Promoting multi-layered peer learning in a course on engineering grand challenges

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Abstract

Peer learning underpins the effectiveness of many engaging pedagogies. This study combined peer learning within teams and learning from more capable peers to form a multi-layered peer learning model. The effectiveness of using this approach in a course on engineering grand challenges was evaluated through pre- and post-tests on students' perception of their abilities, assessment rubrics, and focus groups. Results demonstrated that in a collaborative problem-solving environment, students learned from interacting with each other, and from being challenged with alternative perspectives by peer tutors. Peer tutors learned through reflecting on their own experience.

Keywords: Peer learning, grand challenges, collaborative problem solving, assessment rubric

1. Introduction

It is well established that university students learn a great deal from each other through both intellectual and social interactions (Astin, 1977; Boud et al., 1999; Jawitz and Case, 2009). In fact, peer learning underpins the effectiveness of many engaging pedagogies including cooperative learning (Johnson et al., 1991; Smith, 1986) and problem-based learning (Barrett, 2001; Barrows and Tamblyn, 1980). Another useful approach based on the peer learning concept involves senior or more capable students teaching and helping junior or less capable ones in activities such as supplemental instruction (Stone and Jacobs, 2006), peer mentoring (Hansen et al., 2008), and peer tutoring (Colvin, 2007; Magin and Churches, 1995).

In this paper, a novel approach that combines the best of both worlds is presented, which involves students' learning in a team environment and learning from more capable peers, in a course entitled "Engineering Solutions to Grand Challenges of the 21st Century". The course, which has been piloted twice and will be introduced as a school-sponsored course to all students at HKUST by the School of Engineering in 2012, adopts collaborative problem solving through enquiry (Garvin and Roberto, 2001) as its main pedagogy. Students, working in teams, solve two open-ended problems (i.e., grand challenges) posed by experts in a semester and present their solutions both orally and in writing. In the process, they are expected to identify the key issues involved in the challenges by obtaining information from experts and the literature, and to analyze the problems from multiple perspectives.

Peer learning in the course was systematically introduced in a multi-layered model that consisted of (i) students learning from their own team members, (ii) students learning from members of other teams, and (iii) students learning from peer tutors. Peer tutors were students who took the course in a previous semester and recruited to be peer tutors due to their demonstrated performance in the learning outcomes of the course. This study focused on two research questions: (i) Have the learning outcomes of the course been achieved and to what extent? (ii) How does the multi-layered peer learning model facilitate student learning? Pre- and post-tests, assessment rubrics

specifically developed to allow assessment by self, peers, and instructors, as well as focus groups conducted at the end of the course were used to address these questions.

The following sessions introduce the theoretical background of the multi-layered model, its implementation in an engineering course and the evaluation. Implications to the development of the model and course design will be discussed.

2. Background and literature

The theoretical basis of peer learning can be traced to the social interdependence theory that views cooperation as resulting from positive interdependence among individual goals (Koffka, 1935; Lewin, 1935) and the social-cognitive development theory (Vygotsky, 1978) that describes how one acquires knowledge and skills through active interaction with others in a collaborative environment. Peer learning in a cooperative setting, such as a student team, occurs when individual members work interdependently to achieve shared learning goals (Johnson et al., 2007). As each student perceives that one's achievements depend on the performance of others, individuals engage in activities that promote one another's success, which include helping, assisting, supporting, encouraging, and appreciating one another's efforts (Johnson et al., 1998). This type of learning entails cognitive processes such as explaining, thinking critically, challenging one another, and relating present learning with past knowledge. Based on a review of approximately 305 articles, Smith et al. (2005) summarized that peer learning in a cooperative team could result in higher academic success, higher quality of relationship among students, better psychological adjustment, and more positive attitudes towards learning. Many of the studies reporting successful experiences also highlighted the importance of an appropriate assessment strategy that should be aligned with the pedagogy and learning objectives (e.g., Borglund, 2007; Boud et al., 1999; Hersam et al., 2004).

