Evaluating Innovations from a Critical Thinking Approach

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Evaluating Innovations from a Critical Thinking Approach

One strategic initiative at Clemson University is to promote innovation and entrepreneurship among faculty and students. One of the channels for introducing students to innovation and entrepreneurship at Clemson University is a course offered through the General Engineering program, *ENGR 2200: Evaluating Innovations: Fixtures, Fads, and Flops*. This general education course was designed to actively engage students in deep thinking about the relationships between innovation and society. The goals of this class are two-fold: 1) students gain an understanding of how societal and technological trends drive innovation, and 2) students learn and apply critical thinking techniques to critically analyze the impact of innovations on society and identify opportunities for innovation. The course content introduces engineering students to foundational theories of innovation, product development, and consumer behavior which are used to analyze the success of consumer products and other technological innovations.

A SCALE-UP (Student-Centered Activities for Large-Enrollment Undergraduate Programs) environment is utilized in this course. SCALE-UP is a highly collaborative, hands-on classroom format where the primary emphasis is on learning by guided inquiry rather than by traditional lecturing. Student engagement is fostered using this approach as students are able to work together in small groups to uncover their own thought and biases before discussing difficult or controversial topics surrounding engineering innovation with the class as a whole. While the course is taught specifically with engineering design in mind, the course has attracted students from varying majors which has fostered collaboration and creativity in idea generation. The combination of critical thinking methodology with innovation concepts has led students to not only expand their knowledge of potential applications of engineering, but has lead several students to initiate communication with faculty members regarding their ideas for research opportunities, innovation competitions, and initiated their own projects via applying for University Innovation Fellows program.

Background

Innovation and entrepreneurship have been part of the engineering curriculum for several decades [1]. However, students many not encounter these subjects through their required engineering courses until their junior or senior year, typically during a capstone design course. While opportunities exist for students to learn about innovation and entrepreneurship through elective courses, these options are not typically available to first-year students or do not fulfill a requirement for their academic plan.

First-year courses are the cornerstone experiences that expose students to foundational concepts and foster the development of skills necessary for students to succeed in their field of study and ultimately their career. For disruptive innovators, those behavioral skills include: questioning, observing, networking, and experimenting s [2]. Critical thinking is then used to form associations between content, effectively linking ideas/processes/solutions together which helps innovators generate new uses for existing technologies modification to existing technologies that can improve the effectiveness [3].

One of the recent strategic initiatives of [our] University is promoting innovation and entrepreneurship, specifically within the engineering majors. *Evaluating Innovation: Fixtures, Fads, and Flops* was developed to create a cornerstone experience that infuse innovation and entrepreneurship into the first-year in an intentional way, integrated as a new course offering to fulfill an existing general education requirement. The course engages students in deep thinking about the relationships between innovation and society and consequences of design flaws. The focus of this class is on the reciprocating nature of the interactions between innovation and society. The examination of this relationship lends itself naturally to the use of critical thinking and is used as a tool for evaluation throughout the course. At the end of the course, students should be able to 1) demonstrate an understanding of issues created by the complex interactions among science, technology, and society, and 2) demonstrate the ability to assemble information relevant to a significant, complex issue, evaluate the quality and utility of the information, and use the outcome of the analysis to reach a logical conclusion about the issue.

Course Content and Theoretical Models

The course introduces students to foundational theories of innovation and evaluation methods to engage students in thinking critically about product development from a broad range of perspectives. Specifically, students learn to evaluate innovations from technological, business, human, and environmental perspectives. Figure 1 shows a breakdown of course content. Students are introduced to foundational theories for promoting innovation through company culture [4], individual mindset [5], and design thinking methodology [6]. Additionally, students are exposed to various tools to evaluate innovation from financial [7], social [8], and environmental perspectives [9] as well as a critical thinking approach [3] to analyze an issue to thoroughly and to high quality standards.

Course Content

Distribution of content coverage in this class include:

- Critical Thinking – 20%
  - Elements of reasoning
  - Intellectual standards
  - Heuristics and decision making
- Innovation Mindset – 20%
  - Human-centered design thinking
  - Product development process
  - Innovation (change) style
- Evaluating Innovation Success – 20%
  - Product Life Cycle
  - Market/Situation Analysis
  - Technology Adoption / Diffusion of innovation
- Societal Factors and Implications– 20%
  - Disruptive Innovations
  - Hierarchy of human needs
  - Environmental impact
- Professional Communication – 10%
  - Critical analysis of innovation and innovative technologies (written and presented)
  - Objectively engage in group discussions
- Course Mechanics and Assessment – 10%
  - California Critical Thinking Tests (2)
  - Module Quizzes (10)
  - Exams (3)

