PEDAGOGY FOR EVIDENCE-BASED FLIPPED CLASSROOM – PART 3: EVALUATION

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ABSTRACT

This paper shares the results of an evaluation of flipped classroom, which had been implemented in a Year 3 core module entitled *Plant Safety and Loss Prevention* from the Diploma in Chemical Engineering (DCHE) for the past 2 years. The flipped classroom was designed using an evidence-based teaching approach supported by extensive use of info-communication technology (ICT) tools. The paper firstly provide a brief but concise literature review of the flipped (also known as inverted) classroom approach and its use in different fields of study. Given the conflicting findings to-date, this paper strives to provide a balanced view of the relative merits of the approach, as well as challenges faced from both the perspective of faculty and students. The paper then shares the approach taken by the authors who designed a comprehensive blended learning research to qualitatively assess the effectiveness of flipped classroom as applied in the context of the above said module. Specifically, the authors are interested in identifying which features of the learning designs have significantly impacted student learning (e.g. positively, negatively or other), and on what basis. The research lasted 6 weeks, implemented from mid-April till end-May 2016, although flipped classroom was implemented for the entire 15-week duration of the module. Students are selected to take part in the research as co-participants, providing regular feedback on their learning experience. The first author who conducted the lessons, regularly reflected on his teaching practices, and often made improvements to his teaching materials within days upon the conclusion of each lesson. Lastly, the paper shares the findings from the study, and limitations of current work. It concludes with our frame on the state of flipped classroom and our plans to move forward in this exciting new educational approach.

(288 words)

KEYWORDS

Flipped Classroom, Evidence-based Approach, Chemical Engineering, CDIO Standards 8 and 12

FLIPPED CLASSROOM: ADVANTAGES, DISADVANTAGES & CHALLENGES

In recent years, flipped classroom (also known as inverted classroom) is gaining popularity among educators around the world (Seery, 2015). It was widely attributed to the effort of Baker (2000) and also Lage, Platt & Treglia (2000); and popularized by Bergmann & Sams (2012). Since then, there had been many publications attesting to the usefulness of flipped classroom in improving various aspects of students learning (e.g. Herreid & Schiller, 2013; Berrett, 2012), and many resources offering guidelines and tips for implementing flipped classroom (e.g. Moffett, 2014; Margulieux, Majerich & McCraken, 2013). Strayer (2012), in the teaching of statistics, noted that students in an such a classroom become more aware of their own learning process than those in more traditional settings; and reported increased student cooperation, innovation and task orientation. Based on analysis of self-determination theory and cognitive load theory, Abeysekera & Dawson (2015) suggested that flipped classroom can improve student motivation and help manage cognitive load. Other benefits claimed include increased students greater student engagement and satisfaction with the course of study (e.g. Strayer, 2012; Dove, 2013; Wilson, 2014), addressing misconceptions (Fautch, 2014), and improvement in meta-cognition (van Vliet, Winnips & Brouwer, 2015).

Examples of application of flipped classroom in various programs and courses are shared next, but these are by no means exhaustive. Flipped classrooms had been used in different science and engineering disciplines, for example computer engineering (Redekopp & Ragusa, 2013), mechanical engineering control systems (Mason, Shuman & Cook, 2013), digital engineering (Warter-Perez & Dong, 2012), electrical engineering (Papadopoulos & Roman, 2010), chemistry (Seery, 2015), physics (Deslauriers & Wierman, 2011), dynamics (Stanley & Lynch-Caris, 2014), and chemical engineering (Cheah, et al, 2016) etc. Velegol, Zappe & Mahoney (2015) also provided discussions of flipped classroom implementation in engineering education. Hawks (2014) reported on the use of flipped classroom by various faculty in the medical and health sciences, notably nursing education, medical education, pharmacy, etc. Flipped classrooms are also used in non-engineering courses, for example, in business (King & Piotrowski, 2015), spreadsheet (Davies, Dean & Ball, 2013) and entrepreneurship (Norrman, et al, 2014). Some authors also noted that the use of flipped classroom allow them to cover more contents (Mason, Shuman & Cook, 2013). On student perceptions of flipped classroom, most authors reported positive responses from students (e.g. Redekopp & Ragusa, 2013; Butt, 2014; Murray, Koziniec & McGill, 2015; Seery, 2015). Interestingly, Sinouvassane & Nalini (2016) reported that year one students are more open to accept the flipped classroom model when compared to third year students. For more examples, readers are encouraged to refer the works of O'Flaherty & Phillips (2015) who provided a concise summary of outcomes from 28 flipped classroom initiatives.