Peer learning in a tutoring or mentoring form, which involves senior or more capable students teaching and helping junior students, also produces fruitful outcomes. Peer tutoring results in higher motivation and learning for students as well as learning and empowerment for the tutors themselves (Colvin, 2007). Student tutors usually act as facilitators, whose role is to model learning strategies through developing activities and processes that facilitate students to learn vigorously (Marra and Litzinger, 1997). Students (i.e., tutees) are found more willing to receive guidance on "how to learn" in a safe and non-threatening situation from their peers (Power and Dunphy, 2010). Initially developed at the University of Missouri-Kansas City in 1973 as a measure to assist students in difficult courses (Blanc et al., 1983), the Supplemental Instruction (SI) Program based on the peer tutoring model became one of the few to be designated by the U.S. Department of Education as an Exemplary Education Program in 1981 (Arendale, 1997). As of 2000, SI has been widely implemented in 900 universities and colleges in the United States and 12 other countries (Hodges et al., 2001).

Given the benefits brought by the two different peer learning strategies, an integration of them in a collaborative problem solving environment should be promising. Merrill (2008) argued that peer learning is most effective when learners are engaged in solving real world problems, particularly when the problems are carefully selected and specified. This study will illustrate the implementation of both strategies in an engineering course on grand challenges and present the learning outcomes of both peer tutors and students.

3. The multi-layered model and its implementation

The multi-layered model consists of multiple intertwined learning loops for both students and peer tutors (refer to Figure 1). The learning of students includes (i) learning from team members through constant interaction and discussions within a small project team; (ii) learning from other peers through attending and critically assessing the presentations of other teams; and (iii) learning from peer tutors through asking questions and seeking assistance. The learning of tutors includes (i) learning from explaining the concepts and providing feedback to students; and (ii) learning among peer tutors on tutoring techniques.

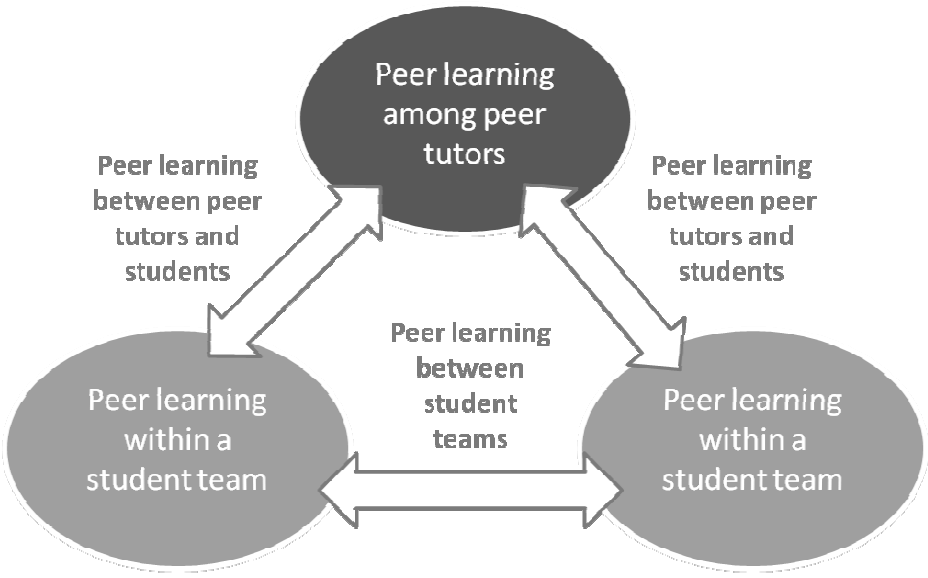

Figure 1. Multi-layered peer learning model

The model was implemented in a course entitled "Engineering Solutions to Grand Challenges of the 21st Century". The main aim of the course is to develop students' abilities in collaborative problem solving. The intended learning outcomes are:

(i) identify the key issues involved in two real-world engineering problems by obtaining information from experts and the literature;

(ii) analyze these problems from multiple dimensions and angles including feasibility, scalability, and sustainability;

(iii) suggest and evaluate solutions to these problems by working collaboratively; and

(iv) present and defend the solutions orally and in writing.