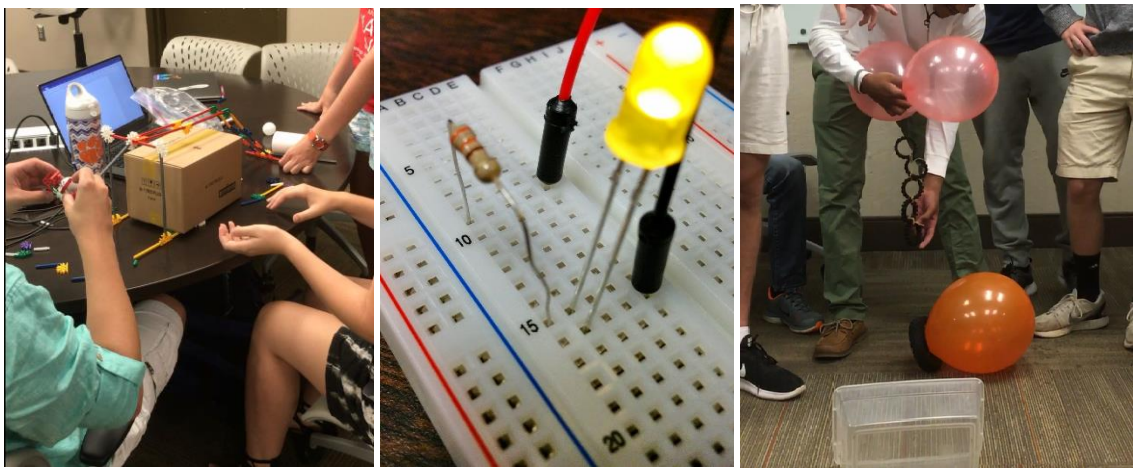
Figure 1: Overview of content delivered in *Evaluating Innovation: Fixtures, Fads, and Flops*

Course Development and Timeline of Interventions

2014-2015- The development of [this course] began in February 2014 when it was proposed as a new course development for a Critical Thinking Faculty Institute encouraging instructors to offer courses that "focused on developing students' ability to think critically and to communicate

effectively." [10] This course was piloted in Spring 2015 as a seminar course for 20 students. Classes were largely class discussions with students driving conversation with topics and experiences relevant to their lives. While this style was effective in developing critical thinking and communication skills, students felt it conflicted with their expectations of an engineering course and requested more hands-on activities.

2015-2016 - In Fall 2015, the course was introduced on a larger scale using SCALE-UP methods for 3 sections of 40 students. SCALE-UP (Student-Centered Activities for Large-Enrollment Undergraduate Programs) is a highly collaborative, hands-on classroom format where the primary emphasis is on learning by guided inquiry rather than by traditional lecturing [11, 12, 13, 14]. Student engagement is fostered using this approach as students are able to work together in small groups to uncover their own thought and biases before discussing difficult or controversial topics surrounding engineering innovation with the class as a whole. Figures 2-4 show some of these activities. Figure 2 shows a design thinking exercise that illustrates the difference in working harder and working smarter. Students are instructed to design a way to get an object from point A to point B where there is a barrier between. Most start by building a bridge or catapult while going around is a simply feasible alternative. As seen in Figure 3, when discussing the differences between incremental, breakthrough, and disruptive innovations, lighting is used as an example to highlight these differences. To expand on the topic, students build an electrical circuit to compare the brightness and voltage drops across incandescent and led bulbs. Figure 4 shows an ideation session to address a grand challenge [15] where students use random objects to simulate a design. This requires students to use diverse thinking and image possibilities beyond traditional uses of existing products. The idea shown simulated a way to remove water impurities using an enclosure with a weight sensor that releases the cover allowing impurities to be lifted out when enough of them had been captured in the containment area. Obviously this idea would need some more intensive work to become a feasible solution, but the creativity is evident and certainly students come out with a stronger awareness for these important engineering problems that are in need of innovative solutions.



Figures 2-4: In-class activities allow students to expand their learning by exercising creative and critical thinking skills in small groups.

2016-2017 – In response to student feedback, two modifications were made to the course: 1) an immersive approach used to introduce critical thinking as a framework within a module on engineering design failures and accident investigation rather than as its own module on critical thinking theory and 2) the use of peer evaluations was eliminated. This stronger connection to application of the theory in the engineering profession improved student engagement with the module. In this module students are shown how the critical thinking framework [3] is used to uncover the sources of the failures and use that knowledge to prevent repeating the same mistake. Next students are led through a discussion of heuristics and errors from cognitive biases. They then self-reflect on their own failures in judgement and self-assess factors that influence their behavior. While students seemed to engage with the content more on commented favorably about the content in this module being exciting and relevant, the reduction in emphasis of critical thinking theory coupled with the reduced emphasis on the practice of evolution peers analyses likely reduced the potential learning gains in critical thinking.