Given the positive vibes surrounding flipped classroom, Goodwin & Miller (2013) went further to claim that it is not just the classroom that had been transformed, but the entire paradigm of teaching, i.e. away from a traditional model of teachers as imparters of knowledge and toward a model of teachers as coaches who carefully observe students, identify their learning needs, and guide them to higher levels of learning.

However, flipped classroom had its fair share of criticisms. Indeed, a review of current literature showed mixed results, although it is probably fair to say that, based on the publications to date, there are more positives than negatives. Betihavas, et al (2016) concluded that the use of flipped classroom in higher education nursing programmes has either increased or had no significant effect on student's academic performance. Mason, Shuman & Cook (2013) for example reported that the flipped classroom “at best improved students' understanding of engineering concepts" and that at worst "did no harm". McLaughlin et al (2013) compared final exam scores of students and found no significant differences. Similarly, Whillier & Lystad (2015) reported that there is no difference in grades or level of satisfaction in a flipped classroom compared to traditional lessons. Likewise, Lape, et al (2014) reported that there is no improved student learning as a result of the inverted format as compared to an active-learning-based course format. In a recent publication, Jensen, Kummer & Godoy (2015) reported that flipped classroom does not result in higher learning gains or better attitudes compared to non-flipped classroom when both utilized an active learning, constructivist approach. These authors proposed that such gains are most likely a result of the active learning style of instruction rather than the use of flipped classroom per se. One of the strongest objections to flipped classroom is a view that it is "simply a time-shifting tool that is grounded in the same didactic, lecture-based philosophy. It's really a better version of a bad thing." (Ash, 2012). Pienta (2016) noted that the literature is clear that flipped classroom, just like other form of active learning, requires engaged students. However, not all students are motivated to put in the required effort to learn lesson materials on their own before coming to class. Lacking "homework culture" (Straw, et al, 2015), these students may come to class unprepared to participate in class activities. Another challenge is the time and money demand on the part of faculty: to produce a flipped classroom required the digitization of lesson materials; and design of classroom activities for every class period.

EFFECTIVENESS OF FLIPPED CLASSROOM: WHERE IS THE EVIDENCE?

Despite its popularity and the above reported shortcomings, there is very little evidence about the specific merits of flipped learning and there had been calls more in-depth investigation of the effectiveness of the method. Bishop & Verleger (2013) for example, called for research with controlled studies that objectively examine student performance throughout a semester, with both traditional and concept-inventory style problems; and a theoretical framework to be used as a guide to the design of in-class activities. In their scoping review of 28 recently published work on flipped classroom, O'Flaherty & Phillips (2015) noted that very few studies actually demonstrated robust evidence to support that the flipped learning approach is more effective than conventional teaching methods. They also noted that whilst some studies referred to a modest improvement of academic performance, through outcomes of increased examination scores or improved student satisfaction, further research is required in this area with longitudinal cohorts evaluating the learning outcomes of utilising flipped approaches compared with traditional teaching methods. Abeysekera & Dawson (2015), based on their literature review in flipped classroom, reported that the publications are mainly in the form of conference proceedings, supplemented by a few journal papers. Most refer to case studies and none of them rely on particularly rigorous research designs. These authors claimed that the flipped classroom approach is "under-evaluated, under-theorised, and under-researched in general." Likewise, Seery (2015) while noting that the "flipped learning approach is likely to be a significant teaching and learning method over the next decade" also called for a more robust framework to implementing flipped classroom.