The course was piloted twice in the Fall of 2010 and Spring of 2011 at HKUST. Thirty-two students enrolled in the Fall semester of 2011 with local Hong Kong Chinese students at 81.3% and non-locals at 18.7%. Students were of different disciplines, including engineering (81.3%), science (9.4%), business (6.3%) and double degree in engineering and finance (3.1%), as well as at different academic year, including foundation year (6.3%), first year (6.3%), second year (31.1%) and third year (56.3%).

The two challenges, i.e., the problems to be tackled in the course, are complex problems facing mankind in the 21st century. The first challenge was on transportation problems. Students were required to work in teams to focus on one of the following aspects to tackle the challenges: (i) study the impacts brought by the increasing loads of transportation globally; (ii) provide solutions to reduce transport-related emissions; (iii) reorganize the urban development pattern of Hong Kong; or (iv) develop a sustainable urban land use and transport pattern for Hong Kong or Shanghai. The second challenge centered on solid waste management. Students in teams were asked to address this issue through one of the following angles: (i) define the current position of Hong Kong; (ii) formulate solutions to manage electronic waste; (iii) develop a strategy to promote organic waste composting; or (iv) draw up a public engagement plan for building waste-to-energy incinerator in Hong Kong. Both challenges were defined and presented by subject matter experts.

Eight teams were formed by the instructor, with four students per team. The principle of assigning students into teams was to maximize the diversity of major and year of study so that they had opportunities to work with people

of different backgrounds. Five undergraduate peer tutors were recruited based on their demonstrated performance in the intended learning outcomes of the course in the previous semester. Among them, four were team coaches, each of whom was assigned to work with two teams. The remaining one was the Peer Tutor Coordinator (PTC) who coordinated all course-related matters among students, instructors, experts, and peer tutors.

Training on collaborative problem solving through inquiry and leadership skills was delivered to students at the beginning of the course. Two librarians were embedded in the course and provided assistant to students on literature search skills. After the presentation of each challenge by the expert, students were required to attend discussion sessions in class and prepare report to tackle the challenges. Feedback on draft report was given to students from time to time. Before the final team presentation of the solutions in front of the experts, students were asked to attend training on oral presentations and rehearse their presentations. The rehearsal was critically assessed by both the instructor and classmates from other teams, with formative feedback provided to the students.

The assessment strategy developed in the course was aligned with learning outcomes and the collaborative problem solving pedagogy. Pre- and post-tests on students' self-reported abilities in the four intended learning outcomes were designed, with each learning outcome represented by two to three sub-items (see Appendix I). Three assessment rubrics focusing on teamwork, oral presentation, and written reports were developed to allow assessment by self, peers, and the instructor or expert (see Appendixes II-IV). Two focus groups were conducted with students and peer tutors to probe into their learning experience and collect feedback for improvement.

4. Results of the assessment

4.1. Pre- and post- tests on self-reported abilities in the intended learning outcomes (ILOs)

The pre-test was taken in the second session of the course and post-test was taken in the last session. Scores collected were processed and items measuring the same learning outcomes were averaged in both tests. The scores were also paired so that the difference measured reflected the actual change of the same group of students. Responses collected in one test without the corresponding record in another test were excluded in the analysis. There were 21 (out of 32) pairs of responses collected. It was noted that students rated themselves rather low in the pre-test, especially in their perceived abilities of the first two items, and there was a large improvement through the course, as reflected in the median scores in post-test. This is an important piece of evidence on the course effectiveness since the first two items reflect the core abilities in collaborative problem solving and the development of them is the main aim of the course. Wilcoxon signed rank test was conducted to compare the median scores reported by students on each ILO. The results (refer to Table 1) showed an improvement in all ILOs.

Table 1. Comparison of scores in pre- and post-tests

	Intended learning outcomes	Median score in pre-test	Median score in post-test	Z value	Significance
(i)	Identify the key issues involved in real-world engineering problems	3.25	4.33	-3.439	P=0.001**
(ii)	Analyze problems from multiple dimensions and angles	3.50	4.50	-3.698	P=0.000**
(iii)	Suggest and evaluate solutions to these problems by working collaboratively	4.00	4.25	-2.410	P=0.016*
(iv)	Present and defend solutions orally in and in writing	3.75	4.00	-3.083	P=0.002**

*Note: *p<0.05; **p<0.01*
All scores ranged from 1 to 5, with 1 being the worst and 5 being the best.

