Adapting Existing Assessment Tools For Use in Assessing Engineering Graduate Attributes

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Abstract – Recently, changes to the Canadian Engineering Accreditation requirements, following the example set by ABET, have called for the measurement of 12 graduate attributes in the engineering curriculum. Some attributes, such as “Knowledge Base,” lend themselves to forms of quantitative measurement; others, such as “Investigation” and “Communication” are inherently difficult to measure quantitatively and comprehensively. To assess these attributes authentically within our current curriculum, methods for adapting existing tools – that both satisfy the objectives of the actual course and the needs of graduate attributes assessment – must be found.

This paper describes the process and challenges involved in adapting existing tools for assessment to measure such graduate attributes, specifically in a large senior research thesis course in a multidisciplinary engineering program. These challenges include balancing both the needs of multiple parties involved in the assessment, maintaining rubric usability, reliability and validity, as well as appropriately matching rubric elements to attributes. Despite these tensions, the results provided by this process provide insight about rubric design, assessment strategies and the students’ strengths and weaknesses within the graduate attributes, providing valuable information to feed back into the graduate attribute and continual curriculum improvement processes.

Keywords: Rubrics, Graduate Attributes, Assessment, Thesis, Undergraduate Research, Accreditation

1. INTRODUCTION

Recent changes to the Canadian Engineering Accreditation requirements, following the example set by ABET, have called for the measurement of 12 graduate attributes in the engineering curriculum [4]. Some attributes, such as “Knowledge Base,” lend themselves to quantitative measurement; others, such as “Investigation” and “Communication” are inherently difficult to measure quantitatively and comprehensively. For these attributes,

a major issue involves identifying an appropriate experience in which to measure them.

Ideal places to perform such measurement may include the one or more significant “capstone” experiences included in many undergraduate engineering programs, designed to give students an opportunity to demonstrate significant learning through the integration of knowledge and skills from across the degree [1, 6]. Such a learning experience, an independent research project required for all senior students in a large, Canadian multi-disciplinary engineering program, forms the context for this paper. This thesis course gives senior undergraduate students an opportunity to work with a faculty member to define and design an original research project, as well as to conduct and communicate engineering-related research. In the 2010-11 school year, nearly 200 students in the program worked with 112 unique supervisors from 22 distinct academic departments, and across theoretical, clinical, design and laboratory settings, demonstrating a vast breadth of project scope. Outside of the student-supervisor relationship, students are provided with assignment guidelines, workshops, and rubrics to scaffold the documentation and communication of the research, which includes four deliverables: a proposal, an interim report, presentation and final research report. The stated learning objectives, taken from the course syllabus, are as follows:

1. Write a strong research proposal, identifying and developing a gap in a science/engineering related field, and develop a plan/method for addressing that gap
2. Conduct and write a literature review, summarizing the state of a science/engineering related field
3. Execute a major, independent research project in a relevant field of study
4. Generate and analyze data as part of a major research project
5. Present research methods, designs, results, and claims effectively, orally and in writing

6. Incorporate feedback from a variety of audiences to help improve the communication of scientific ideas

Given that the undergraduate thesis is a requirement for all students in the program, and that it capitalizes on students' earlier work in engineering communication and experimentation, it provides an excellent opportunity to measure students' skills in these areas at graduation. Capstone experiences, because of these characteristics [4-5], and as they exist in most undergraduate engineering programs [1, 6] are often used for program assessment purposes. In our case, it also presents an ideal opportunity to explore the adaptation of assessment tools for graduate attributes purposes, given that a newly developed common rubric for assessing all thesis projects had recently been completed [5]. Using a thesis course for attribute assessment purposes, however, presents some unique challenges that do not apply to capstone design course; for example, the large number of different assessors and diversity of projects.

Through this paper, we set out to answer the following research questions:

- 1) How can a complex, multidisciplinary undergraduate thesis course be used for the measurement of graduate attributes?
- 2) How can existing assessment tools be used and/or adapted for the graduate attributes process?

More specifically, this paper describes the adaptation of the rubric as an assessment tool designed to provide flexibility to a diverse group of projects and supervisors, as well as a tool worthy of utilizing in the graduate attribute assessment process, which should demonstrate how a cohort performs across the various indicators, or learning outcomes, that comprise an attribute. Yet while a seemingly ideal place for graduate attribute assessment, developing a rubric capable of generating useful data for these two sometimes competing purposes posed significant challenges, especially in relation to ensuring rubric validity and reliability. These challenges included mapping newly defined attributes to an existing assessment scheme, covering a diversity of projects in a large and complex undergraduate learning experience, as well as developing methods for addressing questions of inter-rater reliability within a large assessment team. Despite these tensions, the results provided by this process provide insight about the rubric design, assessment strategies and the students' strengths and weaknesses within the two graduate attributes, providing valuable information to feed back into the curriculum and thesis experience. The process of assessing graduate attributes within a curricular context also demonstrates the importance in allowing major curricular components to help define the learning outcomes associated with the

graduate attributes, rather than relying only on a top-down process, focused on centrally-developed learning outcomes.