2017-2018 – This year brought two more modifications: 1) Digital Storytelling was introduced to improve communication of innovative ideas and 2) the (PREP)ARE modular structure [16] was introduced into the online course management software. The digital storytelling project had students evaluate a grand challenge and ideate potential solutions. They utilize Adobe Spark s to capture an artifact documenting the result of their design thinking process to address the grand challenge of their choice. Figure 5 shows a sample submission. Students express their ideas based on theories from class such as a SWOT analysis and low fidelity prototypes.

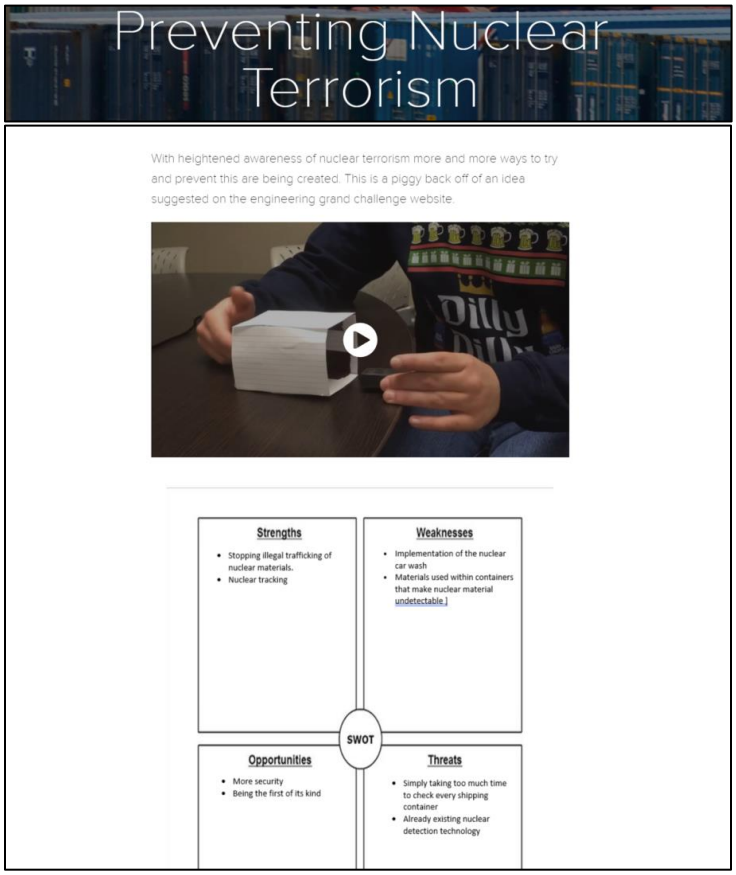


Figure 5: Sample of student work documenting innovation using Adobe Spark

The (PREP)ARE modular structure was introduced following positive results in two foundational courses taught by the GE Program. Figure 6 shows the first page of a (PREP) module presented to students for the module on critical thinking in engineering design.

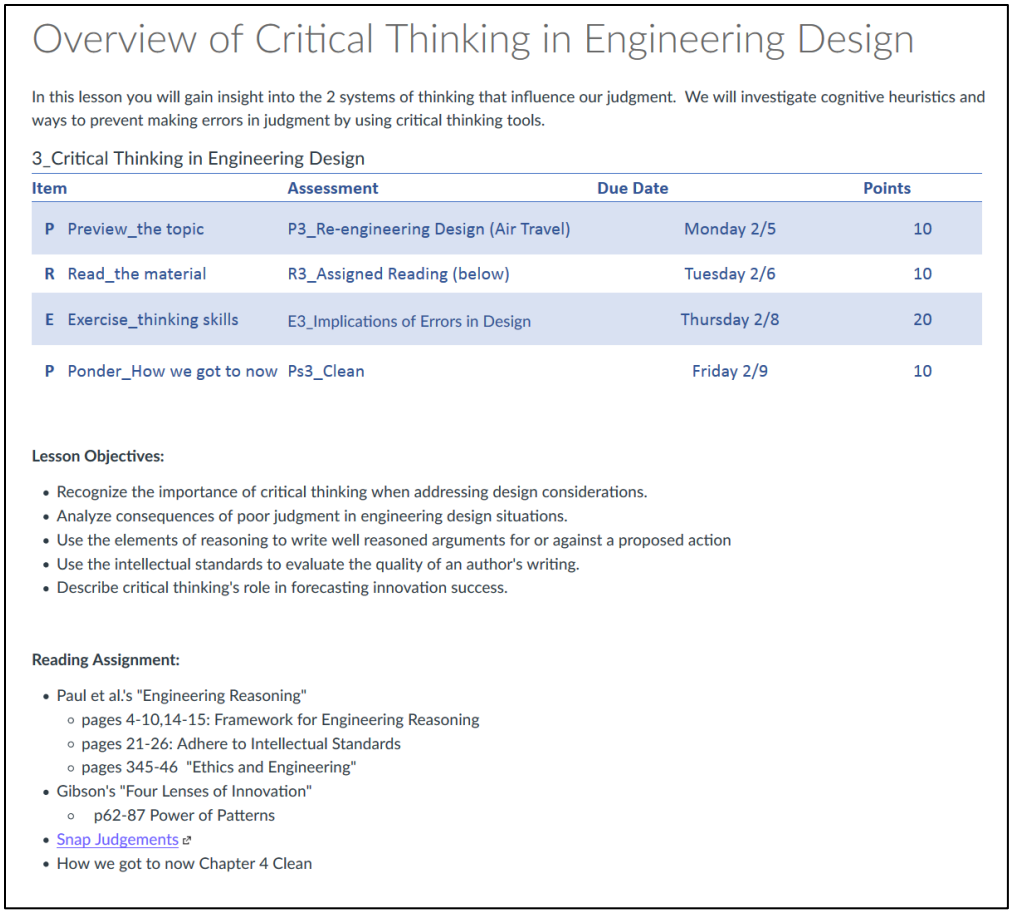
The weekly modules offer a repeated cycle of activities with standardized assessment rubrics. This structure helps guide students through an active learning experience of reflection (Preview), knowledge discovery (Read), hands-on activities and simulations (Exercise), and peer-lead discussions (Ponders). Incorporating the acronym into course assignment names has improved the students' awareness of deadlines and expectations for each class period. Figure 7 shows the assignment submission fields as students interact with them in CANVAS.

Each module consists of four elements:

1) **P**review (discussion post): In this reflective activity, students document their current understanding or beliefs on a topic relevant to the lecture through a discussion board post. Assessments are completed with a Learning *GAIN* Likert scale for two criteria; completion and quality. This gives a way of providing partial credit based on performance, though it is likely to be nearly as effective to grade Preview activities on a Complete/Incomplete with lower grading demand as this still encourages the documentation that leads to deep learning regarding the topic.
2) **R**ead (timed quiz): In this activity students get a low stakes chance of reviewing important concepts and ensure their understanding of the foundational topics before they get to the exam. Each quiz consists of 5 auto-graded questions based on the reading. Questions are mostly multiple choice or matching and students receive immediate feedback from the course management system to assess their reading comprehension.

3) **E**xpand learning (and Exercise Thinking skills): Each live course devotes a class period each week to a hands-on activity allowing students to exercise their creative and critical thinking skills. Both online and live course offerings focus on exercising critical thinking skills by researching a topic and writing a brief essay describing their critical analysis of an innovation based on the critical thinking elements.

4) **P**onder (group discussion): During one class period of the week, students engage in a Think-Pair-Share activity, discussing historical innovations that were disruptive to the culture of the American population, shaping the world as we know it today. Students are broken up into groups of 7, each selecting one of the seven related innovations for a particular industry. Each student becomes "the expert" on their selected innovation and presents a summary of implications of the innovation to the group. Then as class we review the key trends and insights. Individual summaries were assessed with a checklist of items that were consistently used as prompts for each module's *Ponder* assignment.



Overview of Critical Thinking in Engineering Design

In this lesson you will gain insight into the 2 systems of thinking that influence our judgment. We will investigate cognitive heuristics and ways to prevent making errors in judgment by using critical thinking tools.

3_Critical Thinking in Engineering Design

Item	Assessment	Due Date	Points
P Preview_the topic	P3_Re-engineering Design (Air Travel)	Monday 2/5	10
R Read_the material	R3_Assigned Reading (below)	Tuesday 2/6	10
E Exercise_thinking skills	E3_Implications of Errors in Design	Thursday 2/8	20
P Ponder_How we got to now	Ps3_Clean	Friday 2/9	10

Lesson Objectives:

- Recognize the importance of critical thinking when addressing design considerations.
- Analyze consequences of poor judgment in engineering design situations.
- Use the elements of reasoning to write well reasoned arguments for or against a proposed action
- Use the intellectual standards to evaluate the quality of an author's writing.
- Describe critical thinking's role in forecasting innovation success.

Reading Assignment:

- Paul et al.'s "Engineering Reasoning"
  - pages 4-10,14-15: Framework for Engineering Reasoning
  - pages 21-26: Adhere to Intellectual Standards
  - pages 345-46 "Ethics and Engineering"
- Gibson's "Four Lenses of Innovation"
  - p62-87 Power of Patterns
- Snap Judgements
- How we got to now Chapter 4 Clean

Figure 6: Example layout of a module overview page with assignment names coded to match the PREP cycle stage for a general education course on innovation.

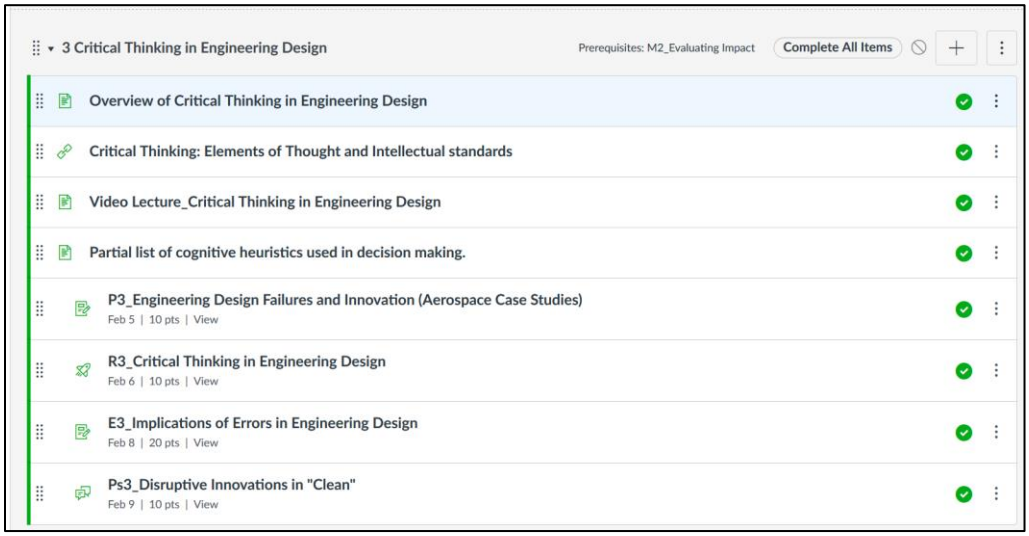


Figure 7: The assignments mimic the acronym PREP to guide students through the module with progressive assignments that follow the pattern set forth by the model.

Assessment of Learning Objectives

The objectives of this course are for students to gain an understanding of how societal factors and innovation influence each other and improve critical thinking, and communication skills. Learning objectives are assessed using the course comprehensive final exam, though progress is also evaluated throughout each module with small stakes assignments, worth 10-20 points compared to the 150 points of an exam. While the assessment have a small impact on final course grades, they provide students the opportunity to learn from their mistakes by reviewing feedback from the grading rubrics. Example rubrics used to evaluate critical thinking exercises for are included in Appendices A and B. Appendix C shows the latest version of the rubric that is currently in use.

Students regularly achieve course performance scores within the target 80-85% accuracy for all objectives of the course. While this measure is important, it is also easy to erroneously make conclusions based only on internal assessment measures. Therefore, critical thinking skills are regularly assessed using an external evaluation measure, the California Critical Thinking Skills Test (CCTST). Pre and post evaluations were conducted and serve as an external evaluation of learning gains. A summary of results is shown in Table 1. In general, gains of about 10 percentile were experienced on average, with a smaller gain seen in Fall 2016. Based on these results, peer evaluations will be reincorporated into the course as well as re-revising the module on critical thinking in engineering design to spend more time actively working through the critical thinking elements when analyzing case studies.

Table 1: Summary of Critical Thinking Learning Gains over the term for each course offering

Semester	Group	Class size	Pre-Test Average Percentile	Post-Test Average Percentile	Critical Thinking GAIN (mean change in percentile)
Spring 2015	General	20	70	80	10
Fall 2015	General	37	63	75	12
	General	39	59	65	6
	RiSE	39	65	77	12
Spring 2016	General	18	72	83	11
Summer 2016	Online	7	58	68	10
Fall 2016	RiSE	38	71	72	1
Summer 2017	Online	9	70	79	9

Conclusions

While the course is taught specifically with engineering design in mind, the course has attracted students from varying majors which has fostered collaboration and creativity in idea generation. So far this course has succeeded in exposing 284 students to innovation and entrepreneurship topics and provided opportunities for the development of critical thinking and communication

skills through the analysis of relationship between science, technology, and society. The combination of critical thinking methodology with innovation concepts has led students to not only expand their knowledge of potential applications of engineering, but has prompted several students to pursue entrepreneurial interest such as approaching faculty members regarding their ideas for input, competing in innovation competitions, and initiating their own makers projects via applying for funding or participating in other entrepreneurial programs such campus programs such as the Design & Entrepreneurship Network (DEN) and nation programs like University Innovation Fellows (UIF). While the course is still under refinement, it is a promising addition to the curriculum and has the potential to inspire young innovators to solve the global engineering challenges.

Future Research

Design (even instructional) is an iterative cycle of assessment and refinement. It is very easy for interventions with good intentions to have unforeseen negative consequences. Here, focusing on incorporating activities to encourage the development of creativity and risk taking to form an innovative mindset seems to have overpowered the focus on developing critical thinking skills. Both are important, and finding the correct balance will be the focus of future work. The

Additionally, a comparison of performance of students from different residential groups will be investigated. In the 2017-2018 academic year, the course will be delivered to four different groups of students: 1) Online, 2) General Engineering Learning Community (GELC), 3) Residents in Science and Engineering Living Learning Community (RiSE), and 4) General population open to all majors. Ongoing research will investigate variations in performance across these populations to determine whether this course is appropriate for the first year engineering student, despite being designed as a sophomore level critical thinking course and whether a prerequisite of English composition is needed to ensure the adequate preparation for the deep thinking and communication skills used in this course.

Works Cited

[1] W. P and B. T, "Entrepreneurship and innovation in engineering education," *Advances in Engineering Education*, vol. 5, no. 1, 2016.

[2] J. Dyer, H. Gregersen and C. Christensen, "The Innovator's DNA: MAstering the Five Skills of Disruptive Innovators," *Harvard Business Review,* 2011.

[3] R. Paul, R. Niewoehner and L. Elder, The Thinker's Guide to Engineering Reasoning, tomales, CaliFornia: Foundation For Critical Thiking Press, 2013.

[4] J. Byrd, "Perspe," in *The Innovation Equation: Building Creativity and Risk-Taking in Your Organization*, Wiley, 2002, p. 224.

[5] R. Gibson, The 4 lenses of Innovation: A power tool for creative thinking, Hoboken, New Jersey: Wiley, 2015.

[6] Stanford d.school, "A Virtual Crash Course in Design Thinking," Hasso Plattner Institute of Design, 2017. [Online]. Available: https://dschool.stanford.edu/resources-collections/a-virtual-crash-course-in-design-thinking.

[7] J. Riley, "Product Life Cycle," 2015. [Online]. Available: https://www.tutor2u.net/business/reference/product-life-cycle.

[8] G. Moore, Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers, Harper Collins, 2014.

[9] thinkstep, "What is the Life Cycle Assessment (LCA) Methodology?," 2018. [Online]. Available: https://www.thinkstep.com/life-cycle-assessment-lca-methodology.

[10] "Clemson Thinks2," April 2013. [Online]. Available: https://www.clemson.edu/academics/programs/thinks2/documents/QEP-report.pdf.

[11] M. Prince and R. Felder, "Inductive teaching and learning methods: Definitions, comparisons, and research bases," *Journal od Engineering Education,* vol. 95, no. 2, pp. 123-138, 2006.

[12] L. Benson, M. Orr, S. Biggers, W. Moss and S. Schiff, "Student-Centered Active Cooperative Learning in Engineering," *International Journal of Engineering Education,* vol. 26, no. 5, pp. 1097-1110, 2010.

[13] R. Beichner, J. Saul and D. Abbot, "Student Centered Activities for Large Wnrollment Undergraduate Programs (SCALE-UP) project," in *Research Based Reform of University Physics,* College Park, MD, American Association of Physics Teachers.

[14] H. Oliver-Hoyo and R. Beichner, "SCALE-UP: Bringing Inquiry-Guided Methods to Large Enrollment Courses," in *Teaching and Learning Through Inquiry: A Guidebook for Institutions and Instructors,* Sterling, Va, Stylus, 2004.

[15] National Academy of Engineering, "NAE Grand Challenges for Engineering," 2018. [Online]. Available: http://engineeringchallenges.org/.

[16] S. Grigg and E. Stephen, "(PREP)ARE: A student centered approach to provide scaffolding in a flipped classroom environment," in *ASEE Annual Conference and Expo,* Salt Lake City, Utah, 2018.

APPENDIX A: Spring 2015, Fall 2016, Spring 2016

Critical Thinking Rubric based on elements of thought and intellectual standards

				Missing 0	Needs Improvement 1	Adequate 2	Good 3	Excellent 4
Elements of Reasoning	Purpose	4	4	Not identifiable in essay	Explains the purpose of the paper in the conclusion only	The purpose of the paper is not directly stated in the introduction but can be inferred from information	Explains the purpose of the paper in the introduction	Explains the purpose of the paper in the introduction, which is distinguished from related purposes and is realistic and achievable
	Questions (Engineering Problem)	4	4	Not identifiable in essay	Mentions a problem being addressed by the object/idea/innovation but does not describe it	Briefly describes a problem being addressed by the object/idea/innovation/regulation under investigation but does not describe the context / environment	Describes a problem being addressed by the object / idea/innovation/regulation under investigation and mentions the context/ environment but does not connect the two	Describes a problem being addressed by the object/idea/innovation/regulation under investigation in relation to the context / environment and describes how the two are connected
	Data/ Information	4	4	Not identifiable in essay	Information is taken from source(s) that are not reviewed / reputable Viewpoints of experts are taken as fact	Information is taken from source(s) that are not reviewed / reputable Viewpoints of experts are taken as mostly fact	Information is taken from reputable source(s). Viewpoints of experts are subject to questioning.	Information is taken from reputable source(s). Viewpoints of experts are questioned thoroughly.
	Key Concepts (Theories)	4	4	Not identifiable in essay	Mention one theory from class but does not clearly incorporate it into the analysis	Mention one or more theory(s) from class but connection to the analysis is weak	Explain relevant theory(s) from class and incorporates it into the analysis	Explain relevant theory(s) from class and incorporates it into the analysis, using the theory to explain or question judgment
	Points of View	4	4	Not identifiable in essay	Specific position (perspective, thesis/hypothesis) is stated, but is simplistic and obvious.	Specific position (perspective, thesis/hypothesis) acknowledges different sides of an issue but does not evaluate them in depth.	Specific position (perspective, thesis / hypothesis) discusses complexities of issues. Limitations of position (perspective, thesis/hypothesis) are acknowledged.	Specific position (perspective, thesis / hypothesis) is imaginative, discusses complexities of issues Limitations of position/perspective, thesis / hypothesis are acknowledged. Others' points of view are acknowledged within position (perspective, thesis / hypothesis).
	Assumptions	4	4	Not identifiable in essay	Shows an emerging awareness of present assumptions (sometimes labels assertions as assumptions).	Questions some assumptions. Identifies several relevant contexts when presenting a position. May be more aware of others' assumptions than own (or vice versa).	Identifies own and others' assumptions and several relevant contexts when presenting a position.	Thoroughly (systematically and methodically) analyzes own and others' assumptions and carefully evaluates the relevance of contexts when presenting a position.
	Inferences	4	4	Not identifiable in essay	Information is taken from source(s) without any interpretation or evaluation.	Information is taken from source(s) with some interpretation /evaluation, but not enough to develop a coherent analysis.	Information is taken from source(s) with enough interpretation/evaluation to develop a coherent analysis.	Information is taken from source(s) with enough interpretation/evaluation to develop a comprehensive analysis.
	Implications	4	4	Not identifiable in essay	Conclusion is inconsistently tied to some of the information discussed; related outcomes (consequences and implications) are oversimplified.	Conclusion is logically tied to information (because information is chosen to fit the desired conclusion); some related outcomes (consequences and implications) are identified.	Conclusion is logically tied to a range of information, including opposing viewpoints; related outcomes (consequences and implications) are identified clearly.	Conclusions and related outcomes (consequences and implications) are logical and reflect student's informed evaluation and ability to place evidence and perspectives discussed in priority order.

				Missing 0	Needs Improvement 1	Adequate 2	Good 3	Excellent 4
Intellectual Standards	Clarity	4	4	Not identifiable in essay	Reasoning is unclear, illogical, and leaves the reader confused	.Reasoning is vague.	Reasoning seems sound, but could use more elaboration and details	Reasoning is clear, presented well, enough elaboration and details or examples
	Accuracy	4	4	Not identifiable in essay	Reasoning is flawed and lacks reliable sources	Reasoning is accurate though does not add anything beyond information learned in class, and lacks reliable sources, uses hearsay as fact	Reasoning is accurate though does not add anything beyond information learned in class, and used reliable sources	Reasoning is accurate, in accordance with engineering theory, and used reliable sources
	Precision	4	4	Not identifiable in essay	Flounders across a range of topics or ideas that are not connected	Flounders across topics, but also includes specific details	Specific but could use more details or at a level that is inappropriate for the audience	Specific and with enough details, appropriate for the audience
	Relevance	4	4	Not identifiable in essay	Reasoning is irrelevant to the purpose of the paper	Reasoning is partially in line with the purpose of the essay but includes some irrelevant topics	Reasoning was in line with the purpose of the essay. Author refrains from discussing irrelevant topics	Reasoning was focused, direct, and in line with the purpose of the essay. Author refrains from discussing irrelevant topics
	Depth	3	4	Not identifiable in essay	Did not include details about the topics	Incorporated detail about the topic under investigation but was vague	Incorporated detail about the topic under investigation but was way too much	Incorporated enough detail about the topic under investigation as appropriate
	Breadth	3	4	Not identifiable in essay	Did not include related topics	Mentioned tangential topics vaguely	Incorporated tangential topics inappropriately with too much information given to them	Incorporated tangential topics as appropriate
	Logic / Significance	4	4	Not identifiable in essay	Mentions only the factor that fits with the authors point of view	Discusses a few factors, but miss some significant ones	Discusses a plethora of factors, but are not the main ones	Discussed the most significant factors
	Fairness	4	4	Not identifiable in essay	Unfairly represents others viewpoints,	Only considers your own interest in the matter	Represents the viewpoints of others, considers your others interest in the matter	Sympathetically represents the viewpoints of others, considers your own an others interests in the matter