4.2. Assessment rubrics and results

The assessment rubric on teamwork, specifying different levels of five essential teamwork elements (refer to Appendix II), was used by students, peer tutors, and the instructor. The oral presentation assessment rubric, focusing on structure, content, communication, use of media, and timing (refer to Appendix III), was used by peer tutors and the instructor. The rubric on report (refer to Appendix IV), covering problem formulation, depth and thoroughness, innovativeness and language, was used by the expert and instructor. Table 2 shows a summary of the averaged scores for each team. It was observed that in the teamwork category, students tended to rate themselves higher than the instructor and peer tutors did. The scores students gave to their teamwork abilities in pre-test were also relatively high compared to other abilities.

A correlation analysis based on Spearman's rho test was performed to examine the association between scores. Scores on teamwork assigned by peer tutor were found as highly correlated with those assigned by the instructor ($r=0.900$, $p=0.002$), indicating that the judgment of peer tutors on teamwork performance aligned with that of the instructor and vice versa. Similarly, the scores given by peer tutors and the instructor on presentations were also highly correlated ($r=0.898$, $p=0.002$). Self-assessment scores of individual students were averaged to derive a team-level score. It was found that students' self-assessment on teamwork was strongly associated with the assessment by peer tutors ($r=0.850$, $p=0.007$). Table 3 shows correlations between scores assessed by different people.

In order to examine the relationship between team processes and performance, the scores on teamwork assessed by peer tutors and the instructor were averaged to derive an overall evaluation on team processes. Meanwhile, the scores on presentation and reports were also averaged to determine the overall performance in the course. The results showed that team processes were significantly correlated with the overall performance ($r=0.837$, $p=0.010$). This indicated that teams with effective processes performed better in the overall performance assessed in the course.

Table 2. Averaged team-level scores on teamwork, presentation and report

	Teamwork			**Presentation**		**Report**
	Students' self-assessment	Assessed by instructor	Assessed by peer tutor	Assessed by instructor	Assessed by peer tutor	Instructor/Expert
Team 1	4.82	4.00	5.00	4.16	4.00	3.60
Team 2	4.26	3.00	3.00	3.56	3.74	2.70
Team 3	4.66	4.00	5.00	4.28	4.28	3.33
Team 4	4.38	4.50	5.00	4.36	4.14	4.60
Team 5	3.72	3.40	3.00	2.88	3.20	3.20
Team 6	5.00	4.00	5.00	4.20	4.20	4.50
Team 7	4.82	4.00	5.00	4.16	4.04	3.00
Team 8	4.18	2.25	3.00	3.82	3.56	2.90
Average	4.48	3.64	4.25	3.72	3.93	3.90

Note: All scores ranged from 1 to 5, with 1 being the worst and 5 being the best. Refer to Appendixes II-IV for details.

Table 3. Correlations between scores assessed by different people

	a	b	c	d	e
a. Self-assessed teamwork	1.000	0.850**	0.612	0.731*	0.590
b. Teamwork assessed by peer tutor		1.000	0.900**	0.845**	0.850**
c. Teamwork assessed by instructor			1.000	0.736*	0.842**
d. Presentation assessed by peer tutor				1.000	0.898**
e. Presentation assessed by instructor					1.000

*Note: * p<0.05; ** p<0.01*

4.3. Focus group with students

Twenty out of 32 students attended the focus group with one independent facilitator. The results showed that students appreciated the collaborative problem solving environment in the course as well as the chance to learn from peers at different levels. During the focus group, students were asked to write down anonymously what they liked and what they disliked about the course on post-it notes, with one idea written on one piece of note. The post-it notes were collected and posted onto a white board so that everyone could see them and make comments. The notes were numbered according to the sequence of being posted. Twenty-one post-it notes were collected, with 11 marked as positive by participants and 10 as negative. One positive aspect emphasized was the "*supportive environment created by helpful professors and teaching assistants*" (i.e., peer tutors) (Note #1) that "*allow us to brainstorm creative ideas*" (Notes #8 & #19). Some wrote down "*I can get exposure to different fields*" (Note #5) and "*learn knowledge in different fields/topics*" (Note #4). Students also acknowledged that they had learned "*problem solving skills*" (Notes #7 & #12) and "*working in a team collaboratively*" (Notes #14, #17, & #20), which were both regarded by students as important for their future study. These comments were confirmed with participants through the discussions after all the post-it notes were posted on the white board.