2. ENGINEERING GRADUATE ATTRIBUTE DEVELOPMENT

The Canadian Engineering Accreditation Board (CEAB) has outlined 12 graduate attributes, which describe both the engineering knowledge base, and engineering-related skills expected of graduates. Programs are required to demonstrate that students are graduating with the demonstrated attributes, and that a continual improvement process is in place, "that demonstrate(s) that program outcomes are being assessed in the context of the graduate attributes, and that the results are applied to the further development of the program" [4]. The CEAB has described the investigation and communication attributes as follows:

Investigation: an ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions

Communication Skills: An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

Engineering schools across Canada are working to develop their own desired learning outcomes associated with each of the Graduate attributes [7]. At the University of Toronto, a Faculty-wide Graduate Attribute Committee was constructed to further develop learning objectives associated with each of the 12 graduate attributes. The Graduate Attribute Committee, or GAC, includes representation from all undergraduate programs along with the Engineering Communication Program, first year and undergraduate studies officers, and graduate studies. The committee members hold strong engineering, teaching and administrative experiences.

Within the committee, learning objectives were developed at two levels: first, a few global outcomes were developed to describe the broader objectives associated with an attribute. Secondly, more specific "indicators" were developed for each of the global outcomes, which were designed to more precisely measure student learning in a specific course or assignment context. This process was followed because it was found to be difficult to move directly from the attributes provided by the CEAB, which

are quite general, to clear, measurable outcomes that can be applied directly to a learning experience. This process assisted the committee in better developing a shared definition of each Attribute, and provided all working group members – and their respective departments and units – with a clear and shared understanding of each attribute. The process developed and carried out by the Graduate Attributes Committee has lead to a lot of useful discussion, and reflection, on what we are teaching, and what we need to be teaching.

The Graduate Attributes Committee commissioned a series of expert subcommittees to develop global outcomes and indicators for each of the 12 graduate attributes. In the case of the Communication attribute, faculty from the Engineering Communication Program developed a set of indicators, and in the case of Investigation, a group of cross-disciplinary faculty members who are active in research and teaching – and in particular the teaching of investigative laboratories – served on the expert committee. The expert groups brought their suggested outcomes and indicators back to the entire Graduate Attributes Committee for review. The committee required at least three passes through in order to converge on a clear set of indicators for each attribute. The Global Outcomes and Indicators for Investigation and Communication are listed below, in Tables 1 and 2.

Table 1: Investigation global outcomes and indicators

Global Objectives	Indicators
Ability to define the problem	<ul style="list-style-type: none"> State the problem, its scope and importance Describe the previous work State the objective of the work
Ability to devise and execute a plan to solve the problem	<ul style="list-style-type: none"> Select a set of tests to be conducted Select, plan and apply the methods for collecting the results Identify limitations of the methods used and their impact on the results.
Ability to use critical analysis to reach valid conclusions supported by the results of the plan	<ul style="list-style-type: none"> Analyze the results Formulate the conclusions Validate conclusions by induction or deduction Compare conclusions with previous work Characterize the limitations and implications of the conclusions

Table 2: Communication global outcomes and indicators

Global Objectives	Indicators
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Ability to identify and credibly communicate engineering knowledge	<ul style="list-style-type: none"> Situate, in document or presentation, the solution or design in the world of existing engineering, taking into account social, environmental, economic and ethical consequences Recognize a credible argument (reading) Construct a credible argument in written or spoken form – to persuasively present evidence in support of a claim Organize written or spoken material– to structure overall elements so that their relationship to a main point and to one another is clear Create “flow” in document or presentation – flow is a logical progression of ideas, sentence to sentence and paragraph to paragraph
Ability to incorporate visual elements in communication	<ul style="list-style-type: none"> Incorporate visual material that enhances communication without detracting from it Incorporate various media appropriately Incorporate principles of visual design appropriately
Ability to develop communication through an iterative process	<ul style="list-style-type: none"> Use iteration to clarify and amplify understanding of issues being communicated Use reflection to determine and guide self-development

The approach of starting with a centralized committee, rather than examining existing assessment tools, was used for a few reasons. First, this allowed the Faculty to build capacity on existing expertise in outcomes development and assessment. Our instructors are not required to develop learning outcomes for their courses, so building expertise within a smaller group who can then make an impact on their respective units was a more suitable approach. This approach also allowed the faculty to develop a set of common global outcomes and indicators; it was determined that some commonality across programs was important, and that individual engineering programs can subsequently adjust, add or eliminate indicators that are not relevant to their program.

3. ADAPTING EXISTING ASSESSMENT TOOLS TO ATTRIBUTE ASSESSMENT

To actually measure whether our students are meeting these graduate attributes, however, tools either need to be developed from scratch, or adjusted for the purposes of attributes assessment. In this case, the second approach was chosen. Utilizing the existing assessment measures associated with an undergraduate thesis course for the measurement of the graduate attributes would maintain

the integrity of the course, while allowing us to determine how well the current curriculum serves our needs.

As part of the adjustments to an outcome-based accreditation process, all programs are mapping the constructed indicators to existing or new course assessment tools, and identifying connections between the criteria on existing rubrics, and the indicators developed by the Graduate Attribute Committee.

3.1 Initial Rubric Development

One of the major challenges for a wide-ranging independent study style course such as this one lies in maintaining some degree of consistency in student workload and experience, as well as in supervisor expectations across projects. Two years prior to the introduction of the graduate attributes, an attempt to facilitate consistency in approach and assessment was launched, with the help of faculty from the Engineering Communication Program, through the development of a set of rubrics for course deliverables. In the case of the thesis course, it was particularly important that the rubrics allowed individual supervisors to emphasize project components most relevant to specific cases, and that the rubric did not standardize the projects to the detriment of the experience.