Deubel (2013) cautioned that flipped classroom is just a different approach to instruction, and that "different does not equate to better". Forsey, Low & Glance (2013) made reference to the "Hawthorne effects" where any change in operating procedures can produce increases in worker productivity and/or satisfaction, and henceforth to treat any survey results with caution. Likewise, Hamdan, et al (2013) noted that the flipped learning mode "might be one way to enable learning" and should "by no means be thought of as a panacea for solving all educational issues". Reviewing the available publications, Yarbro, et al (2014) noted that the flipped learning model "likely does not work in all contexts". Gojak (2012) opined that the question on flipped classroom is not whether to flip or not to flip; but rather how to apply the elements of effective instruction to teach students both deep conceptual understanding and procedural fluency. She noted that "flipped lessons that simply demonstrate how to do a procedure do not encourage understanding, do not ensure that students will remember the procedure, and do not promote adaptive reasoning."

EVALUATING A FLIPPED CLASSROOM

One reason why it is so difficult to evaluate the use of flipped classroom is that there are many variables that existed in active learning, course materials etc that makes it impossible to attribute the success (or otherwise) of the flipped model to any one causal factor (Jensen, Kummer & Godoy, 2015). Van Sickle (2016) cautioned that students did not accurately evaluate their learning in course evaluations, and that student perception in flipped pedagogy needs further study. Our paper hoped to shed some light on the situation by proposing an evidence-based approach to evaluate the effectiveness of flipped classroom.

The approach we had taken is to understand, from the perspective of students, which elements of the flipped classroom best meet their needs in terms of helping them in their learning (Crews & Butterfield, 2014). This is important, because the quality of students' learning is closely related to their perception of their learning experience. Key aspects of the learning context, such as assessment, workload, independence, the quality of the teaching and the clarity of goals and standards are all closely related to the quality of learning they experienced (Ginns & Ellis, 2007). More specifically in our context, our research focused on the effectiveness of in-class activities designed using selected the following high effect size interventions and delivered using the "Russian Dolls" strategy (Hattie, 2009):

- Goals (Learning Outcomes) using Advanced Organizer (start-of-class) and Checklist (mid-point and end-of-class) – effect size: 0.40
- Classroom Discussion with Peer Influences – effect sizes: 0.82 and 0.53 respectively
- Worked Examples, Scaffolding and Space vs Mass Practice – effect size: 0.37, 0.53 and 0.60 respectively
- Feedback and Formative Evaluation – effect size: 0.73 and 0.68 respectively

Cheah, Lee & Sale (2016) had reported on their work done to flip a Year 3 core module in the Diploma in Chemical Engineering entitled *Plant Safety and Loss Prevention*. In that work we shared our initial experience in flipped classroom using an evidence-based teaching (EBT) approach. We had since completed a second run of the module, and had make key improvements to the teaching of the module based on the feedback received. Key amongst these is the refinement of our pedagogy for evidence-based flipped classroom. Details of the work done are presented in a separate paper for this conference (Sale & Cheah, 2017).

This paper presents the results of a fresh evaluation of students' learning experience for this second run, using an evidence-based approach as the guiding heuristics for evaluating the instructional design and teaching practices, as well as the students learning experiences. There are 2 key components to the evaluation process. One is the use of students who volunteer as "co-participants" (Lincoln, 1990) in the research process. The aim is to unpack the components of their experiences and identify which features have most significantly impacted their learning (e.g. positively, negatively or other), and on what basis. These students provide regular feedback on their learning, and that of classmates (where possible) through focus group interviews and questionnaires. The other component is that faculty reflective practice. Sale (2015) argued that evidence-based reflective practice involves more than personal reflections in isolation, but a structured thinking process (e.g. analysis and evaluation) using EBT principles in relation to all valid evidence sources (e.g. students, peers, peer observers). As a holistic process it enable a better understanding of the *reality* of classroom learning (e.g. what is happening, and how this is affecting the learning process). From this base, we can then creatively design and facilitate instructional strategies that have high predictive capability for enhancing the learning experience and attainment levels. Specifically, in evaluating the learning experience we are looking for the presence or otherwise of the following:

- Appropriate method use to maximize learning opportunities in this Situated Context (e.g. learning outcomes, learner profile, learning space and resource access)?
- Clear presentation of learning goal, purpose and expectations to these learners?
- Activation of prior knowledge and subsequent connection to new knowledge presented?
- Emphasis on the key concepts and principles underpinning understand of the topic area?
- Activities (e.g. questions) that facilitated the types of thinking necessary for building understanding?
- Variation in the modes and methods of information presentation and interaction?
- Application of practices consistent with human memory processes (e.g. chunking, linkages, rehearsal and review)?
- Use of Deliberate Practice (where relevant)?
- Use of formative assessment activities to provide quality two-way feedback?
- Rapport building Interactions that promoted a climate conducive to success and some fun in the learning process?
- An aspect(s) of creativity (e.g. story, humour, activity, presentation style, example) that enhanced Intrinsic Motivation?

This enables ongoing appraisal of the instructional strategy, evidence-based diagnosis of student learning, both in terms of attainment and experience. Based on the above heuristics, we crafted a series of survey questions for the student co-participants who provide feedback on their learning experience in *Plant Safety and Loss Prevention*. The module is taught over 1 semester of 18 weeks; made up of a 7-week of lessons (Term 1), followed by 1-week of Mid-Semester Test and a 3-week term break, and concludes with another 7-week of lessons (Term 2). Altogether they responded to two survey questionnaires (one on Week 4, and again on Week 8, after their mid-semester test on Week 7) and attend a focus group discussion with the second author (on Week 11). Questions asked in the questionnaire are shown in the Appendix A. From the EBT point of view, it is much preferred to obtain feedback from students in this manner, compared to the “traditional” approach of student feedback currently employed, which is only carried out at the end of each semester. The questions asked are shown in Appendix B.

SELECTED FINDINGS FROM STUDENT FEEDBACK

Our student co-participants have provided a wide range of data on different aspects of the flipped classroom experience, but only those of most significance to this context are presented here. Overall, students found the use of advance organizers useful, although some found it difficult to understand at first. Students generally cite its usefulness in helping them to keep track of their learning progress and how various topics are connected to form the big picture. They also agreed that the use of self-evaluation exercises after every topic (multiple choice and/or true/false questions in Socrative) are useful. However, some students did not use these exercises the way we intended – they attempted the questions *after* the day's lessons instead of doing it *before* coming to class! As for Google Doc, students reported that classroom discussion is very useful in helping them to learn, especially from each other. This also applied to the case studies where different questions were posed to different groups, so that each group must work on one aspect of the issues presented and jointly contribute to the solution of the whole problem. Here is a typical comment from one of the co-participants:

> "*Yes, the collaborative approach with regards to group discussion is indeed a much more interesting and engaging learning experience. This allows sharing of opinions and ideas, and allows each student to justify their way of thinking. With this, I was able to actively listen to others, and with their responses, make appropriate modifications to my answer in order to achieve a thorough learning …I am able to identify faults in my arguments and answers, thereby promoting a self-marking and self-accessing approach in my own learning*."

The "chunking" of information into smaller bits also proved useful in assisting students in managing their learning. This is especially the case for the virtual plant Amine Treating Unit (ATU) from EnVision Systems. It is a commercially available training package based on dynamic simulation, for use in training of process engineers and technicians in operations and troubeshooting of chemical plants. The ATU is used firstly to provide the necessary background knowledge for our students' lack of real-world working experience in chemical plants; and secondly, to provide the context for applying safety principles learnt in the module. The requisite knowledge on ATU is quite significant, so "chunking" made it possible for students to learn about the plant based on sections of the plant, each of which performs a specific function. This approach, coupled with the use of rubrics for peer marking in a mock tests, enables students to do the necessary thinking to develop good understanding of the requirements of the module. The following examples, illustrate this:

> "*Peer Marking with Rubrics helped me gain a better understanding of this topic area as it guided me on how to assess my peer's answer and hence, give her feedbacks on ways of improvement. In addition, I know what is the lecturer expecting when marking for our test papers too*. "

> "*…teammates would be able to constantly provide feedback on the answering style of different individual, hence suggesting improvements for students to improve*."

Another method that facilitated student learning was the use of a distillation pilot plant (DPP) to activate their prior knowledge. The students had previously worked on the DPP in Year 2 in the module *Separation Processes*, focusing on principles of separating and purifying liquid mixtures to obtain relatively pure products. In the present module, we make use of the safety protective systems in the DPP to introduce them a new topic on Layer of Protection Analysis (LOPA) that they now need to learn. They reported that working on the problems based on the DPP served to reinforce their learning of LOPA. The response below captures this:

> "*It allows us to visualise first hand, how the LOPA concepts can be applied in the DPP plant. Furthermore, it allows us to make hypothetical improvements to the DPP plant so*

that it encompass the LOPA concepts. This enhanced learning, as the team could discuss about the technicalities behind the DPP plant, and move on to applying LOPA."

The DPP is utilized again for study of pressure relief systems. This time students are tasked to visit the laboratory and locate the relief valves installed in the DPP after going through the online lecture recording on pressure relief systems. The comment below clearly revealed that the student "got it":

"*Yes, I able to see how pressure relief system applied in a real plant. We realised that pressure relief valve normally installed at the top of a column and we able to understand theory behind pressure relief system are installed at that location*."

Another approach that proved successful with students is the use of "Let's Get Real" moments during class. These are basically photo collages of the real safety protective systems used in the chemical processing industries. Students generally appreciate knowing how the various devices learnt actually looked like, as compared to symbol representations in the P&IDs (piping and instrumentation diagrams). One participants elaborated:

"*Yes it is interesting and engaging for us because there are definitely a portion of us that are interested in joining the chemical plant upon graduation. In school, the resources are limited and the big solenoid valves, for example, is not found in school. Hence, it is very interesting to be able to know more about the real life plants in Jurong island because there are still a lot of things that we do not know or cannot see until we join the work force. I think that it is good to constantly relate the lesson to the real scenario because at the end of the study journey, we are supposed to be trained for the real world and not just a simulation example*."

From the lecturer's perspective, these in-class activities provide valuable opportunities to walk around and listen to the students' group discussions, which makes their thinking visible. In this way misconceptions can be quickly identified and dealt with and necessary checks in understanding performed. The lecturer now takes on the role of what McWilliam called "meddler in the middle", who challenges students to think and understand differently (McWIlliam, 2005). The lack of such affordance is made painfully clear in Week 3, which is a SP-designated "Home-based Learning" week, where students do not come to campus for lessons but work fully online from elsewhere. Due to the lack of face-to-face classroom interaction, its not possible to usefully ascertain students' ability to sketch the proper engineering diagrams depicting how Safety Instrumented Systems can be implemented. On hindsight, it would have been more effective to ask students to submit their sketches for marking. This issue was only noticed a later week when another in-class activity was introduced that required students to build on this new knowledge in a different application. This immediately prompted the lecturer to conduct a mini-lecture to quickly bring the students "up to speed".

On the other hand, the use of checklist drew mixed responses from students. The checklist was shown in class after 1 hour of lesson as mid-point summary and again at end-of-class summary. One student's response was particularly interesting:

"*No, the checklist (mid-point or end of lessons) has not helped myself as individual to keep track of my learning based on the lesson objectives …Even though, the use of a checklist does push me to think about the learning outcomes, it does not actually prove that I am indeed competent in these aspects."*

As things turned out, the lecturer often did not have sufficient time to go through the checklist in details with the class. On reflection, the checklist could have been included in the workbook instead for students to monitor their own learning, after they had completed all the activities of a given topic.

Lastly, this evaluation exercise also revealed several interesting insights. One insight gained is that students tend to ‘optimize’ their time devoted in the study process by balancing the activities designed for this module with the demand of other modules, especially those with examinations. There was one occasion where the students did not complete some simulation exercises for classroom discussion, and when inquired, they were quite frank in revealing the reason for non-submission was due to the need to submit an important assignment for another module on the same day. On a lighter note, it appears that the students – especially the co-participants – are very motivated by the involvement in this work, when they understand that we are truly interested in finding out how well are they learning the subject. This can be seen form the enthusiastic response (both postitives and negatives, as well as ideas for improvement) written for the surveys and during focus group discussion.

LIMITATION OF THE STUDY

This work focus on the in-class component of flipped classroom, specifically the effectiveness of various high effect size strategies in engaging students in their learning. One limitation of the research is that we have not investigated the efficacy of the online component, which is equally important. Currently just based on narrative of the usual PowerPoint slides using Camtasia, supplemented by occasional reading of selected journal articles or YouTube videos. As noted by Bluic, et al (2007), the most significant need in blended learning research is information on how best to integrate the online and face-to-face portions of the course into a coherent whole. We also obtained a clearer picture of how student motivation can play an important role in coming to class prepared, when they had to juggle the demand from other module, especially those with examinations are often perceived to the of “higher stakes” than modules based on fully in-course assessment such as *Plant Safety and Loss Prevention*.

The teaching team had fully reviewed responses from students co-participants and immersed themselves in a reflective exercise on key learning points. We have reviewed the current state of teaching of chemical process safety, and am convinced that flipped classroom approach is an effective way for students to learn the subject. Key areas of improvement including the use of microlectures to replace the present video-recording has been explored; and shared elsewhere (Cheah, Sale & Lee, 2017). Future work will also involve evaluation of student learning experience in the online component.

CONCLUSION

The feedback from student co-participants had shown that many of the strategies employed in the classroom in the teaching of *Plant Safety and Loss Prevention* via a flipped classroom approach are positively impactful in in supporting their learning, particularly the advanced organizer, use of Socrative for self-evaluation, and Google Doc for classroom discussion. On the other hand, the use of checklist has not been as effective, but this does not necessarily mean the method choice was inappropriate, but rather because it was not effective used. We also need to explore the design on the online or out-of-classroom component of flipped classroom. As teaching is a highly complex and situated actitivity, it is always going to be heuristic, never algorithmic. However, the use of an EBT approach provides our best basis for useful heuristics as it is grounded in validated knowledge relating to how humans learn and an extensive research base on method effectiveness. More work remain to be done to explore the efficicacy of flipped classroom in engaging students in their learning.

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BIOGRAPHICAL INFORMATION

Sin-Moh Cheah is the Senior Academic Mentor in the School of Chemical and Life Sciences, Singapore Polytechnic; as well as the Head of the school's Teaching & Learning Unit. He spearheads the adoption of CDIO in the Diploma in Chemical Engineering curriculum. He currently teaches the module *Plant Safety and Loss Prevention*. His academic interests include curriculum revamp, academic coaching and mentoring, and using ICT in education. He has presented many papers at the International CDIO Conferences.

Dennis Sale is the Senior Education Advisor from the Department of Educational Development at Singapore Polytechnic. He has worked across all sectors of the British educational system and provided a wide range of consultancies in both public and private sector organizations in the UK and several Asian countries. He has authored two books and had conducted numerous workshops in all educational contexts in many countries, and presented papers at international conferences and published in a variety of journals and books.

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APPENDIX A

For each of the question posed, a short paragraph is provided to provide the brief explanation of the intent of the question, so that the student co-participant clearly understand what is being asked of them. When appropriate, selected PowerPoint slides or sections of a learning task is provided for greater clarity.

Questionnaire 1

- **Lesson Preparation** - *Have the learning guides been useful in planning your learning of the topics in each session? If yes, please explain how, with specific example(s) if possible. If no, identify why not for you*.
- **Learning Objectives** - *Has the use of a checklist (mid-point or end of lesson) helped you to keep track of your learning of the lesson objectives? If yes, please explain how you made use of the checklist provided. If no, identify why this was not useful for you.*
- **Advanced Graphic Organizer** - *Was the above diagram helpful for you in keeping track of the progress on the module? If yes, please explain how this helped your learning. If no, identify why not for you.*
- **Self-Evaluation using Socrative** - *Did you find the questions posed in Socrative useful in helping you to check your understand of the key content in the one component of this topic? If yes, explain how this was useful to you. If not, identify why not for you.*
- **Activating Prior Knowledge** - *Was the information curated for Bhopal useful in making this a good learning experience for you (e.g., made the learning more interesting/ engaging; helped you to answer the questions posed in class)? If yes, explain how. If no, explain why not.*
- **In-Class Collaboration using Google Doc** - *Did you find such a collaborative approach (such as discussion in groups) more interesting/engaging learning experience than when the lecturer poses a question and 'nominates' a student to answer? If yes, what made this more interesting/engaging for you? If no, explain why not.*
- **Transfer of Knowledge** - *Are you able to use your understanding on inherently safer design strategies (from Socrative, Bhopal) and apply them in the case of Piper Alpha? If yes, what helped specifically? If not, what was confusing for you?*
- **Feedback** - Have your received sufficient and useful feedback on your learning so far in this module? Identify specifically what has been most useful and why. Also, what has been least useful (or not provided) in terms of feedback support?
- **Overall Learning Experience** - Explain your learning experience thus far, as well as identifying any topic you found particularly difficult; and offer some specific suggestions (citing the topics if possible) to make the lesson more interesting.

Questionnaire 2

- **Collaborative Learning** - *Were you able collaborate effectively with your team members and build a sound understanding of ATU? Please explain your answer with reasons*
- **Prior Knowledge of Topics** - *Did revisiting the DPP help you to better understand how LOPA concepts can be applied in the real world context? If yes, explain how this helped you. If no, what made this difficult for you?*
- **Connecting Prior Knowledge to New Knowledge: Manageable Chunks** - *Did the activities provided about ATU help you to understand this content better? Explain your answer, identifying what worked best (and least - if this was the case for you) and why*
- **Relevance of Learning** - *Did this activity add realism to your learning and help your to better understand the concepts covered in Pressure Relief System? If yes explain what made this helpful for you. If not, identify what you found not useful*
- **Connecting Prior Knowledge to New Knowledge: Transfer of Learning** - *Are there adequate exercises on the topic of pressure relief system for you to apply knowledge learnt in earlier exercises to the present ones? Were some more useful than others – if yes, identify which one's were most useful and what made them useful for your learning.*
- **Scaffolding and Deliberate Practice** - *Did the Mock Assignment and Peer Marking with Rubrics help you gain a better understanding of this topic area? What was most useful and why, and what was least useful and why?*
- **Use of Real-World Examples (intrinsic Motivation)** - *Did the examples and activities make this part of the lesson more interesting and engaging for you? Please explain and illustrate your answer.*
- **Critical Thinking (Systems Thinking)** - *Do you feel that you understand systems thinking from the activities provided? Explain your answer with reasons*
- **Overall Learning Experience: Learning on Your Own** - *Explain if these approach had been useful to you in promoting your own learning. If yes, explain how it had helped you. If no, explain why not*

APPENDIX B

As part of the institution's quality assurance framework, at the end of each semester students are required to provide feedback for the modules they studied and the teaching effectiveness of the lecturer(s) delivering the module. Ratings are given on a Likert Scale of 1 to 5, with "1" being Strongly Disagree, and "5" being "Strongly Agree".

Questions for Module Feedback

Mandatory Questions	
Q1	This module was well taught.
Q2	The course materials in this module were of high quality.
Q3	The workload in this module was manageable.
Q4	Requirements for completing the **assessment** tasks in this module were clear.
Q5	The **library** resources met my needs for this module.
Q6	The **online** teaching and resources in this module enhanced my learning experience.
Q7	Overall, how would you rate this module?
Q8	What aspects of your module were most in need of improvement?
Q9	What were the best aspects of your module?
Additional questions on tutorials and workshops	
Q10	The tutorials were relevant to the aims of the module.
Q11	The tutorials were well taught.
Q12	The tutorials extended my understanding of the subject matter.
Q13	The workshops were relevant to the aims of the module.
Q14	The workshops offered sufficient opportunity to improve my practice of the subject matter.
Q15	The workshops extended my understanding of the subject matter.

Questions for Teaching Feedback

Q1	The lecturer organises the lessons well.
Q2	The lecturer explains and illustrates lessons clearly and makes them easy for me to understand.
Q3	I feel the lecturer knows the subject matter well.
Q4	The lecturer keeps the classroom environment positive for learning (e.g. does not allow sleeping, using the mobile phone, talking unnecessarily, etc.).
Q5	I feel the lecturer is concerned for my learning (e.g. approachable, check our understanding).