When asked about the role of peer tutors in the learning processes, one student commented that

"They raised some questions to us and challenged our assumptions, so we had to re-think about the problem and see if we neglected something…"

Another student supplemented that

"Sometimes we did not know what the topic was really about, and he (i.e., the peer tutor) shared his experience and gave us some background information."

The above two quotes showed that students appreciated the opportunities to learn from their peer tutors but a number of students expressed that they were not aware that they could seek assistance from peer tutors. One said that

"*I knew that they were senior students and yes, they sometimes talked to us, but I did not know whether they were there to help us*."

Students pointed out that they had learned a lot from other student teams. One student wrote on the post-it note about the positive side of the class, "*can see presentation from different teams*" (Note #10). The chance of attending other peers' presentations was valued by a number of students who elaborated during discussion that "*looking at others' presentation makes us clearer about the requirements of the course, especially when we saw the mistakes made by others in their presentation...*" This reflected the usefulness of having rehearsed presentations, during which students evaluated other teams by making reference to the assessment rubric.

While the notes collected on positive side of the course were mostly about learning processes and outcomes, the notes on the negative aspect about the course focused mainly on operational issues, for example, "too *much workload*" (Notes #2, #16 & #18), "*uneven workload distribution across the semester*" (Notes #3 & #21), "*not*

enough time for report 2" (Notes #6 & #15), and "*change of presentation schedule*"(Note #9). Other issues included "*lack of technical background*" (Note #11) and "*not enough interaction between us and the experts*" (Note #13).

4.4. Focus group with peer tutors

Focus group conducted with the five peer tutors illustrated that they formed new views on their own study based on the learning and reflection gained from the coaching experience. Some of the concerns were also revealed that raised the need of training. Peer tutors reported that explaining to students helped them clarify thoughts and reflect on their own learning experience. One of them said that

> *"…(After the coaching experience), I believe that now I have well-achieved all of the four intended learning outcomes to a 100-percent extent or even more. When I took this course as a student last semester, I felt like I only achieved 50 – 60% of them…"*

All other peer tutors echoed this view and they believed that it was like "re-completing the course with a full achievement of all the learning objectives". Another student mentioned a better understanding on the report in particular,

> *"I did not know why a report should look like that way but now I thoroughly understand the reasons behind. ...I must understand it before I could explain the requirements to the students."*

One peer tutor reflected on his own learning experience based on the observation of the student teams. He said,

> *"When I looked at how the students planned and executed the work, you know, …the work was often done just before the deadline, I …(laughed) thought that it was exactly the same as my own practice…It was not good ...I hope I could change this pattern…Actually I am trying…"*

When asked about how they worked with one another, one commented that

> *"I feel like we are a very good team. If you measure us against the teamwork rubric, every item should score high."*

While peer tutors acknowledged their gains, they also expressed some of the concerns regarding being a peer tutor. The following quotes illustrated the confusions over their identity, roles, and the possible interventions that could be taken:

> *"I am not sure about my role in the class. When I saw that my teams were not functioning well, like one person never participated in the discussions, I did not know what to do. I am not Neil (i.e., the instructor) so they (i.e., students) would feel weird if I did something."*
>
> *"In fact, I did not know what I should do. I am not an expert on teamwork or collaborative problem solving. Maybe it is better to let them (i.e., students) figure out the problem in their way."*

5. Discussion

Results in this study demonstrated that peer learning in the course was achieved at different levels. The focus group with students reflected that they learned through interaction with others from different backgrounds in a supportive environment. Learning between teams occurred when students in one team obtained lessons learned by attending and evaluating the presentation of others. Problem-solving abilities and teamwork skills were the two competencies students claimed that they had acquired. This piece of qualitative evidence was strongly supported by the students' perception of their abilities in the intended learning outcomes, as reflected by the improvement in the pre- and post-tests. The differences in median scores were particularly large on the two core abilities, i.e., to identify key issues involved in engineering problems and to analyze problems from multiple dimensions. At the same time, the focus group with peer tutors showed that they clarified their thoughts through explaining the subject matter to students. They also reflected on their own learning pattern by observing students and learning from one another as a tutor team.