Simply choosing to employ rubrics, in a sense, bypasses the debate about the value of rubrics for assessment and instructional purposes. However, the many debates in the literature do help illuminate the value and weaknesses of rubrics, many of which have become important considerations in the development of these rubrics [12-14, 16]. Rubric design guidelines found in the literature were a starting point [8-9, 12-13], but the rubrics produced were highly specialized documents that needed to be needed to be (1) flexible enough to apply to a variety of engineering thesis projects, (2) authentically reflective of the learning objectives of the thesis course and (3) capable of facilitating common assessment practices and inter-rater reliability across a large number of supervisors who serve as primary assessors. A key consideration in the development and design of the rubric involved its usability; in satisfying many of the desired requirements for the rubric, it would have been easy to develop a highly complex and detailed document that would not be usable. The process behind the development of the rubrics is described further in [5], with the different iterations shown in **Appendix A** (Figure 1: 2009-2010 Thesis Document Rubric, Figure 2: 2010-2011 Thesis Document Rubric, Figure 3: 2011-2012 Thesis Document Rubric, Figure 4: 2011-2012 Rough Guide).

The first assessment rubric (Figure 1, Appendix A), created prior to and therefore without regard for the attributes assessment process, provided only short descriptions for each requirement within each section,

limiting those requirements to a minimum within each section, especially for the content requirements. The requirements would describe the expectations for the sections, and supervisors were asked simply whether students met the requirement or not, or if they exceeded expectations for that requirement. In the next version (Figure 2, Appendix A), the first retooled for the attributes assessment process, four levels of performance per criteria were established. This version of the rubric allows for an initial pilot graduate attributes assessment, the results of which fed into more revisions of the rubric for the 2011-2012 school year (Figure 3, Appendix A).

3.2 Adjusting the Assessment Tool for the Graduate Attribute Process

Adjusting the assessment tool for the graduate attribute process included two major steps: mapping the rubric to the indicators developed associated with the communication and investigation attributes, and making further adjustments to the design of the rubric and the criteria within.

3.2a Mapping Rubric Categories and Criteria to Graduate Attributes

Because the rubric was initially developed for the assessment of an undergraduate thesis, its criteria differ from the precise parameters associated with investigation and communication in the graduate attributes. While a new rubric could have been created for the undergraduate thesis that reflected the exact indicator wording provided by the Graduate Attribute Committee, it remains important to maintain the essence of the thesis deliverables, and the specific priorities of the thesis supervisors and undergraduate program as a whole in the assessment process. As a result, there is still not a perfect one-to-one match between the rubric and the indicators, although improvements have been made on the pilot from 2010-2011 described earlier. The challenges of linking curriculum and assessment with graduate attributes, which include: the selection of appropriate assessment pieces; efficient methods of data collection and analysis; and suitable rubric design, have been discussed and documented widely by other institutions [2, 10-11].

While the attributes and subsequent indicators offer some general ways to assess the constructs, they are not rooted in the context of a particular assignment or discipline. It is important to note that the outcomes and indicators associated with each graduate attribute, which have been developed by a central committee, are relatively general and are out-of-context. When they are actually applied to the curriculum, we must allow for a certain degree of latitude in application and interpretation.

To make an analogy, when we examine teacher knowledge, we consider “pedagogical knowledge” and “pedagogical content knowledge” as distinct; that is, teaching processes and outcomes change with disciplinary context. We argue that the same principle applies here, in that a graduate attribute in practice may present as distinct from a graduate attribute outside of a curricular context.

A sample of the mapping exercise is represented in Table 3, with the complete mapping results for Investigation and Communication shown in **Appendix B**. The numbers in the “rubric criteria” column reflect the graphed pilot data in section 4. In considering how the attributes under study map to the thesis course, it is important to note that while all global outcomes (listed in the far left of the tables) must be measured, programs may choose which indicators (listed in the column second from the left) to use. Also, the graduate attributes will be mapped to various aspects of the curriculum, and so the thesis course serves as but one instance of at least 2-3 measurement points in the undergraduate program.

Table 3: Mapping Investigation skills to thesis rubric criteria (See Appendix B for complete mapping results for Investigation and Communication attributes)

Investigation Attribute	Rubric Criteria (from Figure 1)
Ability to define the problem	
Describe the previous work	(1) Establishes context necessary to facilitate thorough understanding of thesis work in a concise manner
	(4) Explains theoretical concepts important to understanding of thesis work
	(5) Identifies, summarizes and synthesizes relevant research in constructing an understanding of current state of field
	(6) Enables deeper understanding of research question/design problem through analysis of research in the field, indicating a path for moving research forward
State the problem, its scope and importance	(2) Establishes a clear research gap/design problem, makes a convincing case for the significance of proposed research work
State the objective of the work	(3) Identifies goal for thesis work that explicitly addresses this gap/problem; provides clear purpose statement
Ability to devise and execute a plan to solve the problem	
Select a set of tests to be	(7) Describes methods or

conducted	design in sufficient detail to enable understanding of work done
	(8) Provides justification for methods chosen or design decisions made
Select, plan and apply the methods for collecting the results	(7) Describes methods or design in sufficient detail to enable understanding of work done
	(8) Provides justification for methods chosen or design decisions made
Identify limitations of the methods used and their impact on the results.	(8) Provides justification for methods chosen or design decisions made

In examining the most recent mapping of the investigation attribute indicators to the rubric criteria, we see a set of relatively clear links. However, there are some distinctions to consider. For example, take the indicators “Select a set of tests to be conducted” and “Select, plan and apply the methods for collecting the results”. These indicators have been mapped to two rubric criteria: 1) Describes methods or design in sufficient detail to enable understanding of work done, and 2) Provides justification for methods chosen or design decisions made. Here, we have made an assumption that if the student can describe and justify methods, that they have likely selected them, or at least demonstrated the potential to make their own selections, though this may not be the case. In the case of the third global outcome, four indicators have been mapped to one of the rubric criteria, which suggests there may be challenges in demonstrating that we have met each of the distinct indicators.

However, as noted earlier, the process that we are following requires us only to demonstrate that we’ve met each of the global outcomes, and not each and every indicator noted. In examining the investigation attribute table, it is noted that the rubric criteria offer a higher degree of precision. For example, the indicator “Describe the previous work” is linked to four rubric criteria, all of which can be considered important dimensions of the indicator. By situating the graduate attribute within the thesis course and this assessment tool, we have provided a more precise description of what it means to “Describe the previous work”. Given that the graduate attributes and their associated outcomes and indicators are new, we would argue that there is still fluidity at play. By using more specific assignment criteria, we may develop a better understanding of what each indicator means, which could have positive implications beyond the assessment of the thesis. While the graduate attribute process in our Faculty started as “top down”, with a central committee outlining the outcomes and indicators, perhaps it is now time to use a bottom-up approach to refine, and better

define the graduate attributes of the undergraduate engineer.

In the case of the Communication Attribute, we see more challenges. First, some of the communication indicators as developed by the Graduate Attribute Committee – for example, the incorporation of visual communication – were not initially assessed in the rubric, although this has been added to the 2011-12 iteration. The third global outcome, “Ability to develop communication through an iterative process”, has encouraged the addition of a new criterion, however we are not directly assessing the “reflection” component. Again, by contextualizing the graduate attributes within the thesis assignment, we can provide more precise descriptions of some of the indicators.

3.2b Changes to the Assessment Tool

While a flexible structure was initially developed for simplicity’s sake, the adaptation of the rubric for graduate attributes assessment has called for a few changes. First, the quality descriptor labels were changed and given grade ranges, to encourage consistency of use and to bring the rubric in line with Faculty practice. More specifically, “poor”, “average”, “good” and “exceptional” became “fails” (0-60%), “adequate” (60-70%), “good” (70-80%) and “exceeds expectations (80-100%)”.

The graduate attribute process also called for more clear differentiation between levels of performance. As the data now had a secondary purpose, these calls came from all audiences, students and supervisors looking for a better sense of how to differentiate between sections, and from administrators looking to be clear on how these might be used in assessing graduate attributes, and ensuring that the attribute performance actually matched the description provided in the rubric. If included within the rubric, however, this information would make the rubric largely unusable - instead, we chose to develop a guide to the rubric that provided the differentiation between these levels – in other words, more specific descriptions of each thesis criteria at the four performance levels. This optional “rough guide” distinguished between levels of performance on a more granular level than the categories names could, focusing on identifying the “amount, intensity, or frequency” [2] of that trait that mapped to that level.

As noted earlier, some new criteria were added to the rubric to reflect the indicators associated with the graduate attributes – more specifically, “Incorporate principles of visual design appropriately” and “Use iteration to clarify and amplify understanding of issues being communicated.” Finally, communication to the supervisors was improved, to include a more thorough explanation of the thesis and graduate attribute assessment process.

The unique nature of the thesis course, presents problems for one important metric for rubric quality, as well as its ability to serve as an effective measure for student learning and performance, especially in the context of graduate attributes assessment: inter rater-reliability. But given the specific nature of this course, effectively an independent study assessed almost exclusively by their supervisors, this problem will be difficult to negotiate. Two factors may help to mitigate this concern for in the context of graduate attributes assessment. First, the students are being assessed by full faculty members, rather than by teaching assistants. While the consistency of the data across the cohort may still be under question, each individual student is being given the professional judgment of an expert in the field. Second, our attempt to be more granular in the “rough guide” can be viewed an attempt to help create clarity across assessors. Writing descriptions of performance levels as a way of increasing inter-rater reliability has been discussed in previous research [9] and in fact, research has found that rubric design itself can offer the clarity needed for use by evaluators with substantial levels of agreement, potentially eliminating the need for formal norming [3]. However, it remains an important challenge to address in revisions of this assessment activity, and a limitation to the data derived from the project.

4. PILOT DATA

A set of pilot data was initially collected in 2011, based on the 2010-11 rubric. This experience was used to encourage some of the changes described in 3.2. After the thesis supervisors had completed the assessment of their students’ work in May 2012, all rubrics were collected and data was compiled on each of the relevant indicators, using the mapping structure in tables A2A and A2B (Appendix B). This data compilation allowed us to review the competencies of the entire cohort on the two Graduate Attributes. This is represented by the following Figures, in which rubric criteria are mapped according to the numbering system in tables A2A and A2B and as described in section 3.2a:

Figure 1: Investigation pilot data

Figure 2: Communication pilot data

In Figures 1 and 2 above, the total number of responses for each relevant criterion, and the four levels of competency, are plotted, based on a sample of 102 rubrics. From these results, we can see that thesis supervisors have generally assessed the final thesis reports as being of very high quality. This, in part, may be due to the grade ranges associated with the top two competencies (“Good” is 70-80, “Exceeds Expectation” is 80-100). However, this data does give us some indication of students’ weaknesses – for example, Criteria 6, “Enables deeper understanding of research question/design problem through analysis of research in the field, indicating a path for moving research forward” and Criteria 15, “Demonstrates grammatically correct, coherent prose that concisely and clearly communicates complex topics in well designed paragraphs.”

5. CONCLUSIONS

Through the exercise of mapping the indicators to the rubric and determining deficiencies, alongside the process of collecting feedback from students and supervisors about the rubrics, as discussed earlier, we were able to

determine where to make adjustments – to the rubric, and to the thesis experience as a whole. In addition to the changes noted earlier, we have also added a criterion to recognize the engineering and science knowledge base applied by the student, as this was cited as an important component to the supervisors.

As noted, we don’t have perfect matching between the rubric and the indicators, and so one may ask, why not simply measure the indicators, as developed by the Graduate Attribute Committee, directly? We must consider the unique nature of our assessment pieces before taking this approach. As the specific global outcomes and indicators associated with the graduate attributes change over time, especially in these early stages of graduate attribute development, assignments will need to change, and we expect there to be an ongoing, iterative process between the development of accreditation-related outcomes and course-based assessment tools. Also, the outcomes and indicators developed by the Graduate Attribute Committee are, in some cases, quite general, and do not provide sufficient detail for direct insertion in an assignment rubric.

The question of the validity of the data derived from the rubric remains an important one. As stated above, the specific nature of the thesis course precludes any real promise of inter-rater reliability in the assessment and use of the rubric. We believe, however, that for the purposes of the thesis course as well as for graduate attributes assessment, this concern is somewhat mitigated by the fact that students are assessed by supervising professors – experts in their respective fields – with the authority to speak to industry and academic expectations. Furthermore, we have attempted to develop a flexible and modular approach to rubric development that provides both appropriate generality – in the rubric itself – and detail – in the published “rough guide” – for different types of users.

In initially developing the rubric, we set out to create something that authentically described the thesis experience, but was flexible enough to allow thesis supervisors to apply their own needs, and the unique features of their project, in the rubric. When the use of the rubric is shifted away from scaffolding one-to-one feedback, to the measurement of a set of collaboratively-constructed graduate attribute indicators, tensions arise, and adjustments need to be made. This work is in-progress, and further efforts will be placed on improving inter-rater reliability, and continuing to explore measures of validity that ensure the rubric is a good fit for both the individual assessments of the thesis experience, and the graduate attributes. Likewise, in measuring the graduate attributes, we must always consider that the attributes are to be contextualized in real learning experiences, and in turn, we can only demonstrate that students have met the attributes in the context of a specific assignment.

However, there are also opportunities here, to use our curriculum to better define the learning outcomes associated with the graduate attributes, utilizing both a top-down and bottom-up approach to outcomes planning and measurement.

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APPENDIX A: RUBRICS AND THE ROUGH GUIDE

FINAL THESIS REPORT RUBRIC – I – ESC499

**Student
Name:** _____

Supervisor: _____

Component	No	Yes	Excep- tional	Requirement	Comments (Please use back if necessary)
Introduction	☐	☐	☐	Establishes context necessary to facilitate thorough understanding of thesis work in a concise manner	
	☐	☐	☐	Establishes a clear research gap, makes a convincing case for the significance of proposed research work	
	☐	☐	☐	Identifies goal for thesis work that explicitly addresses the research gap; provides clear purpose statement	
Literature Review / Background	☐	☐	☐	Explains theoretical concepts important to understanding of thesis work	
	☐	☐	☐	Identifies, summarizes, and synthesizes relevant research in constructing an understanding of current state of field	
	☐	☐	☐	Enables deeper understanding of research question/ design problem through analysis of research in the field, indicating a path for moving research forward	
Methods and Findings	☐	☐	☐	Describes methods or design in sufficient detail to enable understanding of work done	
	☐	☐	☐	Provides justification for methods chosen or design decisions made	
	☐	☐	☐	Results displayed clearly in organized manner, using appropriate figures or graphics; key results highlighted	
Discussion and Conclusions	☐	☐	☐	Engages with and explains results intelligently	
	☐	☐	☐	Identifies key claims to be drawn from results of research or design evaluation, qualifies them appropriately	
	☐	☐	☐	Outlines significance of research done, identifies potential future work that arises from thesis work	
Overall Document Design:	☐	☐	☐	Abstract concisely summarizes purpose, methods, key results of research, and presents conclusions clearly	
	☐	☐	☐	Document length, formatting, structure meets stated requirements, and specific demands of thesis topic	
	☐	☐	☐	Organized well, with content in discrete and appropriate positions in paper, structure clearly laid out, transitions that create flow in document	
	☐	☐	☐	Demonstrates coherent prose that concisely and clearly communicates complex topics in well designed paragraphs	
	☐	☐	☐	Demonstrates grammatical correctness and clarity in sentence design	
	☐	☐	☐	Provides clear attribution of ideas throughout paper using a known referencing standard; uses references effectively to help establish context, back claims, or justify decisions	
Project Experience	☐	☐	☐	Work has contributed to scholarship in field / made a measurable impact	
	☐	☐	☐	Demonstrated initiative and ownership of work throughout thesis project	
	☐	☐	☐	Demonstrated an ability to work independently and manage their work plan, meeting all critical deadlines	
	☐	☐	☐	Quality of effort and thesis work indicative of potential for future research success	

Numerical Score :

/ 100

Figure 1: 2009-2010 Thesis document rubric
Figure 1: Thesis Document Rubric 2009-2010

FINAL THESIS REPORT RUBRIC – I – ESC499

Student Name:					Supervisor:		Grade:	
Component	1	2	3	4	Requirement		Comments (Use back if necessary)	
Introduction	☐	☐	☐	☐	Establishes context necessary to facilitate thorough understanding of thesis work in a concise manner			
	☐	☐	☐	☐	Establishes a clear research gap/design problem, makes a convincing case for the significance of proposed research work			
	☐	☐	☐	☐	Identifies goal for thesis work that explicitly addresses this gap/problem; provides clear purpose statement			
Literature Review / Background	☐	☐	☐	☐	Explains theoretical concepts important to understanding of thesis work			
	☐	☐	☐	☐	Identifies, summarizes, and synthesizes relevant research in constructing an understanding of current state of field			
	☐	☐	☐	☐	Enables deeper understanding of research question/design problem through analysis of research in the field, indicating a path for moving research forward			
Methods and Findings	☐	☐	☐	☐	Describes methods or design in sufficient detail to enable understanding of work done			
	☐	☐	☐	☐	Provides justification for methods chosen or design decisions made			
	☐	☐	☐	☐	Results displayed clearly in organized manner, using appropriate figures or graphics; key results highlighted			
Discussion and Conclusions	☐	☐	☐	☐	Engages with and explains results intelligently			
	☐	☐	☐	☐	Identifies key claims to be drawn from results of research or design evaluation, qualifies them appropriately			
	☐	☐	☐	☐	Outlines significance of research done, identifies potential future work that arises from thesis work			
Overall Document Design:	☐	☐	☐	☐	Abstract concisely summarizes purpose, methods, key results of research, and presents conclusions clearly			
	☐	☐	☐	☐	Document length, formatting, structure meets stated requirements, and specific demands of thesis topic			
	☐	☐	☐	☐	Organized well, with content in discrete and appropriate positions in paper, structure clearly laid out, transitions that create flow in document			
	☐	☐	☐	☐	Demonstrates grammatically correct, coherent prose that concisely and clearly communicates complex topics in well designed paragraphs and sentences			
	☐	☐	☐	☐	Uses and integrates well-designed visuals effectively to communicate key concepts / results			
	☐	☐	☐	☐	Provides clear attribution of ideas throughout paper using a known referencing standard; uses references effectively to help establish context, back claims, or justify decisions			
Project Experience	☐	☐	☐	☐	Work has contributed to scholarship in field / made a measurable impact			
	☐	☐	☐	☐	Demonstrated initiative, ability to work independently, time management skills and ownership of work throughout thesis project			
	☐	☐	☐	☐	Thesis work posed a significant challenge, requiring superb engineering & scientific knowledge and skills			
	☐	☐	☐	☐	Quality of effort and thesis work indicative of potential for future research success			
	☐	☐	☐	☐	Has incorporated feedback and additional research on initial deliverables to improve final thesis document and work			

*1 - Fails (0-60%); 2 - Adequate (60-70%); 3 - Good (70-80%); 4 - Exceeds expectations (80-100%). These numerical equivalents are only approximate; final grade and value of each component is up to the supervisor.

Figure 2: 2010-2011 Thesis document rubric

FINAL THESIS REPORT RUBRIC – I – ESC499

Student Name:					Supervisor:		Grade:	
							/100	
Component	1	2	3	4	Requirement		Comments (Use back if necessary)	
Introduction	☐	☐	☐	☐	Establishes context necessary to facilitate thorough understanding of thesis work in a concise manner			
	☐	☐	☐	☐	Establishes a clear research gap/design problem, makes a convincing case for the significance of proposed research work			
	☐	☐	☐	☐	Identifies goal for thesis work that explicitly addresses this gap/problem; provides clear purpose statement			
Literature Review / Background	☐	☐	☐	☐	Explains theoretical concepts important to understanding of thesis work			
	☐	☐	☐	☐	Identifies, summarizes, and synthesizes relevant research in constructing an understanding of current state of field			
	☐	☐	☐	☐	Enables deeper understanding of research question/design problem through analysis of research in the field, indicating a path for moving research forward			
Methods and Findings	☐	☐	☐	☐	Describes methods or design in sufficient detail to enable understanding of work done			
	☐	☐	☐	☐	Provides justification for methods chosen or design decisions made			
	☐	☐	☐	☐	Results displayed clearly in organized manner, using appropriate figures or graphics; key results highlighted			
Discussion and Conclusions	☐	☐	☐	☐	Engages with and explains results intelligently			
	☐	☐	☐	☐	Identifies key claims to be drawn from results of research or design evaluation, qualifies them appropriately			
	☐	☐	☐	☐	Outlines significance of research done, identifies potential future work that arises from thesis work			
Overall Document Design:	☐	☐	☐	☐	Abstract concisely summarizes purpose, methods, key results of research, and presents conclusions clearly			
	☐	☐	☐	☐	Document length, formatting, structure meets stated requirements, and specific demands of thesis topic			
	☐	☐	☐	☐	Organized well, with content in discrete and appropriate positions in paper, structure clearly laid out, transitions that create flow in document			
	☐	☐	☐	☐	Demonstrates grammatically correct, coherent prose that concisely and clearly communicates complex topics in well designed paragraphs and sentences			
	☐	☐	☐	☐	Uses and integrates well-designed visuals effectively to communicate key concepts / results			
Project Experience	☐	☐	☐	☐	Provides clear attribution of ideas throughout paper using a known referencing standard; uses references effectively to help establish context, back claims, or justify decisions			
	☐	☐	☐	☐	Work has contributed to scholarship in field / made a measurable impact			
	☐	☐	☐	☐	Demonstrated initiative, ability to work independently, time management skills and ownership of work throughout thesis project			
	☐	☐	☐	☐	Thesis work posed a significant challenge, requiring superb engineering & scientific knowledge and skills			
	☐	☐	☐	☐	Quality of effort and thesis work indicative of potential for future research success			
	☐	☐	☐	☐	Has incorporated feedback and additional research on initial deliverables to improve final thesis document and work			

*1 - Fails (0-60%); 2 - Adequate (60-70%); 3 - Good (70-80%); 4 - Exceeds expectations (80-100%). These numerical equivalents are only approximate; final grade and value of each component is up to the supervisor.

Figure 3: 2011-2012 Thesis document rubric

A ROUGH GUIDE TO THE FINAL THESIS REPORT RUBRIC GUIDE – I – ESC499

Component	Fails	Adequate	Good	Exceeds Expectations
Introduction	Missing key elements of context necessary to understand thesis work	Establishes just sufficient context necessary to facilitate a basic understanding of thesis work	Establishes context necessary to facilitate understanding of thesis work	Develops context appropriately and concisely in facilitating thorough understanding of thesis work
	Research gap or design problem remains unarticulated or unclear	Research gap or design problem is identified, but too broad or general to define project clearly	Identifies a clear research gap/design problem	Establishes a clear research gap/design problem, makes a convincing case for the significance of proposed research work
	Goal of thesis work is difficult to identify, or unrelated to gap or problem statement	Stated goal for thesis work is vague, imprecise, or not clearly related to gap/ problem statement	Identifies goal for thesis work that addresses this gap/problem	Explicitly identifies goal for thesis work in a clear purpose statement for the project that addresses gap/problem
Literature Review / Background	Missing key explanations of theoretical concepts important to thesis work	Most theoretical concepts important to work are identified and briefly explained	Identifies and explains theoretical concepts important to understanding of thesis work	Explains theoretical concepts clearly, concisely, in context of thesis work
	Fails to acknowledge or reference key research/prior work in the field	Identifies some important research/prior work in the field, but misses a few essential developments	Identifies and summarizes most of the key research/prior work in developing a nearly complete understanding of the field	Identifies, summarizes, and synthesizes relevant research in constructing an understanding of current state of field
	Analysis of field is incomplete and fails to further develop the research gap/design problem	Analysis of field is mostly complete, and helps to further develop research gap/design problem	Enables understanding of research question/design problem through analysis of research in the field	Enables deep understanding of research question/design prob. via thorough analysis of research in the field, indicating path for moving forward
Methods and Findings	Fails to explain key elements of methods or design	Most elements of methods or design are explained in sufficient detail, missing elements may hamper understanding of work done	Describes methods or design in sufficient detail to enable understanding of work done	Detailed description of methods or design helps facilitate a thorough understanding of project
	Fails to justify key elements of method or design decisions	Provides some justification for most methods chosen/design decisions made	Provides sufficient justification for methods chosen / design decisions made	Justification for methods chosen/design decisions clearly and convincingly articulated, warranting validity of project
	Results not displayed in organized or appropriate manner	Most results are displayed in an organized manner, using appropriate figures or graphics	Results displayed clearly in organized manner, using appropriate figures or graphics	Results displayed clearly in organized manner, using appropriate visuals that help highlight key results and findings
Discussion and Conclusions	Engages with results only superficially, without explanation of significance	Engages with and provides explanation for most results	Engages with and explains key results intelligently	Employs and explain results clearly in the context of research / design claims made
	Fails to make key claims from results of research or design evaluation	Makes appropriate claims from results of research or design evaluation, though claims may not be fully warranted	Identifies and explains key claims to be drawn from results of research or design evaluation	Identifies and warrants key claims to be drawn from results of research or design evaluation, qualifies them appropriately
	Fails to identify significance of research or design work done	Summarizes research / design work done, but fails to place it in context of prior or future work	Clearly identifies significance of research / design work done in context of past work	Outlines significance of research/design work done, identifies potential future work that arises from thesis work
Overall Document Design:	Abstract fails to adequately describe nature and conclusions of project	Abstract provides a vague description of nature and conclusions of project	Abstract summarizes key elements of thesis sufficiently	Abstract concisely and completely summarizes purpose, methods, key results of research, presenting conclusions clearly
	Document length or formatting fails to meet many of the stated requirements	Some inconsistencies in formatting, but mostly meets the stated requirements	Document length, formatting, structure meets stated requirements	Document length, formatting, structure meets stated requirements, and specific demands of thesis topic
	Poorly organized throughout, lacking clear structure and flow throughout document	A few organizational problems detract from an otherwise well structured thesis	Organized well, with content in discrete and appropriate positions in paper, and structure clearly laid out	Organized well, with logical and explicit structure, and transitions that create flow throughout document

*1 - Fails (0-60%); 2 - Adequate (60-70%); 3 - Good (70-80%); 4 - Exceeds expectations (80-100%). These numerical equivalents are only approximate; final grade and value of each component is up to the supervisor.

Figure 4: 2011-2012 Rough guide

A ROUGH GUIDE TO THE FINAL THESIS REPORT RUBRIC GUIDE – I – ESC499

Component	Fails	Adequate	Good	Exceeds Expectations
	Grammatical problems hamper understanding of key elements of the document	Some grammatical problems hamper readability of prose, but not understanding of document	Demonstrates grammatically correct, coherent prose throughout	Demonstrates grammatically correct, coherent prose that concisely and clearly communicates complex topics in well designed paragraphs and sentences
	Visuals not used appropriately or well integrated into document	Visuals employed appropriately, but may not be well integrated into document	Uses and integrates visuals effectively to communicate key concepts / results	Uses and integrates well-designed visuals effectively to communicate key concepts / results
	Poor attribution of ideas throughout, missing key references and failing to use an appropriate referencing standard	Provides clear attribution of ideas throughout paper using a known referencing standard, with only a few gaps	Provides clear and thorough attribution of ideas throughout paper using a known referencing standard	Provides clear attribution of ideas throughout paper using a known referencing standard; references used effectively to help establish context, back claims, or justify decisions
Project Experience	Work makes no contribution to the field, and is only marginally relevant to current good scholarship	While no significant impact is made, work is relevant to good scholarship in the field	Work advances the possibility for future advancements in the field	Work has contributed to scholarship in field / made a measurable impact
	Student lacks the ability to take initiative, work independently, manage their time and/or take ownership over the project, negatively impacting the thesis experience	Student sometimes shows the ability to take initiative, work independently, manage their time and take ownership over the project	Student takes initiative and works independently, demonstrating good time management skills and project ownership	Demonstrated initiative, ability to work independently, time management skills and ownership of work throughout thesis project
	Thesis work completed did not meet expectations, nor showcase the knowledge and skills expected from an undergraduate engineering student	Thesis work required the knowledge and skills expected of an undergraduate engineering student	Thesis work posed a reasonable challenge, requiring engineering & scientific knowledge typical of a senior undergraduate or junior graduate student	Thesis work posed a significant challenge, requiring superb engineering & scientific knowledge and skills
	Student does not demonstrate potential for future research work	Quality of effort and thesis work indicative of some potential for future research work, with more study and experience	Quality of effort and thesis work indicative of some potential for future research success	Quality of effort and thesis work indicative of potential for future research success

*1 - Fails (0-60%); 2 - Adequate (60-70%); 3 - Good (70-80%); 4 - Exceeds expectations (80-100%). These numerical equivalents are only approximate; final grade and value of each component is up to the supervisor.

Figure 4: 2011-2012 Rough guide

APPENDIX B: MAPPING THE ATTRIBUTES TO THE RUBRIC

Table A2A: Mapping Investigation skills to thesis rubric criteria

Investigation Attribute (From Table 1)		Rubric Criteria (from Figure 3)
Ability to define the problem	Describe the previous work	(1) Establishes context necessary to facilitate thorough understanding of thesis work in a concise manner
		(4) Explains theoretical concepts important to understanding of thesis work
		(5) Identifies, summarizes and synthesizes relevant research in constructing an understanding of current state of field
		(6) Enables deeper understanding of research question/design problem through analysis of research in the field, indicating a path for moving research forward
	State the problem, its scope and importance	(2) Establishes a clear research gap/design problem, makes a convincing case for the significance of proposed research work
	State the objective of the work	(3) Identifies goal for thesis work that explicitly addresses this gap/problem; provides clear purpose statement
Ability to devise and execute a plan to solve the problem	Select a set of tests to be conducted	(4) Describes methods or design in sufficient detail to enable understanding of work done (5) Provides justification for methods chosen or design decisions made
	Select, plan and apply the methods for collecting the results	(4) Describes methods or design in sufficient detail to enable understanding of work done (5) Provides justification for methods chosen or design decisions made
	Identify limitations of the methods used and their impact on the results.	(5) Provides justification for methods chosen or design decisions made
	Analyze the results	(6) Results displayed clearly in organized manner, using appropriate figures or graphics; key results highlighted (7) Engages with and explains results intelligently
	Formulate the conclusions	(8) Identifies key claims to be drawn from results of research or design evaluation, qualifies them appropriately
Ability to use critical analysis to reach valid conclusions supported by the results of the plan	Validate conclusions by induction or deduction	
	Compare conclusions with previous work	
	Characterize the limitations and implications of the conclusions	

Table A2B: Mapping Communication skills to thesis rubric criteria

Communication Attribute (From Table 2)		Rubric Criteria (From Figure 3)
Ability to identify and credibly communicate engineering knowledge	Situate, in document or presentation, the solution or design in the world of existing engineering, taking into account social, environmental, economic and ethical consequences	Not assessed in rubric
	Recognize a credible argument (reading)	(4) Explains theoretical concepts important to understanding of thesis work
		(5) Identifies, summarizes, and synthesizes relevant research in constructing an understanding of current state of field
	Construct a credible argument in written or spoken form – to persuasively present evidence in support of a claim	(11) Identifies key claims to be drawn from results of research or design evaluation, qualifies them appropriately
		(12) Outlines significance of research done, identifies potential future work that arises from thesis work
		(13) Document length, formatting, structure meets stated requirements, and specific demands of thesis topic
		(14) Organized well, with content in discrete and appropriate positions in paper, structure clearly laid out, transitions that create flow in document
		(15) Demonstrates grammatically correct, coherent prose that concisely and clearly communicates complex topics in well designed paragraphs
	Create “flow” in document or presentation – flow is a logical progression of ideas, sentence to sentence and paragraph to paragraph	(14) Organized well, with content in discrete and appropriate positions in paper, structure clearly laid out, transitions that create flow in document
Ability to incorporate visual elements in communication	Incorporate visual material that enhances communication without detracting from it	(16) Uses and integrates well-designed visuals effectively to communicate key concepts/results

	Incorporate various media appropriately	
	Incorporate principles of visual design appropriately	
Ability to develop communication through an iterative process	Use iteration to clarify and amplify understanding of issues being communicated	(17) Has incorporated feedback and additional research on initial deliverables to improve final thesis document and work
	Use reflection to determine and guide self-development	(17) Has incorporated feedback and additional research on initial deliverables to improve final thesis document and work