. Students valued the most that they were able to choose a real-world problem for their writing task, fostering creativity and sparking new ideas. This highlights the importance of the use of authentic writing tasks, i.e. embedding contexts that are of importance to the practice of engineers. Therefore, the need for good written communication skills and the link to engineering practice needs to be explicitly mentioned in the course outline for students to be transparent. We further recommend that communication skills in engineering need to be mapped to assessment so that they are seen by the students as an important component of their course.

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