The alignment between scores assessed by peer tutor and the instructor in teamwork and presentation illustrated the utility of assessment rubrics. Through giving detailed descriptions for different levels of performance (i.e.,

exemplary, competent, and needs work) in a number of important areas, an assessment rubric offered a clear standard against which the team processes and outputs were assessed. As noted by Besterfield-Sacre et al. (2004), rubrics improve quality and reliability of the assessment. The alignment also indicated that with the rubrics, peer tutors had sufficient ability in assessing students' teamwork and they could be even in a better position to do so than the instructor as the assessment made by peer tutors on teamwork was highly correlated with the self-assessment by students, whereas the assessment made by the instructor was not. One reason could be that peer tutors worked closely with student teams so they knew more clearly about what was happening in the team. Another possible reason would be that peer tutors shared similar perspectives with students. Relying on rubrics as the main assessment tools, peer tutors could serve as good assessors as well as good advisors to students.

Another important finding was that teams with better teamwork processes also performed better in oral presentation and final report. This was consistent with literature on team processes and performance (e.g., Adams, et al., 2002; Powers et al., 2002). The five elements contained in the teamwork assessment, i.e., trust, commitment, conflict resolution, accountability, and attention to results, were found in the literature (e.g., Lencioni, 2002; West, 2004) as very important for a functioning team. Results in this study, besides confirming the relevance and significance of these items, pointed to the importance of developing students' teamwork skills.

The multi-layered peer learning model appears to be a promising way to improve the scalability of the problem-based learning approach. Class size is a typical concern in problem-based learning. As pointed out by Shipman and Duch (2001), it is difficult for an instructor to monitor the progress in each team when the class size is large than 25. The introduction of peer tutors is useful since they provided timely assistance to students. Peer tutors could communicate with the instructor when they notice that the student team is on a wrong direction. As one peer tutor reflected, "…when they (i.e., students) wanted to know whether they were on a right track, I often confirmed with Neil (i.e., the instructor)...." They could also answer simple questions and explain what is expected according to their experience. This observation conformed to Gafney's (2007) study in which peer tutors are seen as a bridge between the instructor and students.

This study identified the important need of training for peer tutors, instructors, and students. Peer tutors were confused about their roles on when, how, and to what extent they should intervene. Colvin's (2007) study on peer tutoring has similar findings and she pointed out that training for peer tutors should help them accept and appreciate the position they occupy in the class. The following points are thus recommended for implementing the model. Training of peer tutors should include: (i) briefing peer tutors that their roles are similar to an advisor to students based on their previous experience; (ii) preparing them to be ready to communicate with both instructor and students; and (iii) training on tutoring techniques. Instructors need to be aware that the social dynamics in the classroom would become very different with the presence of peer tutors. The expectation of students needs to be managed as well, particularly about the intention that peer tutors are there to assist and not to do the work for them.

Students reflected in the focus group that they had difficulties in managing time, as well as handling uneven workload across the semester. This is in fact common feedback from students participating in problem-based learning (e.g., Ruiz-Gallardo et al., 2011). To help students overcome this difficulty, it is recommended that students be informed of the schedule early in the course and review sessions be arranged at times to ensure the progress of student teams. Peer tutors can also play a role in this as they could share experience on the management of time and motivate students to catch up. As mentioned by one peer tutor during the focus group, "*I kept reminding them (i.e., students) to start writing early as it would be a nightmare if you do it in the last minut*e."

One limitation of this study was that all data were obtained from one class so the findings may not be generalizable. As the course will be offered in future semesters with modifications per findings in this study, further study will utilize longitudinal assessment data across semesters to enhance the generalizability and reliability of the results obtained from a larger sample population.

