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Development of Analytic Rubrics for Competency Assessment Appendix

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Appendix A

Appendix A contains the rubrics for design, communication and teamwork. These indicators were compiled from the literature and then modified and added through a consultation process. After a draft of the descriptors was developed, the rubrics were tested and modifications were made to the descriptors based on the feedback

Final design rubric

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
D1 Find and state an engineering design problem					
D1A Identify an appropriate opportunity or problem for an engineering design project	□ Opportunity or problem is not identified	□ Opportunity or problem is not appropriate for an engineering design project (e.g., due to misconception of engineering design as a well-defined problem with one correct answer)	□ Opportunity or problem is minimally appropriate for an engineering design project (i.e., evidence of some understanding of the nature of engineering design activities)	□ Opportunity or problem is appropriate for an engineering design project	□ Opportunity or problem is unique and ideal for an engineering design project (e.g., industry is "ripe for disruption" problem is challenging but feasible for student design team)
D1B Accurately state the engineering design problem and summarize relevant details (interpret a problem statement if provided)	□ Does not state the engineering design problem □ Does not provide details	□ States the engineering design problem with significant inaccuracies (e.g., misinterprets the problem) □ Includes irrelevant details	□ States the engineering design problem with some inaccuracies □ Details are incomplete or unclear	□ States the engineering design problem accurately □ Summarizes relevant details	□ States the engineering design problem precisely and comprehensively □ Summarizes key details with depth and nuance

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
D1C Describe a suitable design process or design philosophy	□ Does not describe a design process or design philosophy	□ Describes an unsuitable design process or design philosophy (e.g., treats design task as a well-defined, straight-forward problem)	□ Describes a somewhat suitable design process or design philosophy (e.g., design philosophy is unsophisticated, omits a key concept or feature)	□ Describes a suitable design process or design philosophy	□ Describes an exemplary design process or design philosophy (e.g., synthesizes credible sources to define a unique design process suited to the context)
D2 Gather information to understand an engineering design problem					
D2A Stakeholders: **- Identify relevant stakeholders** **- Accurately describe characteristics, perspectives, and needs** **- Provide appropriate justification for stakeholder identification**	□ Does not identify stakeholders □ Descriptions are not provided □ Justification is not provided	□ Identifies irrelevant stakeholders □ Descriptions are inaccurate (e.g., misrepresentative or disrespectful) □ Justification is inappropriate	□ Identifies some relevant stakeholders (may underestimate project's reach) □ Descriptions are superficial □ Justification is incomplete or vague (unconvincing)	□ Identifies relevant stakeholders □ Describes stakeholders accurately □ Justifies stakeholder identification appropriately (e.g., based on interest in or influence on the project)	□ Meets+ □ Identifies stakeholders with any direct or indirect connection to the project □ Descriptions are informed and empathetic □ Uses evidence to rank/prioritize stakeholders
D2B Identify and describe engineering design priorities and/or social and professional concerns relevant to the problem (i.e., Design for X, client ethics and values)	□ Does not identify engineering design priorities or concerns □ Descriptions not provided	□ Identifies irrelevant concerns and/or excludes essentials (e.g., safety, cost) □ Descriptions are erroneous	□ Critical gaps in design priorities or concerns indicate an underestimation of the project's impact □ Descriptions are superficial and not specific to the engineering design problem	□ Identifies expected engineering design priorities or concerns □ Descriptions relate to the specific engineering design problem	□ Identifies both expected elements of engineering design and specific, novel elements that suit the problem □ Descriptions are insightful

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
D2C Integrate information from stakeholders and other appropriate sources to enhance understanding of the problem	□ No sources provided □ No information integrated □ No change in understanding of the problem	□ Sources are inappropriate □ Information is presented separately/ unconnected □ Misunderstandings or unidentified gaps in knowledge will prevent successful problem framing	□ Sources are minimally appropriate □ Some additional information is integrated (addresses some gaps in problem statement) □ Understanding is insufficient and will limit problem framing	□ Sources are appropriate (i.e., reliable, diverse, credible) □ Information is integrated with existing knowledge of problem and stakeholder interests/ concerns □ Understanding of the problem is enhanced sufficiently for problem framing	□ Meets+ □ Evaluates and synthesizes information from a variety of authoritative sources □ Resolves discrepancies between new information and stakeholder interests/ concerns □ Understanding is greatly enhanced, enabling informed problem framing
D2D Identify and describe the context (design environment, service environment, or operating environment) of the design problem	□ Does not identify design context □ Descriptions not provided	□ Identifies irrelevant design context (i.e., too broad, too narrow, misplaced) □ Descriptions are incorrect	□ Identifies minimally relevant design context □ Descriptions are superficial and not specific to the engineering design problem	□ Identifies relevant design context □ Descriptions are correct	□ Meets+ □ Thorough research performed □ Demonstrates insightful understanding of problem
D3 Frame a problem in engineering design terms					
D3A Define and justify an appropriate project scope	□ No definition of scope □ No justification of scope	□ Defines an inappropriate (e.g., trivial or infeasible) project scope □ Justification is inappropriate (e.g., misuse of evidence)	□ Scope is minimally appropriate □ Justification is incomplete or vague (unconvincing)	□ Defines an appropriate project scope □ Justifies scoping decisions (e.g., prioritization of design concerns reflects project and designers)	□ Meets+ □ Mature and realistic project scope □ Demonstrates insightful understanding of problem

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
D3B Define appropriate, measurable requirements for evaluating potential engineering design solutions	□ No definition of requirements	□ Documents inappropriate requirements (e.g., will not help distinguish between alternatives) □ Requirements are not measurable (i.e., subjective)	□ Defines some appropriate requirements □ Requirements are somewhat measurable (may not be feasible or reliable)	□ Defines appropriate requirements for the engineering design problem □ Requirements are expressed in measurable terms	□ Skillfully integrates information to document comprehensive requirements □ Requirements are precise and measurable, promoting objective judgement of solutions
D3C Recognize uncertainty and assumptions in requirements; explain uncertainty and make logical assumptions	□ Does not acknowledge uncertainty □ Does not make explicit assumptions	□ Erroneous explanations of uncertainty (i.e., complete problem miscomprehension) □ Makes illogical or unreasonable assumptions	□ Explanations of uncertainty contain minimal errors □ Makes simplistic assumptions and/or assumptions are unsupported	□ Explains uncertainty in requirements □ Makes logical assumptions supported with evidence as needed	□ Explanations of uncertainty demonstrate deep insight into the problem □ Makes elegant assumptions justified with convincing, credible arguments
D3D Define an appropriate project plan and provide a timeline that accurately anticipates the tasks and resources required	□ Project plan not defined □ Timeline not provided	□ Defines an inappropriate project plan (e.g., ignores course deliverables or client expectations) □ Timeline is infeasible and/or does not recognize critical tasks and resources	□ Project plan includes most key activities □ Timeline is inaccurate (e.g., underestimates some tasks or resources)	□ Defines an appropriate project plan (e.g., based on an accepted model) □ Timeline accurately anticipates tasks and resources required	□ Meets+ □ Integrates academic and industry practices to define project plan □ Timeline demonstrates creativity, foresight, and engineering judgement
D4 Generate or identify alternative solutions (i.e., diverge)					
D4A Apply ideation tools to identify a diverse	□ No application of ideation tools	□ Erroneous application of decision-making tools (e.g., evidence of	□ Superficial application of ideation tools (e.g., superficial	□ Methodical application of ideation tools	□ Intensive application of multiple ideation tools □ Alternative solutions are highly creative (i.e. novel,

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
set of alternative solutions	□ Solutions are not identified	fixation or favouritism) □ Alternative solutions are unoriginal or derivative	alterations to existing ideas) □ Alternative solutions are minimally diverse	□ Identification of a diverse set of alternative solutions	divergent, alternate, contradictory and exploratory)
D4B Reflect on the ideation process: analyse the selection and application of ideation tools and assess the diversity of identified solutions	□ Does not analyse the selection and application of ideation tools □ Does not assess the diversity of alternative solutions	□ Erroneous analysis of ideation tools (e.g., does not determine whether appropriate tools were used) □ Makes inappropriate claims about the diversity of solutions	□ Superficial analysis of ideation tools □ Makes minimally supported claims about the diversity of solutions	□ Analyses the selection and application of ideation tools (e.g., identifies limitations of the ideation process) □ Assesses the diversity of identified solutions	□ Meets+ □ Evidence of informed reflection and iteration throughout the ideation process to apply appropriate tools and identify a diverse set of alternative solutions
D5 Select candidate solutions for development (i.e., converge)					
D5A Apply decision-making tools to select valid candidate solutions for further development	□ No application of decision-making tools □ Candidate solutions are not selected	□ Erroneous application of decision-making tools (e.g., evidence of favouritism/bias or arbitrary selection) □ Candidate solutions are inappropriate for the design problem	□ Superficial application of decision-making tools (e.g., rule-based judgements) □ Candidate solutions are minimally appropriate	□ Methodical application of decision-making tools □ Candidate solutions are mostly valid	□ Considers outcomes of multiple decision-making tools □ Selects multiple valid candidate solutions

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
D5B Reflect on the selection process: analyse the selection and application of decision-making tools and assess the validity of candidate solutions	□ Does not analyse the selection and application of decision-making tools □ Does not assess the validity of candidate solutions	□ Erroneous analysis of decision-making tools □ Makes inappropriate claims about the validity of candidate solutions	□ Superficial analysis of decision-making tools □ Makes minimally supported claims about the validity of candidate solutions	□ Analyses the selection and application of decision-making tools (e.g., identifies limitations of the selection process) □ Assesses the validity of candidate solutions	□ Meets+ (e.g., Evidence of informed reflection and iteration throughout the selection process to apply appropriate tools and select a valid set of candidate solutions)
D6 Develop an engineering design solution					
D6A Implement a plan to produce a developed engineering design	□ No implementation plan; engineering design not produced	□ Unsuccessful divergence from development plan (e.g., errors in design, final product is no more evolved than conceptual design)	□ Inconsistent implementation of plan (e.g., some elements of design developed or final product is more developed to some degree)	□ Methodical implementation of plan to produce a developed engineering design	□ Meets+ □ Successful divergence from plan in consideration of goals, constraints, system and interactions □ Developed design is in-service or ready for use
D6B Evaluate a developed engineering design against requirements to verify that it is an acceptable solution	□ No evaluation of engineering design	□ Evaluation method is inappropriate and/or conclusions are illogical	□ Evaluation of developed engineering design is incomplete and/or superficial	□ Evaluation of developed engineering design against requirements verifies that it is an acceptable solution	□ Uses multiple approaches (e.g., evaluation against refined requirements, client feedback, user testing) and engineering judgement to assess the quality of a design

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
D6C Iteratively improve or redevelop an engineering design	□ No iteration	□ Ineffective use of standard sequential engineering design process □ Design remains flawed or decreases in quality	□ Some minimally effective iteration within guidelines □ Superficial effort made to improve known weaknesses in design	□ Methodical iteration (i.e., suitable and effective deviation from sequential process) □ Deficiencies are identified and design is improved	□ Tailored execution of global and local iteration cycles (e.g., proactive deviation via credible, calculated risks tailored to design problem) □ Design is significantly improved
D7 Represent an engineering design					
D7A Create prototypes, models or simulations to explore and analyse design components	□ No creation of prototypes, models or simulations □ No exploration or analysis of design components	□ Creates inappropriate prototypes, models or simulations □ Counterproductive exploration and/or analysis	□ Creates minimally useful prototypes, models or simulations □ Superficial exploration and/or analysis of design (e.g., structural details)	□ Creates prototypes, models or simulations that are representative of design components □ Explores and analyses design components	□ Creates prototypes, models and/or simulations that elegantly represent design components □ Exploration and analysis of design components enhances understanding of system
D7B Provide meaningful descriptions of an engineering design at the holistic (system) and/or analytic (component) level	□ No descriptions of the engineering design	□ Descriptions are erroneous or confusing (i.e., misrepresentative of design)	□ Holistic and/or analytic descriptions are vague or superficial, may focus on structure rather than function	□ Meaningfully represents an engineering design by providing holistic and analytic descriptions	□ Meets+ □ Elegant articulation of an engineering design □ Sustained use of specific, accurate and insightful functional descriptions

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
D7C Use appropriate representation(s) to document technical details of an engineering design for future implementation	□ No documentation of design	□ Uses inappropriate representation(s) in attempt to document an engineering design	□ Uses appropriate representation(s), but documentation is incomplete or inaccurate, hindering future implementation	□ Uses appropriate representation(s) to document technical details of an engineering design for future implementation (i.e., another engineer could produce the intended design)	□ Elegantly and unambiguously documents technical details of an engineering design for flawless implementation
D8 Reflect on the engineering design process					
D8A Accurately describe activities performed during the engineering design process and assess strengths and weaknesses	□ Does not describe engineering design activities □ Does not assess strengths or weaknesses of specific activities	□ Erroneous description of activities (e.g., inconsistent with factual experience, misuse of engineering design terms) □ Incorrect perception of strengths and weaknesses in activities	□ Describes engineering design process □ Lists strengths and weaknesses in a general or superficial manner	□ Accurately describes engineering design activities □ Assesses strengths and weaknesses of specific activities	□ Expertly articulates engineering activity □ Meaningfully organizes, compares and synthesizes strengths and weaknesses
D8B Reflect on how elements of the engineering design process impacted the final product	□ Does not reflect on the impact the engineering design process had on the final product	□ Makes erroneous connections between engineering design process and final product	□ Incomplete or superficial reflection on how the engineering design process impacted the final product	□ Reflects on how elements of the engineering design process impacted the final product	□ Meets+ □ Insightful reflection □ Considers potential impact of alternate design processes

Final communication rubric

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
C1 Structure a logical argument					
C1A Select appropriate content and components (e.g., sections) for audience and purpose		☐ Content and components are inconsistent with the audience and purpose	☐ Content and components lack relevance to audience and purpose	☐ Content and components are appropriate for audience and purpose	☐ Content and components are nuanced and expertly selected for audience and purpose
C1B Provide a clear introduction that orients the reader to the subject of the document or talk	☐ No introduction	☐ Introduction does not orient the reader to the subject of the document or talk	☐ Introduction minimally orients the reader to the subject of the document or talk	☐ Introduction orients the reader to the subject of the document or talk	☐ Introduction orients the reader to the subject of the document or talk in a succinct and complete manner
C1C Make interpretive and analytical claims using reasonable inferences from evidence	☐ Makes no claims	☐ Makes claims that are not based on reasonable inferences from evidence (twists evidence to fit claims or evidence dumps (i.e., merely lists facts)	☐ Makes claims that are based on vague or incomplete inferences from evidence	☐ Makes claims that are based on reasonable inferences from evidence	☐ Makes claims that are based on sophisticated inferences from evidence that are unique and insightful
C1D Supports claims with use of evidence and reasoning	☐ Claims are unsupported	☐ Claims are supported by irrelevant evidence and reasoning	☐ Claims are supported by weak evidence and reasoning ☐ Claims are inconsistently supported	☐ Claims are supported by credible evidence, (or evidence used credibly) and sound reasoning	☐ Meets + ☐ Makes claims based on sophisticated handling of evidence and reasoning ☐ Acknowledges opposing evidence and claims and

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
		☐ No linkage between evidence and claims	☐ Weak linkage between evidence and claims	☐ Claims are consistently well supported ☐ Sufficient linkage between evidence and claims	presents a reasonable counterpoint
C1E Incorporate evidence from a range of different sources	☐ Lacks sources	☐ Sources lack appropriate range	☐ Evidence is from a minimal range of sources	☐ Evidence is from an appropriate range of sources	☐ Evidence is from a wide range of sources; the work demonstrates extensive research that goes beyond standard or typical sources
C1F Make use of a logical reasoning pattern (e.g., deductive, inductive reasoning) to structure argument	☐ Does not use a logical reasoning pattern to structure argument	☐ Poor execution of logical reasoning weakens argument	☐ Logical reasoning pattern is only vaguely apparent, creating a weak argument structure	☐ Logical reasoning pattern is evident resulting in an effective argument structure	☐ Logical reasoning pattern is both evident and compelling, enabling a highly effective structure for argument
C1G Provide a clear, logical conclusion	☐ No conclusion	☐ Conclusion is vague/unclear ☐ Conclusion is disconnected from the key claims or evidence ☐ Conclusion does not identify any areas for further work	☐ Conclusion is weak or poorly formulated ☐ Conclusion is poorly linked to the evidence or key claims ☐ Conclusion makes passing mention of or alludes to further work	☐ Conclusion is clear without being wordy ☐ Conclusion is clearly rooted in/linked to the evidence or key claims ☐ Conclusion identifies areas for further work	☐ Meets+ ☐ Conclusion is engaging and thoroughly explores the implications and significance of the topic/issue

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
C1H Convey a clear and consistent central message throughout document or presentation	☐ No central message	☐ Multiple inconsistent messages throughout the text/talk	☐ Central message can be deduced but is not explicitly stated or reinforced	☐ Central message is clear and consistent throughout the text/talk	☐ Central message is compelling, precisely stated, appropriately repeated and strongly supported
C1I Use genre and disciplinary standards and conventions when appropriate		☐ Demonstrates inaccurate or inappropriate use of genre and disciplinary standards and conventions	☐ Demonstrates some familiarity with genre/disciplinary standards and conventions; inconsistent use of standards and conventions	☐ Demonstrates consistent and appropriate use of important conventions particular to a specific discipline and/or writing task(s)	☐ Demonstrates detailed attention to and successful execution of the appropriate disciplinary standards and conventions
C2 Organize communication					
C2A Provide a concise abstract or executive summary that summarizes purpose, methods, key results and presents conclusions	☐ No abstract or executive summary	☐ Abstract or executive summary is unclear and/or ☐ Does not summarize the purpose, methods, key results or conclusions	☐ Abstract or executive summary is weak or poorly formulated and/or ☐ Minimally summarizes the purpose, methods, key results or conclusions	☐ Abstract or executive summary is clear and concise and ☐ Summarizes the purpose, methods, key results and conclusions	☐ Meets+ ☐ Abstract is engaging and provides a clear context that impressively situates the key results and conclusions
C2B Adapt mode of communication to meet an audience's needs		☐ Mode is inappropriate in meeting audience's needs	☐ Inconsistent relationship between mode and needs of audience	☐ Uses and adapts appropriate mode to meet the needs of the audience	☐ Uses and adapts appropriate mode to effectively match the

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
					medium and needs of the audience
C2C Use explicit structure (e.g., headings) to direct an audience	☐ No explicit structure	☐ Structure is confusing to audience	☐ Demonstrates an attempt to use structure but requires effort to navigate	☐ Intentionally uses an explicit structure that directs the audience	☐ Structure of text/talk makes it easy for the audience to navigate the material in multiple ways[1]
C2D Transition effectively between paragraphs and/or sections	☐ Transitions are missing	☐ Transitions show no logical connection between paragraphs and sections	☐ Transitions do not clarify the relationships between paragraphs and sections	☐ Transitions effectively show logical relationships between paragraphs and sections	☐ Transitions contribute to coherence, and strengthen logical relationships between paragraphs and sections
C2E Organize communication elements (e.g., introduction, conclusion etc.) so that their relationship to the main point and one another is clear	☐ No relationship among communication elements ☐ No relationship between communication elements and the main point	☐ Unclear relationship among communication elements ☐ Unclear relationship between communication elements and the main point	☐ Inadequate relationship among communication elements ☐ Inadequate relationship between communication elements and the main point	☐ Clear relationship among communication elements ☐ Clear relationship between communication elements and the main point	☐ Clear relationship and support among communication elements ☐ Clear relationship and support between communication elements and the main point, making it easy for the reader/audience to follow

1 Nonlinear "jumping" — you can start from any point and still understand the document/talk

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
C2F Provide context before detail at the sentence, paragraph and section level (i.e., flow)	☐ Document/ talk lacks context and detail	☐ Details are presented before or without any context	☐ Document/talk inconsistently provides context before detail or does not have a coherent thread	☐ Sentences and paragraphs build logically by providing context before detail	☐ Presentation of detail emerges naturally from context and helps build a convincing argument
C3 Develop clear, correct and cohesive sentence and paragraph structures for written communication					
C3A Choose appropriate rhetorical structures for paragraphs and sentences	☐ Paragraphs and sentences lack specific rhetorical structure	☐ Rhetorical structures are not appropriate for paragraphs and sentences, and do not align with the goals of the text	☐ Inconsistent relationship between rhetorical structures of paragraphs and sentences and goals of the text	☐ Rhetorical structures are appropriate for paragraphs and sentences, and align with the goals of the text	☐ Meets + ☐ Rhetorical structures facilitate thorough understanding of the text
C3B Build each paragraph around a focus or claim, usually signalled by a topic sentence	☐ Paragraphs have no focus/claim or topic sentence	☐ Paragraphs have multiple inconsistent claims or focus areas	☐ Paragraph focus/claim is vague or unclear; requires some effort to understand	☐ Paragraphs have a clear focus or claim usually signalled by a topic sentence	☐ Paragraphs sustain focus throughout ☐ Claims are signalled by a topic sentence where appropriate and supported with explanation, evidence and/or sufficient detail
C3C Use appropriate formatting (e.g., headings, bullet points etc.) to achieve purpose		☐ Formatting is not appropriate for purpose, audience and genre	☐ Formatting presents some inconsistencies with purpose, audience and genre	☐ Formatting is appropriate for purpose, audience and genre	☐ Formatting is highly effective for the purpose, audience and genre
C3D Make clear and appropriate		☐ Vocabulary is very limited (i.e.,	☐ Vocabulary choices are limited	☐ Vocabulary is varied and appropriate for audience and topic	☐ Meets+ ☐ Vocabulary is sophisticated, precise,

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
vocabulary choices		excessive repetition) ☐ Errors in vocabulary are distracting and hinder understanding	and occasionally ineffective ☐ Errors in vocabulary occasionally hinder understanding	☐ Errors in vocabulary do not hinder understanding	compelling and enhances the effectiveness of the text/talk
C3E Demonstrate grammatical accuracy and clarity in sentence structure		☐ Problems in grammar and sentence structure hinder understanding of key elements of the document/talk	☐ Some problems in grammar and sentence structure hinder readability of prose but not understanding of the document/talk	☐ Grammar and sentence structure are mostly accurate and clear throughout document/talk	☐ Grammar and sentence structure are accurate and coherent, and clearly communicate complex topics in well-designed paragraphs and sentences
C4 Design and deliver oral communication effectively to an intended audience					
C4A Choose appropriate rhetorical structures for oral communication	☐ Talk lacks specific rhetorical structure	☐ Rhetorical structures are not appropriate for the context of the talk	☐ Inconsistent relationship between rhetorical structures and the context of the talk	☐ Rhetorical structures are appropriate for the context of the talk	☐ Meets + ☐ Rhetorical structures engage the audience and facilitate thorough understanding of material
C4B Present in a natural but prepared manner		☐ Delivery is unnatural or ☐ Delivery is unprepared (i.e., heavily reliant on notes or slides)	☐ Delivery is mechanical with occasional instances of natural delivery ☐ Some preparation evident but frequently reads from notes or slides	☐ Delivery is natural and helps build rapport with audience ☐ Delivery is prepared (occasionally reads from notes or slides)	☐ Delivery is natural and helps builds engagement with audience ☐ Delivery is thoroughly prepared (rarely reads from notes or slides)
C4C Engage with audience through appropriate eye contact and non-	☐ No appropriate or useful	☐ Body gestures/language are distracting or inappropriate	☐ Body gestures may occasionally distract audience	☐ Body gestures/language facilitate audience engagement	☐ Body gestures/language are fluid and natural, and enhance audience interest and understanding; speaker

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
distracting body gestures/ language	gesturing/body language ☐ No eye contact	☐ Very little eye contact with audience or speaks only to one audience member	☐ Intermittent eye contact with audience or engages with minimal audience members	☐ Reasonable eye contact with most of the audience	appears comfortable and enthusiastic ☐ Sustained eye contact creates an effective connection with entire audience
C4D Use appropriate auditory mechanics (volume, articulation, pace and tone)		☐ Volume is too soft to hear or distractingly loud ☐ Articulation is poorly executed/ unclear; mumbles or runs words together ☐ Pace is too fast or too slow to understand ☐ Tone is unprofessional and inappropriate for purpose and audience	☐ Volume is sometimes inaudible or inappropriately loud ☐ Articulation is occasionally clear ☐ Pace is inconsistent (at times too fast or too slow) ☐ Tone is occasionally professional and appropriate for purpose and audience	☐ Volume is consistently audible/able to be heard by the entire audience ☐ Articulation is consistently clear ☐ Pace is appropriate to facilitate audience understanding ☐ Tone is consistently professional and appropriate for audience and purpose	☐ Volume is audible and varied to emphasize key points and enhance audience interest ☐ Articulation is clear, precise and engaging ☐ Pace is natural and varied to emphasize key points and enhance audience interest ☐ Tone is consistently engaging, appropriate and professional
C4E Provide verbal and visual cues to guide the audience throughout the presentation	☐ Provides no verbal or visual cues during the presentation	☐ Verbal or visual cues are misleading or undermine understanding of presentation	☐ Provides few verbal or visual cues	☐ Usually provides verbal and visual cues that guide the audience throughout the presentation	☐ Consistently provides verbal and visual cues that guide the audience

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
C4F Manage time effectively; cover important points within the allotted time		☐ Goes significantly over or under allotted time ☐ Misses important points completely	☐ Struggles to deliver presentation in allotted time (e.g., may rush at the end of the presentation) ☐ Spends too little or too much time on important points	☐ Delivers presentation in allotted time ☐ Sufficiently covers important points within the allotted time	☐ Meets + ☐ Devotes more or less time to components of the presentation based on relative importance ☐ Demonstrates an understanding of how to modify timing of presentation based on unanticipated constraints
C5 Create clear and appropriate visuals to present ideas					
C5A Create visuals with a clear purpose	☐ No visuals present where needed	☐ Visuals have no evident purpose or relationship to the text/talk	☐ Visuals appear to support the text/talk, but purpose of visuals has to be inferred or is not consistently clear throughout	☐ Visuals have a clear purpose and support the text/talk	☐ Visuals have a clear purpose, are unified, thoughtful and thoroughly enrich the work
C5B Select visual type appropriate to purpose and audience		☐ Visual type is not appropriate to purpose and audience	☐ Visual type is appropriate to some degree, but a better selection could have been made	☐ Visual type is appropriate to purpose and audience	☐ Visual type is selected appropriately, and expertly contributes to a thorough understanding of the material
C5C Use graphical components that highlight key ideas and limit noise		☐ Graphical and textual components are noisy (i.e., thoroughly distracting and/or significantly hinder	☐ Graphical and textual components demonstrate some key points but are impeded by noise	☐ Graphical and textual components highlight key points and limit noise	☐ Meets + ☐ Graphical and textual components are simple yet elegant; they make interpretation of the text/talk intuitive

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
		understanding of material) and/or do not demonstrate key points			
C5D Integrate visuals into text or talk so that they support and clarify key points		☐ Visuals are disconnected from the key points (e.g., do not refer to slides)	☐ Visuals are not clearly related to the key points	☐ Visuals support and clarify key points	☐ Visuals simplify explanations and deepen understanding of text/talk
C5E Format visuals effectively		☐ Visuals are poorly formatted	☐ Visuals are not ideally formatted	☐ Visuals are usually formatted appropriately	☐ Visuals are always formatted appropriately
C6 Iterate and reflect on the communication					
C6A Incorporate feedback to inform future iterations	☐ Does not incorporate feedback	☐ Misinterprets feedback; does not understand how to incorporate feedback effectively	☐ Incorporates some feedback but does not sufficiently improve final document or project work	☐ Incorporates feedback to improve final document or project work	☐ Meets + ☐ Successfully uses feedback in an unexpected way
C6B Identify and explain strengths and weaknesses in the various aspects of communication	☐ Does not identify or explain strengths and weaknesses	☐ Misidentifies strengths and weaknesses	☐ Lists strengths and weaknesses in a very general manner	☐ Identifies and explains specific strengths and weaknesses in the various aspects of communication	☐ Meaningfully organizes, compares and synthesizes strengths and weaknesses

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
(e.g., organization, argument, delivery method etc.)					
C6C Reflect on how specific parts of the development process impacted the final communication product(s)	☐ No reflection conducted	☐ Makes erroneous connections between development process and final communication product(s)	☐ Reflection is overly general; does not identify specific parts of the development process and/or final product(s)	☐ Reflects on how specific parts of the development process impacted the final product(s)	☐ Meets + ☐ Outlines constructive next steps for future assignments based on specific aspects of the development process
C6D Use reflection to determine and guide self-development	☐ No reflection apparent	☐ Reflection is highly superficial or irrelevant to the assignment/course ☐ Reflection does not guide self-development	☐ Reflection is overly general ☐ Reflection does not sufficiently determine and guide self-development	☐ Reflection is sufficiently specific ☐ Reflection sufficiently determines and guides self-development	☐ Reflection is highly specific ☐ Reflection demonstrates self-awareness, an (emerging) engineering identity and a plausible vision for improvement

Final teamwork rubric

Indicator	Fails *Not Demonstrated*	*Misconception*	Below	Meets	Exceeds
T1 Build a Collaborative Team Environment					
T1A Communicate respectfully with team members, using effective tone, body language and facial expressions [individual]	☐ Does not communicate with team members	☐ Communicates disrespectfully with team members using ineffective tone, body language and facial expressions	☐ Communicates respectfully but does so inconsistently and/or to select team members	☐ Communicates respectfully with all team members using effective tone, body language and facial expressions	☐ Meets + ☐ Encourages other team members to communicate respectfully using effective tone, body language and facial expressions
T1B Use effective alternative strategies to communicate with speakers of differing language backgrounds, skills and preferences [individual]	☐ Does not use alternative strategies to communicate with speakers of differing language backgrounds, skills and preferences	☐ Alternative strategies are used but are not effective for speakers of differing language backgrounds, skills and preferences	☐ Attempts to use effective alternative strategies, but does so inconsistently or has to be supported by other team members	☐ Deliberately and consistently uses a variety of effective alternative strategies to communicate with speakers of differing language backgrounds, skills and preferences	☐ Meets + ☐ Supports team members in communicating effectively with speakers of differing language backgrounds, skills and preferences
T1C Convey a constructive attitude about the team and its work [individual]		☐ Conveys a negative attitude about the team and its work in a way that hinders team	☐ Attempts to convey a constructive attitude about the team and its work but is inconsistent	☐ Consistently conveys a constructive attitude; demonstrates an understanding of when to be positive and appropriately critical	☐ Meets + ☐ Encourages other team members to adopt a constructive attitude about the team and its work

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
		cohesiveness and effectiveness		about the team and its work	
T1D Motivate team members in ways appropriate to the situation and goal (e.g., by emphasizing confidence in their success, by emphasizing importance of the task or by emphasizing team control over the outcome etc.) [individual]	☐ Does not motivate team members	☐ Discourages or limits the abilities of others to contribute to the team	☐ Occasionally demonstrates an interest in motivating team members but requires prompting to do so	☐ Consistently and actively motivates team members in ways appropriate to the situation and goal	☐ Meets + ☐ Actions inspire others to motivate team members
T1E Provide assistance to team members as needed or required [individual]	☐ Does not assist team members when needed or required	☐ Intervenes and disrupts the work of other team members	☐ Assists some team members but ignores others who need help and/or provides very limited assistance	☐ Consistently provides assistance to all team members as needed or required	☐ Meets+ ☐ Provides support to team members in finding ways to meet their individual team obligations
T1F Apply formal models of team and individuals (e.g., psychometrics, team role	☐ Demonstrates no knowledge or use of formal models of team and individuals	☐ Erroneously applies models of team and individuals to address team needs	☐ Demonstrates some knowledge of formal models, but does not use them to address team needs consistently	☐ Demonstrates considerable knowledge and consistent use of formal models of team and individuals to address team needs	☐ Meets + ☐ Formal models consistently improve team cohesiveness and effectiveness

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
models, etc.) to address team needs [team]					
T1G Offer new suggestions that build on the ideas of others [individual]	☐ Offers no suggestions	☐ Only offers their own suggestions without building on the ideas of others	☐ Repeats suggestions made by others without incorporating any novel or useful ideas or rarely builds on the ideas of others	☐ Offers new suggestions that build on the ideas of others	☐ Meets + ☐ Synthesizes and refines the suggestions of others to offer helpful ideas that advance the work of the group and/or notices when someone is not making any suggestions and respectfully invites them to engage
T1H Articulates the merits of alternative ideas from others [individual]	☐ Does not articulate the merits of alternative ideas from others	☐ Diminishes the ideas of others	☐ Seems to recognize the merits of alternative ideas, but valuing of the ideas is not clear	☐ Recognizes and articulates the merits of alternative ideas from others	☐ Meets+ ☐ Inspires others to articulate the merits of alternative ideas
T1I Identify and address conflict [individual]	☐ Does not identify conflict ☐ Does not address conflict	☐ Contributes to the escalation of conflict	☐ Identifies conflict but makes little effort to address it or effort is ineffective	☐ Identifies conflict and addresses conflict in the team	☐ Meets + ☐ Encourages an atmosphere of open dialogue and constructive argument[2] to address destructive conflict on an ongoing basis
T1J Stay actively engaged with team conflict	☐ Does not participate in team conflict mediation	☐ Actively works against mediation by continuing behaviours that	☐ Passively engages in team conflict mediation	☐ Stays actively engaged with team conflict mediation	☐ Actively mediates team conflict until resolution is reached

2 Encourages team to reach a solution that is better than any of the ones provided

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
mediation [individual]		perpetuate conflict			
T1K Redirect team focus toward common ground [individual]	☐ Does not contribute/assist in developing team focus	☐ Escalates team differences and conflict in a way that hinders team focus	☐ Makes limited contributions to developing team focus	☐ Redirects team focus toward common ground to facilitate team cohesiveness and effectiveness	☐ Meets+ ☐ Integrates the perspective of all team members in finding common ground
T1L Modify behaviour based on the needs of or changes to the team (e.g., in team roles, schedules, objectives, priorities etc.) [individual]	☐ Does not modify behaviour based on the needs of or changes to the team	☐ Modifies behaviour in response to changes to the team in ways that are detrimental	☐ Does not readily modify behaviour; has to be prompted by others	☐ Modifies behaviour based on the needs of or changes to the team as necessary and appropriate	☐ Meets+ ☐ Constructively helps others modify their behaviour based on the needs of or changes to the team
T2 Manage Team Productivity					
T2A Establish norms of practice (e.g., rules, roles, charters, etc.) [team]	☐ Does not establish norms of practice; there is no understanding of the rules (or there are no rules), tasks and who does what in the team	☐ Establishes destructive norms of practice	☐ Begins to informally identify norms of practice, but they will not make significant advances in guiding the team	☐ Establishes norms of practice that will help guide the team	☐ Meets+ ☐ Incorporates follow-up activities that hold team members accountable to norms of practice
T2B Utilize norms of practice over the course of the project [individual]	☐ Does not utilize norms of practice	☐ Utilizes norms of practice to create conflict or alienate team members	☐ Utilizes norms of practice inconsistently or at select points during the project	☐ Utilizes norms of practice throughout the course of the project	☐ Meets + ☐ Respectfully follows up with team members who consistently fail to utilize the team's norms of practice

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
T2C Outline clear and relevant agenda items for team meetings [team]	☐ Does not outline any agenda items for team meetings	☐ Agenda items deter from important team tasks	☐ Agenda items are not clear or relevant to the task at hand	☐ Outlines clear agenda items for team meetings that are relevant to the task at hand	☐ Outlines and prioritizes clear agenda items that are relevant and contribute to efficiency in team meetings
T2D Attend team meetings regularly and on time [individual]	☐ Does not attend any team meetings	☐ Often late and/or absent without notifying the team	☐ Sometimes late and/or absent; may notify team	☐ Attends team meetings regularly and on time; consistently notifies team if late or absent	☐ Makes an exceptional effort when necessary to attend team meetings regularly and on time; notifies team as far as possible in advance of lateness or absence and/or ☐ Follows up with team members to catch up on what they missed if late or absent
T2E Complete all assigned tasks by (external and/or internal) deadline [team]	☐ Assigned tasks are not completed or ☐ Assigned tasks are not completed by deadline		☐ Completes some tasks by deadline or ☐ Sometimes completes tasks by deadline or completes tasks by deadline if repeatedly reminded or significantly supported by others	☐ Completes all assigned tasks by deadline	☐ Completes work in advance with enough time to improve the quality before deadline

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
T2F Produce quality work that advances the team [individual]	☐ Does not produce work	☐ Work is not usable; must be completely redone by others	☐ Quality of work is inconsistent; occasionally needs to be checked or redone by others to be acceptable	☐ Quality of work is satisfactory; only minor improvements required	☐ Meets+ ☐ Proactively helps team members who produce work that requires improvements
T2G Make individual contributions that advance the project, either directly or indirectly [individual]	☐ Makes no contribution to advance the project	☐ Any contributions made do not advance the project	☐ Makes few contributions that do not significantly advance the project either directly or indirectly	☐ Makes contributions that consistently advance the project either directly or indirectly	☐ Meets + ☐ Proactively helps others make contributions that advance the project (e.g., notices when someone is not contributing and respectfully invites them to do so)
T3 Reflect on Team Practices					
T3A Assess team productivity and refine norms as needed over the course of the project [team]	☐ Does not assess team productivity and/or does not refine norms as needed over the course of the project	☐ Assesses team productivity incorrectly and/or refines norms in ways that detract from team productivity	☐ Assesses productivity superficially and/or inconsistently refines norms over the course of the project	☐ Assesses team productivity and refines norms as needed over the course of the project	☐ Meets+ ☐ Team has a codified way of monitoring its productivity and adjusting its processes
T3B Identify team strengths and weaknesses with respect to teamwork and team management [team]	☐ Does not identify team strengths and weaknesses with respect to teamwork and team management	☐ Misidentifies team strengths and weaknesses with respect to teamwork and team management	☐ Identifies general team strengths and weaknesses, but does not relate them to teamwork and team management	☐ Identifies team strengths and weaknesses with respect to teamwork and team management	☐ Meaningfully organizes, compares and synthesizes team strengths and weaknesses with respect to teamwork and team management, demonstrating clear evidence of critical thinking
T3C Accurately report on	☐ Does not report on other team	☐ Misreports other team	☐ Identifies others' contributions to the	☐ Accurately reports on others' specific	☐ Meets +

Indicator	Fails		Below	Meets	Exceeds
	Not Demonstrated	*Misconception*			
other team members' contributions to the team activity [individual]	members' contributions to the team activity	members' contributions to the team activity	team activity but is overly general	contributions to the team activity	☐ Articulates connections/interactions between team members' contributions (e.g., understands that A has to complete Task 1 before B can complete Task 2)
T3D Reflect on how one's own contributions impacted the work of the team [individual]	☐ No reflection conducted or ☐ Provides no examples of how one's own contributions impacted the work of the team	☐ Reflection is highly inaccurate ☐ Exaggerates one's own contributions or unreasonably denigrates contributions made by others	☐ Reflection is overly general ☐ Examples of how one's own contributions impacted the work of the team are limited or general	☐ Reflection is specific ☐ Provides a selection of relevant examples of how one's own contributions impacted the work of the team	☐ Reflection is specific and outlines constructive next steps to improve one's own contributions to the team ☐ Provides multiple relevant, concrete and diverse examples
T3E Reflect on how specific parts of the team process impacted the team's deliverables [individual]	☐ No reflection conducted or ☐ Provides no examples of how parts of the team process impacted the team's deliverables	☐ Reflection is highly inaccurate ☐ Misidentifies the connections between team process and impact on deliverables	☐ Reflection is overly general ☐ Examples of how parts of the team process impacted the team's deliverables are limited or general	☐ Reflection is specific (i.e., reflects on how specific parts of the teamwork process impacted the team's deliverables) ☐ Provides a selection of relevant examples	☐ Reflection is specific and outlines constructive next steps to improve team's deliverables ☐ Provides multiple relevant, concrete and diverse examples
T3F Identify how the team evolved during the course of a project [individual]	☐ Does not identify how the team evolved during the course of a project	☐ Misidentifies how the team evolved during the course of a project	☐ Identification is overly general, superficial or exaggerated	☐ Accurately identifies specific ways in which the team evolved during the course of a project	☐ Meets + ☐ Addresses how the team evolved by outlining specific, actionable plans for future projects

Appendix B

Appendix B contains the indicators for problem analysis and investigation. These indicators were developed using a Delphi method. Starting with a set of indicators compiled from the literature, modifications and additions were made through an iterative inquiry process with a set of instructors who teach courses relevant to these competencies.

Indicators for Problem Analysis competency

1. Define the problem
P1A. State the problem in their own words
P1B. Identify primary problem goal(s)
P1C. Characterize the type of problem and the type of solution sought
P1D. Represent the problem visually (e.g., free body diagram, circuit schematic)
P1E. Identify known information
P1F. Recognize unknown information
P1G. Identify relevant models, concepts or theories
P1H. Identify relevant assumptions
2. Explore relevant knowledge and solution processes
P2A. Reframe complex problems into interconnected sub problems
P2B. Identify appropriate techniques and methods to solve the problem
P2C. Recognize “off-the-shelf” solutions or routine solution processes
P2D. Incorporate information from other sources into the solution process (e.g., looking up the speed of light)
P2E. Determine methodological constraints
P2F. Predictively compare and contrast alternate solution processes in terms of relevant metrics (e.g., accuracy, precision, efficiency, reliability, feasibility, risk, impact, etc.)

P2G. Combine the information from the problem with the appropriate model, concept or theory to create a solvable system
3. Propose a solution process
P3A. Plan a systematic solution process (i.e., identifies measurable tasks that support sub-goals) P3B. Modify "off-the-shelf" solution process within problem context
4. Implement a solution
P4A. Implement a defined solution process to solve the problem P4B. Competently use appropriate analysis tools (e.g., computational, experimental, analytical) P4C. Express the solution in an appropriate form
5. Evaluate results
P5A. Evaluate whether the solution is suitably accurate for the type of problem P5B. Determine if the solution is valid and correct, or is clearly not correct P5C. Interpret and evaluate alternative solutions and select a final solution P5D. Identify limitations and sources of error or uncertainty in the solution P5E. Specify conclusions or future work (including improvements or modifications to the solution) that can be supported by the analysis

Indicators for Investigation competency

1. Define their research
I1A. Define a research problem, question or gap I1B. Decompose a complex problem into similar related problems I1C. Develop a hypothesis I1D. Develop a research plan

2. Collect information
I2A.Gather existing background information on the topic from literature and other relevant sources I2B. Synthesize existing information I2C. Perform a critical review of a research paper or article
3. Define a research methodology
I3A. Identify protocols, strategies or methods for investigation I3B. Select and combine appropriate research methodologies I3C. Construct and describe a research methodology I3D. Identify necessary resources to carry out the methodology I3E. Identify assumptions of the research methodology I3F. State the limitations of the research methodology
4. Follow a research methodology
I4A. Execute a research methodology I4B. Collect and organize data carefully and effectively I4C. Modify methodology based on preliminary results I4D. Maintain a safe working environment and display safe lab practice while performing research
5. Perform research analysis
I5A. Organize and synthesize evidence to support or address the research questions or hypothesis I5B. Apply critical thinking processes and strategies to analyze the data
6. Formulate conclusions

I6A. Objectively draw conclusions based on experimental outcomes/results I6B. Explain unexpected results I6C. Characterize the limitations of the research I6D. Characterize the significance of the research
7. Describe future research directions
I7A. Outline next steps or future work I7B. Suggest methodological improvements
8. Engage in learning
I8A. Appropriately connect/use course concepts in the investigation process I8B. Identify/reflect on lessons learned I8C. Manage time and resources effectively to complete the investigation

Appendix C

Publications

During the project the author team published preliminary results in a set of papers:

Dawe, N., Lesmond, G., McCahan, S., & Romkey, L. (2015). *Development of Analytic Rubrics for Competency Assessment*. Paper presented at the Canadian Engineering Education Association Annual Conference, McMaster University, May 31–June 3, 2015. Hamilton, ON.

Dawe, N., Romkey, L., McCahan, S., Lesmond, G. (2016). *User Testing with Assessors to Develop Universal Rubric Rows for Assessing Engineering Design*. Paper presented at the American Society for Engineering Education Annual Conference, June 26–29, 2016. New Orleans, LA.

Lesmond, G., Dawe, N., McCahan, S., & Romkey, L. (2016). *Update on the Development of Analytic Rubrics for Competency Assessment*. Paper presented at the Canadian Engineering Education Association Annual Conference, Dalhousie University, June 19–22 June 2016). Halifax, NS.

Lesmond, G., Dawe, N., McCahan, S., & Romkey, L. (2016). *Using a Delphi Approach to Develop Criteria for an Analytic, Competency-Based Rubric*. Paper presented at the American Society for Engineering Education Annual Conference, June 26–29, 2016. New Orleans, LA.

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