APPENDIX B: Summer and Fall 2016, Summer 2017

Summer 2016- Critical Thinking Rubric based on Skills

Name	Critical Thinking Essay		
Description			
Rubric Detail			
	Levels of Achievement		
Criteria	**Well done!**	**Adequate**	**Inadequate**
Intro_Interpretation	**2 Points** States the purpose of the writing, the question being asked, and your point of view completely.	**1 Points** Minor Error	**0 Points** Major error
Body_Analysis and Inference	**2 Points** Uses relevant information and researched topics of an appropriate breadth and depth. Inferences follow logically from premises and are supported by theory or concepts from class.	**1 Points** Minor Error	**0 Points** Major error
Body_Evaluation	**2 Points** Investigates the accuracy and fairness of perspectives of the source of information.	**1 Points** Minor Error	**0 Points** Major error
Body_Self regulation	**2 Points** Discusses the limitations of the argument including precision and significance of the information used to inform your decision. Discuss any assumptions you made.	**1 Points** Minor Error	**0 Points** Major error
Conclusions_Explain	**2 Points** Clearly communicates implications of your reasoning.	**1 Points** Minor Error	**0 Points** Major error
Overall quality	**5 Points** Well done! Addresses all essay requirements	**3 Points** Did not address all aspects of the essay.	**0 Points** Major error

Fall 2016 and Summer 2017- Critical Thinking Rubric based on Skills with GAIN scale

Critical Thinking Rubric					
Criteria	**Ratings**				**Pts**
Explain the answer the purpose/question with clarity	3.0 pts Great	2.0 pts Adequate	1.0 pts Insufficient	0.0 pts No Marks	3.0 pts
Analyze the information compared to relevant theory/concepts ensuring accuracy, precision, and relevance	3.0 pts Great	2.0 pts Adequate	1.0 pts Insufficient	0.0 pts No Marks	3.0 pts
Make inferences regarding alternative soluutions: examining the question with enough breath and depth	3.0 pts Great	2.0 pts Adequate	1.0 pts Insufficient	0.0 pts No Marks	3.0 pts
Justify your recommendation: highlight significance of potential implictions and consequences of inaction	3.0 pts Grear	2.0 pts Adequate	1.0 pts Insufficient	0.0 pts No Marks	3.0 pts
Evaluate your recommendation: what are the limitations that may bias your judgement	3.0 pts Great	2.0 pts Adequate	1.0 pts Insufficient	0.0 pts No Marks	3.0 pts
					Total Points: 15.0

APPENDIX C: Critical Thinking PROCESS rubric

Spring 2018

Critical Thinking PROCESS rubric.

Criteria	Ratings				Pts
Present the Point (Purpose/Question): *The introduction sets the stage to describe what you will be writing about. Be clear and precise! (What is the problem and what do you want to do/encourage others to do about it?) State your stance clearly.*	3 pts Good	2 pts Adequate	1 pts Inadequate	0 pts No Marks	3 pts
Represent the model (Point of view/Concepts) *In the body of the essay, introduce the framework you use to form your argument. (What relevant theories/concepts did I use to analyze information?) Ensure the model you choose is relevant.*	3 pts Good	2 pts Adequate	1 pts Inadequate	0 pts No Marks	3 pts
Organize evidence (Information) *Next, present information to support your argument and address any evidence against your argument. (What are the significant facts, costs, benefits?)*	3 pts Good	2 pts Adequate	1 pts Inadequate	0 pts No Marks	3 pts
Calculations and other Considerations (Interpretation and Inferences) *Examine the topic with enough breadth and depth for a thorough analysis. Inferences should logically follow from the evidence. (What are you basing your reasoning on?)*	3 pts Good	2 pts Adequate	1 pts Inadequate	0 pts No Marks	3 pts
Evaluate effect of action/inaction (Implications and Consequences) *Ensure you are using credible information from sources that are reputable and fairminded. Check that your recommendation will not have adverse outcomes for stakeholders. (Have you considered all perspectives and how the action would impact different groups?)*	3 pts Good	2 pts Adequate	1 pts Inadequate	0 pts No Marks	3 pts
State Recommendation (Revisit the purpose) *In the concluding paragraph, reiterate the point of the writing. Justify your recommendation. Highlight significance of potential implications and consequences (What did you attempt to accomplish through this writing?)*	3 pts Good	2 pts Adequate	1 pts Inadequate	0 pts No Marks	3 pts
Self-Regulation (Assumptions / Limitations) *Ensure your argument meets intellectual standards for critical thinking. Address any caveats, indicating your confidence or competence in making this claim. (What are the limitations that may bias your judgment?)*	2 pts Good	1.5 pts Adequate	1 pts Inadequate	0 pts No Marks	2 pts
					Total Points: 20