6. Conclusion

The ability to tackle complex problems collaboratively is extremely important for engineers in the contemporary society. A course on grand challenges offers an excellent opportunity to develop this ability by allowing students to work in a setting that mimics the actual work environment. We have demonstrated the usefulness of aligning learning outcomes with pedagogy and assessment in the delivery of such a course. In addition, the effectiveness and scalability of the course could be improved by adopting a multi-layered peer learning model. We believe this general approach is applicable for the design of similar courses that focus on the development of professional skills in a technical context.

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Appendices

Appendix I Items for pre- and post-test on intended learning outcomes

Please indicate to which extent you agree or disagree with the following statements:

		Strongly disagree				Strongly agree
1.	I am confident that I can identify the key issues involved in real- world engineering problems.	1	2	3	4	5
2.	I have the necessary skills to obtain useful information from experts.	1	2	3	4	5
3.	I have the necessary skills to search for useful information in the literature through library and online sources.	1	2	3	4	5
4.	I am able to analyze engineering problems from multiple dimensions and perspectives.	1	2	3	4	5
5.	I consider various issues, including feasibility, scalability and sustainability, when analyzing engineering problems.	1	2	3	4	5
6.	When I work in a team, I often give suggestions to solve problems.	1	2	3	4	5
7.	When I work in a team, I often evaluate solutions to problems with team members.	1	2	3	4	5
8.	When I work in a team, I acknowledge conflicts and resolve them.	1	2	3	4	5
9.	I can work collaboratively with people from different disciplines.	1	2	3	4	5
10.	I am able to deliver a professional oral presentation.	1	2	3	4	5
11.	I can defend my ideas when challenged by others in the presentation.	1	2	3	4	5
12.	I am able to write a project report effectively.	1	2	3	4	5
13.	I can use appropriate contents to develop ideas logically in a report.	1	2	3	4	5

Appendix II Teamwork assessment rubric

Team: Assessor Date:

Category/Criteria	Exemplary (5)	Competent (3)	Needs Work (1)	Score
Trust	Team members are genuinely open with one another. They always share their weaknesses and mistakes.	Team members are reasonably open with one another. They occasionally share their weaknesses and mistakes.	Team members are not open with one another. They rarely share their weaknesses and mistakes.	
Conflict	Team members actively embrace different ideas and commit to resolving conflicts as they arise. Team meetings are always lively and interesting.	Team members are willing to discuss different ideas and deal with conflicts occasionally. Team meetings are often lively and interesting.	Team members shy away from conflicts and are not willing to discuss different ideas. Team meetings lack energy.	
Commitment	Team members are very clear about the team's direction and priorities and totally committed to realizing the team's goals.	Team members can agree on the team's direction and priorities and commit to realizing the team's goals.	Team members have different ideas of what the team goals are and lack the commitment to move forward as a team.	
Accountability	Team members always put the team's interests ahead of individual interests and keep one another accountable.	Team members attempt to let one another know when individuals do not act in the best interest of the team.	Team members avoid keeping one another accountable for actions and behaviors that would hurt the team's progress.	
Results	Team members always stay focused on team goals, maintain a high level of motivation, and celebrate success along the way.	Team members stay reasonably focused on team goals and can make steady progress towards them.	Team members are easily distracted and lose sight of team goals, resulting in a loss of motivation or lack of progress.	

Things that the team did well:	Things that the team could have done better:

This assessment rubric is adopted from the model in: Lencioni, P. (2002). *The five dysfunctions of a team: A leadership fable*. San Francisco: Jossey-Bass.

Appendix III Presentation assessment rubric

Team: Assessor: Date:

Category/ Criteria	Exemplary (5)	Competent (3)	Needs Work (1)	Score
Structure	• The presentation has a concise and clearly stated focus that is relevant to the audience. • The presentation is well-structured with a clear storyline. • Ideas are arranged logically; they strongly support the presentation focus. • Sections are well- connected with smooth transition.	• The presentation has a focus; but it is not concise or not clearly stated. • The presentation is somewhat structured. • Ideas are arranged logically; but the connection with the presentation focus is not very strong. • Sections are connected.	• The presentation lacks a focus. • The presentation is ill-structured. • Ideas are presented without obvious order or logical connection. • Transitions between sections are jumpy.	
Content	• Materials are coherently organized, demonstrating the presenter's mastery of the subject knowledge. • All materials presented are relevant and lead naturally to the conclusion/recommendation. • Ideas are supported by evidence, with appropriate use of facts, examples, statistics and references.	• Content shows subject knowledge and depth; but sections may not show a strong coherence with the whole. • The materials adequately support the conclusion/recommendation. • Ideas are sometimes supported by information research.	• The content is fragmented; it fails to demonstrate the presenter's subject knowledge. • The materials presented are not clearly linked to the conclusion/recommendation. • Ideas are stated without support or references.	
Communi-cation	• The presenter is fluent and articulate; the use and variation of tone and pace is effective. • The presenter demonstrates good grammar and choice of words. • The presenter maintains proper eye contact with audience; posture and gestures show a good level of confidence and enthusiasm.	• The presenter's pronunciation is average. Some tone and pace variations are used to facilitate the delivery. • The presenter's vocabulary and grammar accuracy are average. • The presenter maintains eye contact some of the time. Posture and gestures display a moderate level of confidence and enthusiasm.	• The presenter does not speak clearly, speaks too fast or too slowly, rarely uses tone or pace variation to help the delivery. • The presenter uses very limited vocabulary and poor grammar. • The presenter does not look at the audience. The body language shows a lack of confidence and enthusiasm.	
Use of media (if any)	• Visual aid is clear, relevant and well-designed. • Creative effort is evident in making the presentation more captivating.	• Most visuals are clear and/or relevant. • Traditional use of media, but effective and professional.	• Visuals are irrelevant, difficult to understand, or poorly designed. • Ineffective use of media.	
Time management	• The presentation lasts 20 +/- 1 minutes.	• The presentation lasts 20 +/- 2 minutes.	• The presentation lasts 20 +/- 4 minutes.	

Strengths of the presentation:	Areas for improvement:

Appendix IV Report assessment rubric

Team: Assessor: Date:

Category/ Criteria	**Exemplary (5)**	**Competent (3)**	**Needs Work (1)**	**Score**
Formulation of the challenge	Challenge is developed and articulated in an excellent manner. Effective thinking is clearly and creatively expressed.	Challenge is clearly developed with some supporting details and there is evidence to support a central theme in the challenge.	Challenge is poorly developed with supporting details that are absent or vague. Simple ideas and unclear wording reflect a lack of understanding of the challenge.	
Depth and thoroughness of analysis	Develops logical and consistent plan to meet the challenge, articulates the reasons. Develops clear connections between solutions and supporting details. Excels at sophistication in thought and thoroughness.	Considers various approaches and develops a plan to solve the challenge. Less acceptable approaches are rejected with little consideration or justification.	Uses only a single approach to consider and solve the challenge. Presents the solution with insufficient supporting details.	
Innovativeness and feasibility of proposed solutions	Actively seeks out and follows through in untested directions. Extends a novel or unique idea to create a feasible new solution that is technically creative.	Experiments with creating a novel idea to the challenge. Does not explore in depth. Attempts to connect ideas and solutions in novel ways.	Reformulates a collection of available ideas without offering new insights. The solution is unimaginative.	
Language	Wide variety of sentence structures. Excellent word usage and precise word choices, spelling, correct grammar and punctuation, technically accurate. Sources correctly cited.	Some sentence variety; adequate usage of wording, grammar and punctuation with acceptable technical accuracy. Some cited sources used.	Writing lacks sentence variety. Significant deficiencies in wording, spelling, grammar, or presentation. Technical wording inaccurate. Sources poorly cited	
Overall presentation	Report is clearly structured around the relevant theme. Each component of the report is clear and relates to others in a well-planned framework. Excellent integration of information. Style of presentation is professional and attractive.	The structure of the report demonstrates some form of organization related to the relevant theme. Not all components are logically presented, but some theme is evident throughout. Style of presentation is professional.	Report is unfocused and poorly structured with the main theme and details presented in a disorganized and unrelated manner. Style of presentation is unattractive.	

Strengths of the report:	Areas for improvement: