Engineering Design Survey

Iman Moazzen*; Mariel Miller**; Peter Wild*; LillAnne Jackson*; Allyson Hadwin**
imanmoaz@uvic.ca fgage@uvic.ca pwild@uvic.ca engradu@uvic.ca hadwin@uvic.ca

* Faculty of Engineering, University of Victoria, BC, Canada

** Faculty of Education, University of Victoria, BC, Canada

Abstract – *Design is one of twelve graduate attributes that needs to be assessed as part of the accreditation process for engineering programs in Canada, as required by the Canadian Engineering Accreditation Board (CEAB). However, assessment of design competence is a complex task due to the fact design process is non-linear and depends on many factors including communication skills, teamwork skills, individual knowledge and skills, and project complexity. This study aims to capture undergraduate students' design and teamwork skills and the challenges they face in their design projects. To this end, a low-cost assessment tool which can be implemented and analyzed relatively fast is presented. The tool is a new survey which assesses students' self-reported intentions and skills for four key dimensions of team-based engineering design: (a) design process, (b) design communication, (c) teamwork, (d) regulation of teamwork. The survey was administered to the first year students enrolled in "Design and Communication I" after completion of a final design project. In this paper, the survey development and key findings from the collected data are discussed in detail.*

Keywords: Engineering Design, Assessment, Teamwork

1. INTRODUCTION

Design is a central activity to all types of Engineering. According to the Canadian Engineering Accreditation Board (CEAB), an accredited program must "culminate in significant design experience" [1]. Thus, engineering design is a fundamental learning objective for engineering students in Canadian universities [2]. In response to this need, many cornerstone and capstone design courses have been integrated into engineering curriculum. Rigorous assessment of students' design knowledge is crucial to create effective learning environments that facilitate development of design knowledge [2]. Assessment provides students with valuable feedback regarding their progress with respect to the intended learning outcomes as well as areas in which they may need to improve. Assessment further helps educators improve the curriculum and address public concerns about the quality of educational programs [3].

However, assessment of design competence is a complex task [10]. Engineering design consists of multiple skills and competencies such as communication and teamwork as well as individual knowledge. Assessment tools that are systematic, flexible, and time and cost efficient are needed if we wish to adequately gauge students' design competencies as they progress through university programs [10]. As such, in the current study we aimed to develop a questionnaire that systematically targets fundamental aspects of engineering design. The survey along with the findings from the collected data is discussed in detail.

2. PROPOSED SURVEY

2.1. Purpose and Objectives

The proposed survey is a part of an ongoing design assessment project which aims to:

- Capture how undergraduate Engineering students develop design knowledge and expertise
- Capture the challenges students face in their undergraduate design work
- Inform evidence-based decision making about design instruction and program development
- Inform theory and research about engineering design and effective teamwork

2.2. Survey Overview

The survey assesses four key components of Engineering Design informed by Hyman's model of the engineering design process [9], Davis et al. [3] and models of regulated collaboration [8]. These included: **(a)** *design process* (following a plan to build a product which satisfies the client needs) **(b)** *design communication* (documenting and presenting information needed to implement desired design solutions), **(c)** *teamwork* (fulfilling roles & responsibilities, climate, time/task management, team communication), and **(d)** *regulating teamwork* (planning teamwork, strategically enacting the tasks, monitoring and evaluating progress and products, and making changes to optimize collaboration when needed).

The current survey contains three main sections: (a) Section 1 assesses the extent to which students intended to engage in each component of design during a recent project (b) Section 2 assesses how challenging students found each component of engineering design during the project; and (c) Section 3 asks students to reflect on the most significant challenge they encountered and the most important thing they learned during the project. As such, the survey examines students design intentions and skills as they relate to a specific task in one undergraduate course. That is, the task provides a snapshot of students' design skills at the current point of progression through the program. Design components and sub-components for each section are summarized in Table 1. The survey is provided in the Appendix.

3. CONDUCTING THE PILOT SURVEY

3.1. Selected Course for the First Set of Data Collection

To evaluate the pilot survey and analyze the appropriateness of its questions, we conducted the survey in a mandatory first-year design course, Design and Communication I (ENGR 110/112), offered in Fall 2013 in the undergraduate Engineering program at the University of Victoria. The course consisted of two main parts, "Design" and "Communication" which were taught by in close cooperation between Faculty of Engineering and English Department. This course exposes students to the introductory principles of engineering design process through practical projects defined by clients. Further, it provides students with opportunities to improve their presentation and research skills at the University level. The survey was conducted at the end of the term when the students finished their design project for the Capital Region District (CRD), a regional government and service provider on Southern Vancouver Island.

The objective of the design project was to improve cycling modal share in the Capital Region by designing a new or enhancing an existing infrastructure solution, product or system that will inspire and motivate more residents and visitors to cycle. The students worked on the project as fixed groups of four/five for about two months. The final deliverables were posters and oral presentations. Students were encouraged to make functional/non-functional prototypes to illustrate their solution(s).

3.2. Participants

Participants in the first pilot implementation were 53 consenting students enrolled in ENGR 110/112. Participant demographics are summarized in Table 2. All students enrolled in ENGR 110/112 were invited to complete the survey and participate in the research (400 students). Two invitations to participate were distributed

via online course announcement by the lab instructor. Students wishing to participate in the research completed the survey online using FluidSurveys. Survey response rate was low (13.75%, $n = 55$). Two respondents declined to participate in the research and were excluded from analysis.

Table 2. Participant Demographics

		Proportion	N
Gender	Male	66.0%	35
	Female	34.0%	18
Age	17 to 20	75.5%	40
	21 to 30	22.6%	12
	31 to 40	1.9%	1
Year of Program	1 st year	94.3%	50
	2 nd year	5.7%	3

3.3. Survey Completion

- Only 61.81% of all students completed all three sections of the survey ($n=34$).
- Mean time to complete the pilot survey was 21.10 minutes (SD = 10.67).
- There is a jump in survey attrition after Section 1 (Figure 1).

Figure 1. Number of Responses across Survey Sections 1- 3 by Consenting Students

The above findings suggest the students may have found the current survey to be too lengthy. One explanation for the steep jump in attrition after Section 1 could be that the items for Sections 2 were much longer and may have been tedious or difficult to answer.

3.4. Design Priorities

Results indicated students rated most aspects of the design process, design communication, and teamwork as a high or very high priority for the project (Figure 2), and rarely indicated that items were not applicable for the project. Mean priority ratings for each item are displayed in Figure 2.

- Teamwork appeared to be the highest priority for students ($M=3.47$, $SD=0.72$) which was expected due to the major emphasis on teamwork in the class and lab activities.
- Testing/Validating appeared to be the lowest priority for students ($M=2.92$, $SD=0.85$) which was not surprising since the required deliverables for the course were posters and presentations.

Table 1. Sections and Categories included in Each Section of the Survey

Section	Categories and Items
Design Priorities Extent to which students intended to make use of components of Engineering Design during a project <i>Rate each item from 1 (not at all a priority for me) to 4 (high priority for me) or 5 (not applicable to this project).</i>	Need Identification (Recognizing the need) Problem Formulation (Defining the problem) Planning the project Gathering information Generating Solutions Evaluating Alternatives Selecting the Preferred Design Implementing the Design Testing/Validating the Design Documenting and Presenting the design (Communication) Working as a team Other
Design and Teamwork Challenges How challenging students found enacting key components of Engineering Design in a recent project <i>Rate each item from 1 (Very easy for me) to 4 (Very challenging for me) or "Did not do this/Not Applicable to my Project"</i>	Design Process Need identification/ Problem Formulation Planning the Project Gathering Information Generating Solutions Evaluating Alternatives / Selecting Design Implementing/ Testing / Validating Taking an Iterative Approach Design Communication Documenting / Presenting Teamwork Roles & Responsibilities Team Climate Task/Time Management Communication Team Regulation Planning Monitoring/Evaluating Working Strategically Adapting
Project Outcomes Reflections on the biggest challenge encountered in the project and the biggest thing learned	What was the biggest challenge you encountered in this design project? (Choose 1) Need Identification Problem Formulation Planning the project Gathering information Generating Solutions Evaluating Alternatives Selecting the Preferred Design Implementing the Design Testing/Validating the Design Documenting and Presenting the design Working as a team Other Describe why this was the biggest challenge - what happened? What is the most important thing you learned about Engineering Design in this project?

Figure 2. Mean priority ratings for each design project item

These results suggest students may have had difficulty distinguishing design skills that were important for the project from those that were not. For example, implementation was not a focus for the ENGR110/112 project. However, on average, students rated this as being a high priority ($M=3.09$, $SD=0.86$), and 0% of students indicated it was not applicable for the project.

3.5. Design and Teamwork Challenges

In Section 2 of the questionnaire, students rated the extent to which they found design process, design communication, teamwork, and regulating teamwork easy or challenging in the project. We examined students' scores for each category (design process, design communication, teamwork, and regulating teamwork) as well as scores for sub-components that make up each category (e.g. roles & responsibilities, team climate). Category scores were computed by taking the mean of items that make up that category. For example, Design Process score was calculated by summing ratings on all design process items and computing the mean. Scores for each sub-component were computed by taking the mean of the items that make up the sub-component. The results are summarized in Figure 3 and Table 3.

Students reported few difficulties with design process, design communication, teamwork, or regulating teamwork in the project (Figure 3).

- At the category level, teamwork was rated as the least challenging aspect of the project ($M=1.84$,

$SD = 0.49$) and design process was rated as most challenging ($M=2.34$, $SD=0.35$).

- At the sub-component level, Implementing & Testing the design was rated as most challenging ($M=2.40$, $SD=0.55$) while Team communication was rated as least challenging ($M=1.69$, $SD=0.47$).

These findings are unexpected as students are in the first year of their program and likely do not possess well developed skills for design. There are number of possible explanations for these results:

- The ENGR110/112 Project may not have required extensive use of these types of skills.
- Due to inexperience and novice level knowledge of design, students may have had difficulty distinguishing what design skills were used in the project from those that were not and may have had difficulty accurately self-assessing the extent to which they effectively used these design skills.
- Students may have felt pressure to demonstrate their expertise in design by rating themselves highly.

Students infrequently reported items as not applicable/did not do this (Figure 4). Three exceptions were Implementing & Testing/Validating (26.0% of responses), documenting/presenting design (11.78%), and adapting teamwork (11.78%).

3.6. Key Challenges

Students most often reported that working as a team was the most significant challenge they encountered during the design project (29.41%, $f=10$), followed by Gathering Information (11.8%, $f=4$) and Planning the Project (11.8%, $f=4$) (Figure 5).

These results were unexpected considering that students generally reported teamwork to be 'easy for them' in Section 2. One possible explanation for this finding is that teamwork items asked students about their own teamwork skills (easy vs. challenging for me) while this item asked about teamwork in general (working as a team). This explanation is corroborated by preliminary analysis of students' explanations of 'what happened' in which one emerging theme was difficulty dealing with others' working schedules, unequal participation from others in the group, etc. Few of these responses referenced students' own shortcomings in teamwork skills.

Figure 3. Mean challenge ratings for Design Process, Design Communication, Teamwork, and Regulating Teamwork

Table 3. Challenge ratings for Design Process, Design Communication, Teamwork, and Regulating Teamwork

Category	Sub-Component	Mean	SD	N
Design Process	Needs Identification/Problem Definition	2.38	0.41	39
	Planning the Project	2.36	0.57	38
	Gathering Information	2.37	0.46	38
	Generating different solutions	2.26	0.51	35
	Evaluating solutions/ Selecting design	2.36	0.41	35
	Implementing & Testing/Validating	2.40	0.55	35
	Taking an Iterative Approach	2.20	0.59	35
	All process items	2.34	0.35	39
Design Communication	Documenting/ Presenting	2.13	0.53	35
Teamwork	Roles & Responsibilities	1.87	0.68	32
	Climate	1.92	0.68	32
	Task/Time Management	2.06	0.81	32
	Communication	1.69	0.47	32
	All teamwork items	1.83	0.49	32
Regulating Teamwork	Planning Teamwork	2.11	0.64	32
	Regulating Monitoring & Evaluating	2.10	0.68	32
	Adapting Teamwork	2.10	0.84	31
	Working Strategically	1.92	0.70	32
	All regulating teamwork items	2.07	0.60	32

Figure 4. Proportion of “not applicable/did not do this” responses for each sub-component of Design Process, Design Communication, Teamwork, and Regulating Teamwork.

Figure 5. Proportion of items indicated as the most significant challenge identified during the Design Project

4. CONCLUSIONS & NEXT STEPS

Results of the pilot survey indicated that students felt all aspects of engineering design were important for the project, and reported few difficulties in enacting design skills. While these results might seem positive, participants were first year students in an introductory engineering course, and not all components of engineering design were required in the project. As such, students appeared to have difficulty distinguishing design skills that were relevant for the project from those that were not and assessing their own skills. Furthermore, the response rate and completion rate for the survey was lower than expected. There are a number of possible explanations for these results:

1- The likely inflated self-ratings and little variability suggest the response scale (e.g. easy for me vs. challenging for me) appears to be introducing some social desirability bias. In other words, students may feel pressure to evaluate themselves highly in order to present themselves in a positive light.

2- The 4-point bipolar Likert scale may have contributed to this issue. For example, when deciding between the middle points of the scale “somewhat easy for me” and “somewhat challenging for me,” students may have felt more comfortable selecting the higher of the two middle points.

3- Some items were long and complex. It is possible that students had difficulty interpreting them and they may have contributed to the low completion rate for the questionnaire.

4- Since projects have different requirements across years, item wording requires a not applicable option. Not applicable options may make it difficult to distinguish gains in engineering design competencies across 1st to 4th year and these preliminary results suggest students have difficulty distinguishing which are applicable and which are not.

Recommendations for next steps:

- 1- Wording of items could be revised to ask students to rate their agreement about whether the project helps them to develop design process skills, design communication skills, teamwork skills, and regulating teamwork skills required of a professional engineer.
- 2- Agreement could be rated on a 5 point Likert scale from “Strongly disagree (did not do this)” to “Strongly agree”.
- 3- Wording of each item could be simplified to increase students’ ability to answer the questions accurately (e.g. refine items with long and complex with multiple dependencies in wording).
- 4- Administering the questionnaire after students have received their design project grades may help them to more accurately self-assess their skills and feel less pressure to evaluate themselves positively.
- 5- Response and completion rates could be boosted by using alternative modes of delivery (e.g. in class) and using results to eliminate redundant items.
- 6- Decisions about questionnaire scoring (one overall score; factor score?)
- 7- Validity of the questionnaire could be explored by (a) examining how scores correlate with students’ project grade, course grade, GPA (Institutional Data), (b) consultation with subject matter experts (both instruction and industry).
- 8- A second pilot phase would be useful to increase sample size. This would enable use of statistical tests to determine the reliability and validity of the instrument (e.g. Cronbach’s alpha for internal consistency, confirmatory factor analyses to quantitatively test questionnaire factors)

1. ACKNOWLEDGEMENTS

The authors greatly acknowledge funding from NSERC, Canada.

2. REFERENCES

- [1] Bazylak, J., and Wild, P., “Evaluation system for capstone engineering design reports”, 2010.
- [2] Bailey, R., and Szabo, Z., “Assessing engineering design process knowledge”. *International Journal of Engineering Education*, Vol. 22, No. 3, pp. 508-518, 2006.
- [3] Davis, D.C., K.L. Gentili, M.S. Trevisan, and D.E. Calkins., “Engineering Design Assessment Processes and Scoring Scales for Program Improvement and Accountability.” *Journal of Engineering Education*, pp. 211-221, 2002.
- [4] Frank, B., and Strong, D., “Survey-based assessment of design skill development in engineering project courses”, 2008.
- [5] Frank, B., and Strong, D., “Development of a Design Skill Assessment Tool”, 2010.
- [6] Frank, B., and Strong, D., Boudreau, J., and Pap, A. “Design skill assessment from pre-university to third year”, 2009.
- [7] Gentili, K., Lyons, J., Davishahl, E., Davis, d., and Beyerlein, S., “Measuring added-value using a team design skills growth survey”, 2005.
- [8] Hadwin, A. F., Järvelä, S. & Miller, M, “Self-regulated, co-regulated, and socially shared regulation of learning”, *Handbook of Self-Regulation of Learning and Performance* (pp. 65-84). New York: Routledge.
- [9] Hyman, B. (2003), *Fundamental of Engineering Design*, Second Edition, Prentice Hall.
- [10] Moazzen, I., Hansen, T., Miller, M., Wild, P., Hadwin, A., and Jackson, L., “Literature Review on Engineering Design Assessment Tools”, *Proc. Canadian Engineering Education Association (CEEAA13) Conference*, Montreal, Canada, 2013.
- [11] Okudan, G., Ogot, M., Zappe, S., and Gupta, S. “Assessment of learning and its retention in the engineering design classroom”, *American Society for Engineering Education*, 2007.

Participant Consent Form

Department of Educational Psychology
& Leadership Studies

Technology Integration and Evaluation
Research Lab

Exploring Teamwork in Engineering Design

Principal Investigators

Dr. Allyson Hadwin (Hadwin@uvic.ca)

Dr. Peter Wild (pwild@uvic.ca)

Funded by the NSERC Chair in Design Engineering at the University of Victoria grant & the SSHRC Promoting Adaptive Regulation for 21st Century Success (PAR-21) grant.

Purpose and objectives

As part of improving instruction in the Engineering department, we are researching students' experiences in their design projects. Specifically, we aim to:

- Understand how undergraduate Engineering students develop design knowledge and expertise
- Understand the challenges students face in their undergraduate design work
- Inform evidence-based decision making about design instruction and program development
- Inform theory and research about engineering design and effective teamwork.

Importance of this research

- This research will help members of the UVic community and the broader scholarly community to understand affordances and barriers in students' development of design competencies.

Participating in this research involves:

- Completing a short questionnaire about your experiences in your last design project
- Allowing researchers to access institutionally collected data for research purposes (e.g., university and high school GPA, course enrolment, discipline and program) throughout your undergraduate degree

Inconvenience, risks, & benefits

- The only inconvenience will be the time you spend completing the questionnaire.
- There are no known or anticipated risks.
- Potential benefits include reflecting on your design skills and how to improve them and contributing to program development and scholarly research on this topic.

Researchers relationship with participants

- Dr. LillAnne Jackson, Engineering Associate Dean Undergraduate Programs (Principal Investigator) will not know you are participating in this research. All names and identifying information will be removed before releasing data to Dr. Jackson.
- If you are enrolled in ENGR 110/112 and your course instructor is Dr. Wild (Principal Investigator), he will not know who has consented to participate or have access to the data until after the course is complete and final grades have been submitted.

Participation is voluntary; You can withdraw at anytime

- You are being asked to participate because you are an undergraduate student enrolled in a course containing a design work component/assignment in the Faculty of Engineering.
- Your participation in this research is completely voluntary. There will be no negative consequences for students who choose not to participate.
- If you decide to participate, you can withdraw at any time without any consequences or explanation. If you do withdraw from the study, your data will not be included analysis.

Anonymity and confidentiality

- Questionnaires and institutional data with your name or student ID are not anonymous. However, your confidentiality will be protected by (1) replacing your name and identifying information with a random

case number, and (2) summarizing data across many students. When specific examples are used, names will be replaced with pseudonyms and all references to specific people, courses, and assignments will be removed.

What will happen to data and how will findings be shared?

- All data will be stored on a password protected server or locked filing cabinet only accessible to the researchers. DATA will be stored for 10 years, after which electronic data will be erased and paper copies will be shredded.
- Data will be analyzed by the principal investigators and research collaborators. Data may also be analyzed by the principal investigators and their research collaborators as part of the engineering program accreditation process for the Canadian Engineering Accreditation Board (CEAB). Data may also be analyzed by other researchers for purposes such as for MA theses and Doctoral dissertations. Any data provided to other researchers will be fully anonymous and include no identifying information. Findings will be presented through academic publications/presentations, research websites (<http://allysonhadwin.wordpress.com/>), student theses and dissertations, and reports to university administrators.

Contacts

If you have any questions regarding this study or wish to withdraw at any time, you may contact Dr. Allyson Hadwin, Faculty of Education (250.721.6347 OR hadwin@uvic.ca). In case of questions and concerns, you may also contact Dr. Tom Tiedje, Dean of Engineering (250.721.8612 or engrdean@uvic.ca).

- Note: Do not contact Dr. LillAnne Jackson because she is Engineering Associate Dean, Undergraduate Programs and cannot know which students are participating. If you are enrolled in ENGR 110/112 do not contact Dr. Peter Wild because he is a course instructor and cannot know which students are participating until course grades are submitted.

You may verify the ethical approval of this study, or raise any concerns you might have, by contacting:

- Human Research Ethics Office at UVic (250.472.4545 or ethics@uvic.ca)

Consent

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers, and that you consent to participate in this research project.

Name of Participant

Signature

Date

Engineering Design Experiences Questionnaire

Challenges are normal when you work on team-based design projects. The purpose of this survey is to help you to distinguish between easy and challenging aspects of a recent design project and to become aware of the areas in which you may need to improve. Also, by completing this survey you help educators adjust the curriculum and learning environment to support your learning. Your valuable feedback would be highly appreciated by the Faculty of Engineering and the assessment team.

Full Name _____ **V Number:** _____

Age ☐ Below 17 ☐ 17 to 20 ☐ 21-30 ☐ 31 to 40 ☐ Over 40

Year of Program ☐ 1st Year ☐ 2nd Year ☐ 3rd Year ☐ 4th Year or Higher

Gender ☐ Male ☐ Female ☐ Other

Name of the course in which you received this survey (e.g. ENGR 110/112):

--

Name and briefly describe the most recent Design Project you completed in this course

--

Design Priorities

Think about the design project that you described. Which of the following were priorities for you in this Design Project? Rate each item below from 1 (very low priority for me) to 4 (very high priority for me) or 5 (not applicable to this project).

1	2	3	4	5
Very Low Priority For Me	Somewhat Low Priority For Me	Somewhat High Priority For Me	Very High Priority For Me	Not Applicable To This Project

Recognizing the need for the design project	1	2	3	4	5
Defining the problem including design goals, objectives and constraints	1	2	3	4	5
Planning the project	1	2	3	4	5
Gathering information	1	2	3	4	5
Generating different design solutions	1	2	3	4	5
Evaluating alternative design solutions	1	2	3	4	5
Selecting the preferred design based on the appropriate evidence	1	2	3	4	5
Implementing the preferred design	1	2	3	4	5
Testing/Validating the performance of the implemented design	1	2	3	4	5
Documenting and presenting the design	1	2	3	4	5
Working as a team	1	2	3	4	5
Other	1	2	3	4	5
If other, please specify:					

Design Challenges

Think about how things went in the design project. What was easy and what was challenging for you? Rate each item below from 1 (Very easy for me) to 4 (Very challenging for me) or “Did not do this/Not Applicable to my project”

	1	2	3	4	5
	Very Easy For Me	Somewhat Easy For Me	Somewhat Challenging For Me	Very Challenging For Me	Did not do this / Not applicable to my project
Fully identifying the client’s need (which implies that you know who the client is and the client knows what their need is)	1	2	3	4	5
Describing an appropriate design goal (e.g., brief, general, and ideal response to need statement)	1	2	3	4	5
Defining measurable objectives to help decide how well the design meets the clients’ expectations	1	2	3	4	5
Describing the conditions under which the design must perform	1	2	3	4	5
Making sure the design objectives were well aligned with the project needs	1	2	3	4	5
Identifying the constraints (go/no-go conditions) the design must satisfy in order to be eligible for consideration	1	2	3	4	5
Allocating adequate time for problem formulation in the design process	1	2	3	4	5
Listing the tasks needed to complete the design project	1	2	3	4	5
Estimating the duration of each task	1	2	3	4	5
Ordering the tasks in a sequential manner based on their logical relationships to each other	1	2	3	4	5
Estimating the cost for each task	1	2	3	4	5
Determining personal assignments for each task	1	2	3	4	5
Identifying what information is needed to carry out design activities	1	2	3	4	5
Identifying appropriate sources for required information (e.g., industrial standards, handbooks, textbooks, user surveys, technical magazines, conference papers and journals, technical reports, company catalog and brochures)	1	2	3	4	5
Gathering information to help stimulate creativity (e.g., patent literature on the related topics)	1	2	3	4	5
Gathering economic information (e.g., to evaluate the market prospect and estimate cost)	1	2	3	4	5
Determining how reliable and credible the information is	1	2	3	4	5
Figuring out how gathered information applies to the problem at hand	1	2	3	4	5
Using effective techniques to actively gather information (e.g., questioning, talking to a colleague or professor about the information you are seeking)	1	2	3	4	5
Deciding when to stop looking for more information	1	2	3	4	5
Generating alternative solutions for the design problem	1	2	3	4	5
Thinking outside the box (e.g., going beyond existing patterns and boundaries)	1	2	3	4	5
Securing an appropriate work space for concept generation (e.g., appropriate lighting, comfortable work area, etc.)	1	2	3	4	5
Using effective techniques for generating ideas	1	2	3	4	5
Generating design alternatives as an individual	1	2	3	4	5
Generating design alternatives as a group (e.g., brainstorming)	1	2	3	4	5
Identifying appropriate criteria for evaluating alternative solutions	1	2	3	4	5

1	2	3	4	5	
Very Easy For Me	Somewhat Easy For Me	Somewhat Challenging For Me	Very Challenging For Me	Did not do this / Not applicable to my project	
Estimating the performance of each alternative solution from technical point of view by means of appropriate techniques (e.g., analyzing underlying theories , running computer simulations or doing practical experiments)	1	2	3	4	5
Evaluating the initial and life-cycle cost for each alternative solution (e.g., maintenance cost)	1	2	3	4	5
Fully assessing the social impact of each solution	1	2	3	4	5
Evaluating the environmental impact of each solution	1	2	3	4	5
Using effective techniques for choosing the preferred design (e.g., weighted objective chart)	1	2	3	4	5
Fully assessing appropriate evidence/issues to make decisions	1	2	3	4	5
Rationally justifying design decisions as valuable to customer	1	2	3	4	5
Elaborating on the selected design in greater detail (e.g., determining exact sizes, required materials, cost estimate, fabrication requirement, etc.)	1	2	3	4	5
Creating detailed engineering drawings for each component (hard copy or computer files)	1	2	3	4	5
Anticipating the interaction between different components	1	2	3	4	5
Providing an assembly drawing to display how the components fit together	1	2	3	4	5
Constructing a scale model or a full-scale prototype	1	2	3	4	5
Using sophisticated computer-based drawing software for modeling (e.g., Solidwork)	1	2	3	4	5
Implementing the design to create a product	1	2	3	4	5
Analyzing performance using appropriate tests and scenarios	1	2	3	4	5
Implementing a design that meets requirements	1	2	3	4	5
Refining or changing the problem definition when necessary (e.g., the client’s perception of the need changed, and you were forced to re-examine the need)	1	2	3	4	5
Adjusting or changing the goal when needed (e.g., broadening or narrowing the project scope)	1	2	3	4	5
Refining or changing design objectives and constraints when needed	1	2	3	4	5
Continuously gathering information when needed during the design process	1	2	3	4	5
Generating new concepts and ideas when needed	1	2	3	4	5
Adjusting or changing decisions when needed	1	2	3	4	5
Adjusting or changing implementation when needed based on test results	1	2	3	4	5
Approaching the design project in an iterative / non-linear way	1	2	3	4	5
Writing technical reports in a clear and concise style	1	2	3	4	5
Including all key elements in technical reports (e.g., title page, abstract, table of contents, introduction, results and discussion, conclusions, recommendations, references, and appendices)	1	2	3	4	5
Using diagrams, tables, graphs, and examples where appropriate	1	2	3	4	5
Carefully proofreading the report before final submission	1	2	3	4	5
Effectively presenting the design orally (e.g., clear, audible, well-paced, natural)	1	2	3	4	5
Including an appropriate amount of data/words in the formal presentation	1	2	3	4	5
Finishing the technical report or oral presentation within the allotted time	1	2	3	4	5
Presenting information in a logical and organized way	1	2	3	4	5
Tailoring technical reports/presentations to the target audience	1	2	3	4	5
Using graphical techniques such as drawing or sketches when needed (e.g., formulating a design problem, clarifying design ideas, explaining the design to others, etc.)	1	2	3	4	5

Teamwork Challenges

Think about how your team worked together in this project. What was easy and what was challenging for you? Rate each item below from 1 (Very easy for me) to 4 (Very challenging for me) or 5 (Did not do this).

	1	2	3	4	5
	Very Easy For Me	Somewhat Easy For Me	Somewhat Challenging For Me	Very Challenging For Me	Did Not Do This
Knowing what my role/responsibilities were in the team	1	2	3	4	5
Carrying out my roles and responsibilities in my team	1	2	3	4	5
Equally participating/contributing to my team's design project	1	2	3	4	5
Being supportive of my team members	1	2	3	4	5
Being accepting of personal differences in the team	1	2	3	4	5
Dealing with team members' different working styles	1	2	3	4	5
Respecting others in the team	1	2	3	4	5
Trusting other team members	1	2	3	4	5
Helping to establish mutual respect in the team	1	2	3	4	5
Helping my team to achieve a positive team attitude	1	2	3	4	5
Using time effectively in my team	1	2	3	4	5
Achieving our team goals on time	1	2	3	4	5
Working productively in my team	1	2	3	4	5
Listening when my other team members talked	1	2	3	4	5
Listening to others without interrupting	1	2	3	4	5
Practicing good non-verbal communication (e.g., eye contact, body language)	1	2	3	4	5
Sharing my ideas with my team members	1	2	3	4	5
Encouraging team members to share their ideas	1	2	3	4	5
Being open to my team members' ideas	1	2	3	4	5
Understanding what my team members had to say	1	2	3	4	5
Clarifying what others have said	1	2	3	4	5
Giving / receiving constructive feedback in my team	1	2	3	4	5
Maintaining constant communication between team members in the project	1	2	3	4	5
Making sure everyone had the same understanding about what our job was on this project	1	2	3	4	5
Making sure everyone was working towards the same objectives	1	2	3	4	5
Establishing common goals for the team	1	2	3	4	5
Agreeing on common standards for work between all team members	1	2	3	4	5
Establishing expected levels of commitment/contribution in my team	1	2	3	4	5
Deciding on an action plan for working together with my team	1	2	3	4	5
Working with my team to establishing a clear focus for our design efforts	1	2	3	4	5
Deciding on what each team member would be accountable for	1	2	3	4	5
Assigning team member roles and responsibilities	1	2	3	4	5
Checking on how well our project was going with my team	1	2	3	4	5
Deciding on whether our project was going well or not	1	2	3	4	5
Figuring out how to check on our project progress as a team	1	2	3	4	5
Figuring out when to check on our project progress as a team	1	2	3	4	5
Making changes when we weren't working well together	1	2	3	4	5
Making changes when things weren't going well in the project	1	2	3	4	5
Doing something to help if/when team conflict occurred	1	2	3	4	5

1	2	3	4	5
Very Easy For Me	Somewhat Easy For Me	Somewhat Challenging For Me	Very Challenging For Me	Did Not Do This

Figuring out what each team member was good at	1	2	3	4	5
Making use of different team members' skills/knowledge to achieve our goals	1	2	3	4	5
Using team members' individual strengths to achieve our goals	1	2	3	4	5
Working together strategically to succeed in the project	1	2	3	4	5

Project Outcomes

What was the **biggest** challenge you encountered in this design project?

Choose 1

- ☐ Recognizing the need for the design project
- ☐ Defining the problem including design goals, objectives and constraints
- ☐ Planning the project
- ☐ Gathering information
- ☐ Generating different design solutions
- ☐ Evaluating alternative design solutions
- ☐ Selecting the preferred design based on the appropriate evidence
- ☐ Implementing the preferred design
- ☐ Testing/Validating the performance of the implemented design
- ☐ Documenting and presenting the design
- ☐ Working as a team
- ☐ Other (please specify): _____

Describe why this was the biggest challenge - what happened?

Overall, what is the most important thing you learned about Engineering Design in this project?