APPLICATON OF CDIO SKILLS IN ARTIFICIAL INTELLIGENCE AND ANALYTICS PROJECTS

Ho Teck June

School of Computing
Singapore Polytechnic

ABSTRACT

All final year students of the School of Computing (SOC) in Singapore Polytechnic have to complete a capstone project module. The aim of the capstone project is to encourage students to think critically and develop soft skills such as teamwork, planning and communication, and apply their technical knowledge to solve real-world problems. The capstone project provides students with the opportunity to integrate the technical knowledge and skills learnt in the core modules (business communication, database management system, business intelligence, business analytics and predictive analytics), and apply CDIO skills in projects such as Artificial Intelligence (AI) and Analytics projects.

This paper reports on a survey conducted to solicit students' perception of the application of professional and interpersonal skills required to complete the capstone project successfully. This paper also reports on the use of an online team-based self and peer assessment tool.

Finally, this paper identifies challenges the students faced when engaging with clients as well as professional and interpersonal skills needed to overcome these challenges. Suggestions to further enhance the learning experience for the capstone project are also discussed.

KEYWORDS: analytical reasoning, system thinking, attitude, communication skill, teamwork skill, self and peer assessment, CDIO Standards: 1, 2, 5, and 12

INTRODUCTION

In the SOC, all final year students are required to complete a capstone project module. The aim of the capstone project module is to provide students with an opportunity to integrate the knowledge and technical skills they have acquired from the course to a real-world problem. Students will go through the different stages of conceiving, designing and developing an application and in that process strengthen their technical knowledge as well as soft skills including presentation and communication skills. In the project, students are expected to apply technologies they have acquired throughout the course such as Python programming, JSP, SQL server technologies, data visualisation, data analytics, and predictive analytics.

The Diploma in Business Information Technology (DBIT) is one of the diploma courses offered by the School of Computing in Singapore Polytechnic. The DBIT curriculum includes 28 core modules, one of which is the capstone project module. It is a semester-long module requiring 210 hours of work. There are three different types of projects that students can choose from: mobile application development, web application development, or AI and analytics application. AGILE project management framework is adopted as it provides a lightweight process framework that embraces iterative and incremental practices, helping students to deliver

working or proof-of-concept (POC) prototypes such as data analytics dashboards, chatbots, or predictive analytics solutions.

For the capstone project, students worked in groups of four or five with a faculty member as their project supervisor. The role of the project supervisor is to provide guidance to students in defining the project scope and timeline as well as identifying project requirements. There are two key milestones for the project with two phases: phase one lasts for 7 weeks and phase two for 8 weeks. In phase one, every group is required to submit a project specification, which includes the project scope, the conceptual design (wireframe), a preliminary prototype, and the hardware and software requirements, which will be presented to the client for acceptance. In phase two, every group is required to produce a user guide, a technical reference manual, and a deployment kit, which will be demonstrated to the client.

This paper reports on an attempt to review the capstone project module to determine if it indeed provides students with opportunities to integrate the technical knowledge and skills they have acquired in their program of study to develop industry-sponsored IT applications. It reports on outcomes of a survey focusing in particular on their professional and interpersonal skills. This paper also discusses how these skills can be more effectively developed.

LITERATURE REVIEW

E.Crawley, J.Malmqvist and K.Edstrom (2014) has highlighted that there is a growing understanding that besides a good command of technical knowledge, our graduates must also be equipped with a range of personal, interpersonal, professional and engineering skills with engineering disciplinary knowledge in order to prepare innovative and entrepreneurial engineers. K.Edstrom, S.Gunnarsoon and G. Gustafsson (2009) further emphasized that personal and interpersonal skills, and product, process, and system building skills are highly interwoven into mutually supporting courses, relieving the potential tension between technical disciplines and skills.

One of the key ideas in the CDIO initiative is that the personal and interpersonal knowledge, skills and attitudes should be integrated into the curriculum (Standard 3). This means providing students with the opportunities to learn the skills together with disciplinary knowledge (K.Edstrom S.Gunnarsoon, G. Gustafsson, 2009). For example, the roles within the team and with respect to the customer, technical experts, etc, should be defined. Communication is another essential skill in the project, both within the project group and with the client. By presenting the project ideas and solutions to both their peers and the client, students acquire the ability to communicate technically, and develop the confidence to express themselves within their field of work.

The CDIO syllabus, a key document in the CDIO initiative, specifies the knowledge and skills an engineer should possess to function at the work place. The CDIO syllabus has been adapted into the DBIT curriculum. This paper focuses on two categories in the CDIO syllabus: Personal Professional Skills and Attributes (Section 2) and Interpersonal Skills of Teamwork and Communication (Section 3). These are envisaged to be implemented via the DBIT capstone project module.

The capstone project module aims to help students to integrate knowledge and skills acquired in the past modules. It is expected that the industry-commissioned projects will expose students to work methods used in industry and also provide students with the opportunity to make connections between the technical knowledge they have learned and their professional and career interests.

METHODOLOGY

The research questions in this paper are the following:
(a) Did the students have the ability to apply professional skills to their project?
(b) Did the students have the ability to apply interpersonal skills to their project?
(c) Did all team members contribute fairly to the project?

A questionnaire was administered online via Google Forms to 40 final-year DBIT students from the School of Computing at the end of the semester. (Refer to Appendix A for the questionnaire.) Students who participated in the survey were informed that the information provided by them would be kept confidential and that the data would be collated, analysed and used to improve future teaching and learning. There was a 82.50% response rate to the survey.

The questionnaire comprises a list of statements relating to the students' experiences with the CDIO skills. In total, there were 18 close-ended questions rated on a 5-point scale; where 5 represents a perception of "strongly agree" and 1 represents "strongly disagree", and four open-ended questions.

The close-ended questions were based on the following CDIO skills:
1. Professional Skills (Analytical Reasoning, System Thinking and Attitudes in learning)
2. Interpersonal skills (Teamwork Skill and Communication Skills)

The open-ended questions were used to gather insights on the important skills learnt, challenges faced and feedback on the module.

SURVEY RESULTS

The results of the survey are elaborated below. The frequency distribution and means of the 4 skill categories is shown in Table 1 below. Each skill category may have 3 to 5 questions (refer to Appendix A on a list of questions for each category).

Table 1: Frequency distribution (with percentages in parenthesis) and means of students' perception of their proficiency levels for the 4 skills (n=33).

Likert Scale / Skills	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean
Professional Skill: **Analytical Reasoning & System Thinking**	106 (64.24%)	50 (30.30%)	8 (4.85%)	1 (0.61%)	0 (0%)	4.58
Professional Skill: **Attitude in learning**	79 (59.85%)	46 (34.85%)	6 (4.55%)	1 (0.76%)	0 (0%)	4.54
Interpersonal Skill: **Teamwork Skill**	72 (72.73%)	23 (23.23%)	3 (3.03%)	1 (1.01%)	0 (0%)	4.68
Interpersonal skill: **Communication Skill**	61 (61.62%)	35 (35.35%)	3 (3.03%)	0 (0%)	0 (0%)	4.59

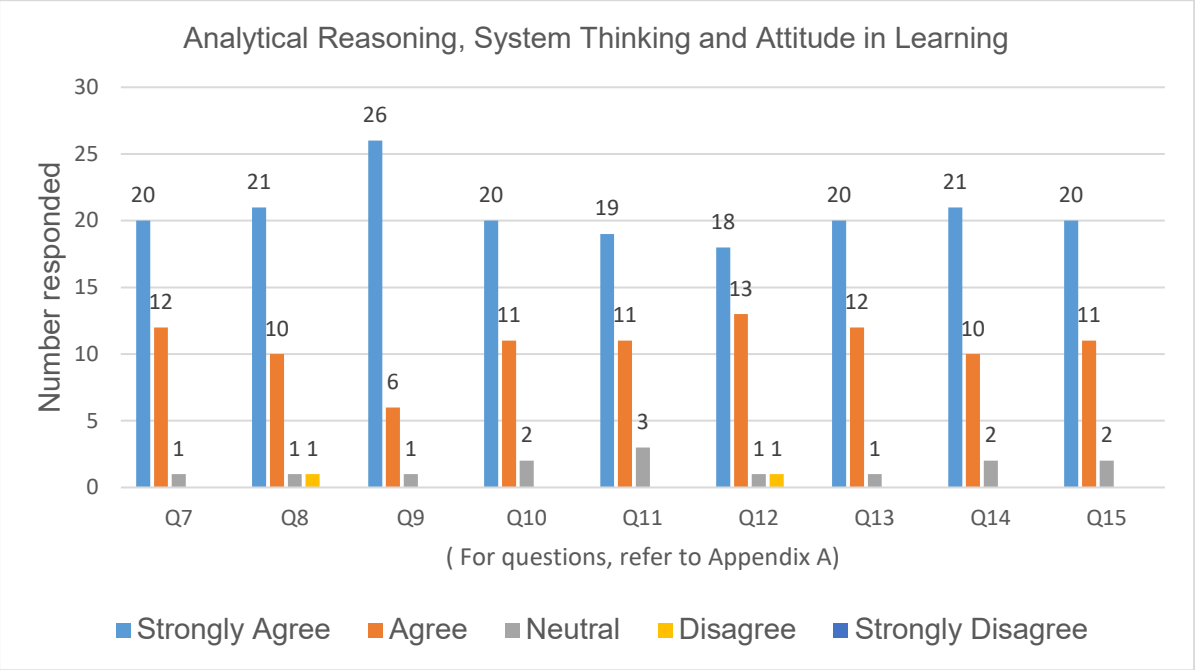
The mean rating for analytical reasoning and system thinking is 4.58. The third year project module requires students to apply their analytical reasoning and system thinking skills to design and develop the final year project. Students are fairly good at identifying key features and suitable models or algorithms for their projects.

Conversely, the mean rating for attitude in learning was lowest at 4.54. I observed that students who were interested and highly motivated had the courage, enthusiasm and determination to accomplish project objectives. However, students who were disinterested would only do the bare minimum to pass the final year module. There is a small number of students in the cohort who were not very motivated to do well for the course.

When comparing the means of the 4 skill categories, students gave the highest mean rating of 4.68 for teamwork skill and 4.59 for communication skill. As students have already started working in groups for at least one assignment in their year 1 and year 2 modules, they may have realised that good team work is important in order for the team to be awarded good results.

Figure 1 below is a detailed illustration of the survey results for professional skills.

(a) Did the students have the ability to apply professional skills to their project?



Q7:mean is 4.58	Q8:mean is 4.55	Q9:mean is 4.76	Q10:mean is 4.55	Q11:mean is 4.48
	Q12:mean is 4.45	Q13:mean is 4.58	Q14:mean is 4.58	Q15:mean is 4.55

Figure 1: Survey results of analytical reasoning, system thinking and attitude in learning

There are 9 questions in Figure 1 above; questions 7 to 11 are questions related to analytical reasoning and system thinking whereas questions 12 to 15 are questions related to attitudes in learning. For the analytical reasoning and system thinking category, there were 26 (78.79%) students who strongly agreed to question 9. The mean rating of question 9 has the highest mean rating of 4.76. Question 9 was, “I am able to identify the key features of my application”. This could be attributed to the fact that the core and optional project requirements were discussed and confirmed with the client at the start of the project. It is heartening to know that students had a clear understanding of the main features of the application. There were 21 (63.64%) students who strongly agreed to question 8. Students were familiar with background research in the context of their project. The lowest mean rating for the analytical reasoning and system thinking category is question 11. For question 11, there were 19 (57.58%) students who strongly agreed that they were able to draw conclusions supported by facts or findings for the project. Drawing conclusions is considered as a higher order thinking skill; one has to evaluate complex information, categorize, manipulate, connect facts, ideate and develop

insightful reasoning before drawing concise conclusions. This skill could be better developed when students work on more industry IT projects.

For attitude in learning category, the mean rating for question 14 is the highest. The mean rating is 4.58. There were 21 (63.64%) students who strongly agreed that they had the opportunity to demonstrate professionalism and integrity. A majority of 3rd year students are mature students with ages ranging between 19 and 21. These students demonstrated good business sense and could conduct themselves well when they met up with the project client to gather project requirements. The lowest mean rating for this category is question 12. The mean rating is 4.45, which is 0.13 lower than as compared to question 14. There were 18 (54.56%) students who strongly agreed that they were able to display self-confidence, courage, enthusiasm and determination to accomplish the objective. The lowest mean rating is Q12 where the question was, "I am able to display self-confidence, courage, enthusiasm and determination to accomplish objectives". This could be due to the fact that the project represented the first time that these students were working on an industry IT project and thus were unsure about the project objectives. Furthermore, students may also lack the enthusiasm and determination to accomplish the objectives.

The next category is teamwork and communication skills. From the survey results, it is evident that students could apply soft skills such as teamwork and communication skills better than analytical reasoning and system thinking skills when they were working on the final year project.

(b) Did the students have the ability to apply interpersonal skills to their project?

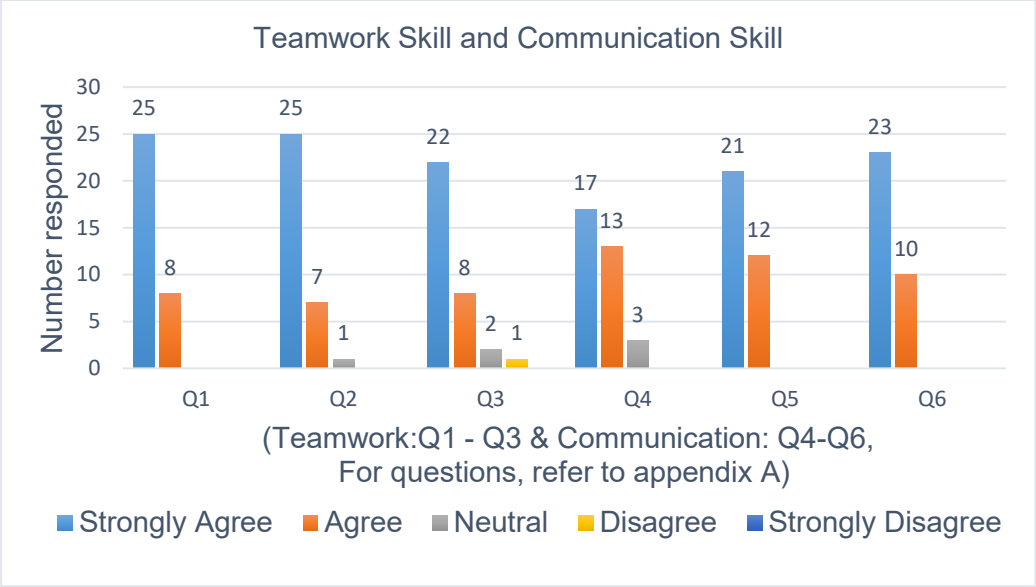


Figure 2: Survey results on Teamwork Skill and Communication Skill

There are two types of interpersonal skills; teamwork skill and communication skill. For teamwork skill, there were at least 25 (75.75%) students who mentioned that they strongly agreed that they could collaborate with team members to ensure the project's success and that team members demonstrated effective teamwork and communication among themselves. There were 22 (66.67%) students who mentioned that team members agreed on common goals and ground rules when they worked on the final year project.

For communication skill, there were 17 (51.52%) students who strongly agreed that they were able to design communication strategies according to the purpose, audience and context of the presentation. There were 23 (66.67%) students who mentioned that they were able to

demonstrate active and empathetic listening when they worked in a team or when they were responding to questions by clients. There were 21 (63.64%) students who mentioned that they were able to use appropriate charts, diagrams to illustrate a concept during project presentation and demonstration. In view of the several presentation sessions that students were exposed to in year 1 and year 2, these third year students have built confidence over time and most were able to articulate and apply good presentation techniques such as speaking with clarity and presenting in a coherent manner to clients. There were no students who mentioned that they had challenges in applying communication skills to the final year project. These could be attributed to the three communication skills modules in the Diploma curriculum.

From the open-ended question where students were asked to highlight the important skill set in the final year project, a large majority of the students perceived communication skills as more important than other skills such as problem-solving and project management. There were 23 (69.70%) students who mentioned that communication is an essential skill for the completion of a final year project. There were 11 (33.33%) students who mentioned that teamwork is an important skill for the completion of the final year project. Below is a comment from a student on importance of interpersonal skills in project work:

> "When I started working on the project, one of the most important skill I have learnt is communication. Being able to communicate our ideas well and ask questions to understand our project scope is important to ensure that we do not lose track and we know what we are doing while working on the project. The next one is teamwork. As this is a big project for a real client, it is important for our team to cooperate with each other so that we can work well together and produce high quality work to our client."

(c) Did all team members contribute fairly to the project?

An online team-based self and peer evaluation tool is used to collect students' response on the contribution of individual group members. The tool calculates the SPA (Self and Peer Assessment) factor score and SAPA (Self-Assessment over Peer Assessment) score. The online assessment is a formative tool to allow a supervisor to identify dysfunctional groups and to put appropriate support strategies in place. For the SPA score, students were asked to evaluate their peers' individual contributions to group work by splitting 100 marks between the members of the group, including themselves. An SPA score between 0.95 and 1.15 is considered as acceptable teamwork. Unlike the SPA score, the SAPA score gives an indication of how realistically students judge their individual contribution to the group project. It compares the score a student allocates to themselves against the average that all the other students have given them. The SAPA is used to highlight students who are trying to "game" the system. For formulae on SPA and SAPA scores, please refer to "PAF Formula and Moderation Overview - eLearning - University of Queensland (uq.edu.au)".

As the capstone project is a group assignment, it is important to know the percentage of individual contribution to the group work as this facilitates a supervisor's award of marks to every team member. All final-year students taking the capstone project module were required to participate in the online team-based SPA exercise mid-way into the project. Table 2 shows the summary of SPA results of all 33 respondents.

Table 2: Self and Peer Assessment (SPA) results of all 33 respondents.

SPA score	Interpretation	Meaning	Number responded
More than 0.85 to <=0.95	Slacker	They are considered as slackers loafers and were usually be mentored with the	2
More than 0.95 to <=1.00	Acceptable Teamwork	This student put in almost just the right amount of effort for group work.	17
More than 1:00 to <= 1.05	Good Teamwork	The student is working well with the group	12
More than 1.05 to <= 1.15	Leader	The student is showing definite leadership qualities and/or has been putting in	2

There were 2 students who had SPA scores less than 0.95. These two (2) students were considered as slackers who were usually mentored with the group's help. The majority of the students (29, 87.88%), had SPA scores within 0.95 to 1.05. There were 2 students who had SPA scores between 1.05 and 1.15. These two students were project leaders who had put in significant extra effort in the final year project. A project Leader is the scrum-master who had to schedule meetings with the client, monitor the progress of the team and contribute to development work, hence, project leaders normally contribute more to the project.

Table 3 shows the SAPA results. More than half of the students received SAPA scores of more than 1.0. This means that students believe that they did more than their group members thought. There were 6 out of 33 students who believed that they contributed fairly to the group project. Finally, about one third of the students had SAPA scores less than 1.0. These students undervalued their contributions to the group work.

Table 3: Self-assessment over Peer-assessment result of all 33 respondents.

SAPA Score	**Interpretation**	**No. of students**
> 1.0	Indicates that the student believes they do more in the group project than their group members think.	17
= 1.0	Student has contributed fairly to the group project	6
< 1.0	Indicates the student undervalues their contribution to the group project.	10

Once students have completed the online self and peer assessment exercise midway into the project, project supervisors would view the SPA and SAPA scores and the qualitative comments provided by team members. Project supervisors would then provide feedback to students so that the entire team could collaborate and contribute effectively to the successful completion of the project.

DISCUSSION

For the capstone project, there were some challenges that students encountered. Table 4 is a summary of challenges that students encountered when they worked on the capstone project.

Table 4: Summary of challenges encountered

Items	Number responded
Lack of technical skills such as using new software, program coding or identifying appropriate algorithms	18
Bad time management	10
Unclear of user's requirements and datasets	3

There were 18 (54.5%) respondents who mentioned that there were challenges in having to learn a new software such as Django, MS Power BI, Plotly, etc., within a short period of time and having to apply this knowledge and work on the project immediately. However, all final-year projects are software development projects and real-world software development is all about solving problems. One has to commit to making time for learning and be familiar with the software before the person has the confidence to commit to the project deliverables.

To address this issue and enhance the learning experience of students for the capstone project in future, all final-year students will be advised to set aside at least 2 weeks to make time for learning by attending technical workshops or attending online learning platform courses such as Plural Sight or Data Camp, to learn new software and technology that is related to the final year project. As all Singapore Polytechnic students are granted free access to the online learning platforms, students are required to adopt a self-directed learning approach to enhance their technical skills before they embark on the project.

About 30% of the respondents mentioned that time management was a challenge. Some mentioned that they hardly had enough time to produce quality work for the industry-sponsored IT project because they had to handle two other modules' assignments in the semester apart from the Capstone Project module. To help students in this aspect, project supervisors could emphasize and advise on the importance of good time management. Good time management maximizes our productivity in achieving our goals. One of the key concepts of a successful time management strategy is to be conscious of time. Some suggestions are to create a time audit and find areas to improve, put a time limit on tasks, create a daily plan, add a "done list" to your to-do list, complete the most important and demanding tasks first thing in the morning when you are fresh, and to not get hung up on small details.

There were 3 (9.1%) respondents who commented that "user requirements were unclear" as a challenge. This project was the first time that students were required to work on a client project and a client's requirements are often not as specific or as clear compared to assignment guidelines given in a module by a lecturer. To improve this area, project supervisors could guide the students in identifying a list of key project requirements for a project, teach the students how to translate non-specific client requirements into system design specifications. This would enhance the students' learning experience for final year project.

CONCLUSION

The findings show that the majority of students were able to integrate the knowledge and skills learnt in the core modules and apply them to the capstone project such as AI and Analytics projects. A large majority of the students perceived that they have very good interpersonal skills such as teamwork and communication skills. More than three quarters of the students put in a fair amount of contribution to the project because they are aware that the success of the project depends on good team dynamics. The use of online team-based self and peer assessment tool is highly recommended for group assignments or project work because it provides opportunities for students to independently assess their own and their peers' progress with confidence rather than relying only on teacher judgement. When students have to do a self and peer assessment, they are actively involved in the learning process and their independence and motivation is improved. It encourages students to take greater responsibility for their leaning.

When comparing interpersonal and professional skills, students perceived that they are better at interpersonal skill rather than professional skills. The mean rating for professional skills is slightly lower by 0.075. Professional skills such as analytical reasoning and problem solving skills are essential for gathering data, solving problems and producing quality projects. To sharpen the professional skills, lecturers could encourage students to ask questions during lessons when they were in year 1 and year 2. When students ask questions, it engages their cognitive functions. This can help to develop better problem-solving skill, retention and memory of a subject. In addition, lecturers could strongly encourage students to prepare alternative solutions to a given problem for their assignment when they were in year 1 and year 2. An example of an module assignment, such as predicting the housing prices, students could test out multiple prediction algorithms and evaluate the different models before deciding which is the best algorithm for the given scenario. Just like any other skill development, the more you practice and apply, the analytical skills and problem solving skills will come naturally.

There were 3 challenges that the students encountered when they were working on the capstone project. Some suggestions for improvements for the next cohort include recommending students to set aside 2 weeks to attend scheduled technical workshops or to enrol in online learning platforms to equip the relevant technical skills that are required for the project. As for time management and identifying client's project requirements, supervisors could teach students time management skills and guide the students on how to translate non-specific client requirements into system design specifications.

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BIOGRAPHICAL INFORMATION

Ho Teck June is a Specialist (AI and Analytics) and a Course Chair of Specialist Diploma in Data Protection and AI Governance in the School of Computing at Singapore Polytechnic. She is a recipient of Singapore Polytechnic's Journal of Teaching Practice Award since 2003. She has written a few publications and presented in a number of renowned conferences, both local and oversea. Her current focus is to strengthen AI and Analytics aspects in the School of Computing.

Corresponding author
Ho Teck June
Singapore Polytechnic
School of Computing
500 Dover Road, Singapore 139651
Tan_Teck_june@sp.edu.sg

APPENDIX A

Survey on a list of interpersonal and personal skills used when you are working on the Final Year Project module

The purpose of this questionnaire is to gather feedback on student's perception on professional, Interpersonal, conceptualisation, design and implementation skills you used when you are working on the Final Year Project module. There are 18 close-ended questions and 4 open-ended questions.

Please note that all the information provided, will be kept confidential.

When you answer the questions below, you may start with the following phrase: "When I worked on the project,"

Thank you for your participation in advance. For queries, please write to tan_teck_june@sp.edu.sg.

* Required

Email address *

Student Name (Full Name) *

Student Admin No ('p' prefix is not required) *

IChat email account: *

Select one of the choices (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree & 5=Strongly Agree)

1. I collaborate with my team members to ensure the project's success. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

2. I am able to demonstrate effective team work and communication such as active listening, collaboration, providing and obtaining information and etc. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

3. My team members and I agree on common goals and ground rules *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

4. I am able to design appropriate communication strategies (e.g. when making presentations) according to the purpose, audience and context. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

5. I am able to use appropriate wireframes, diagrams, charts and tables for project presentation and documentation. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

6. I am able to demonstrate active and empathetic listening in a range of communication situations, e.g. working in team, responding to question, formal argument, negotiation, etc. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

7. I am able to identify key features of the application and could provide a workable solution to address the key features. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

8. I am able to classify primary and secondary research information in the context of my project. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

9. I am able to identify the key features of my application. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

10. I am able to explain how the different components/modules are interrelated in my application. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

11. I am able to draw conclusions, supported by data, facts and/or findings. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

12. I am able to display self-confidence, courage, enthusiasm and determination to accomplish objectives. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

13. I am able to demonstrate perseverance, resourcefulness and flexibility in adapting to change. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

14. I have the opportunity to demonstrate professionalism and integrity. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

15. I have the opportunity to show initiative, e.g. analyse potential benefits and etc. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

16. I am able to understand my client's core business goals and requirements. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

17. I am able to prepare a project plan and schedule. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

18. I am able to identify possible development process improvements when I work on my application. *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

19. Identify two important skill you learnt when you are working on the Final Year Project Module *

20. Identify two challenges you faced when you are working on the final year project module *

21. Explain challenges you faced when you are interacting and working with your client.*

22. Do you have any other comments or feedback about the Final Year Project Module?*

Thank you very much for your participation.