ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022
Paper ID #37808

Introducing Entrepreneurially-Minded Learning to a New Cohort of Faculty

Anna K. T. Howard (Teaching Professor)

Dr. Anna Howard graduated from Penn State University having worked with the Rotorcraft Center of Excellence there; her research investigated the aeromechanical stability of tiltrotors. She works at NC State as a Teaching Professor researching ways to provide active learning to large numbers of students and investigating the role technology can play in improving student learning and retention. Her newest research focus is on entrepreneurially-minded learning in the classroom with the goal of having NC State become a KEEN partner school.

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Abstract: At NC State University we have begun a new program to imbue the Mechanical Engineering curriculum with Entrepreneurially-Minded Learning (EML). EML has been adopted by a growing number of universities to help faculty and students focus on curiosity, connections between material and the real world, and creating value in their own work for all stakeholders. NC State is new to teaching this mindset around the technical content for our students. This paper will present the process we took to initiate this program, the next steps we plan for it, and a description of the changes made to the courses. More information about the projects will be published on Engineering Unleashed in the coming year.

Introduction:

Some mid-career faculty become "burned out" with low levels of motivation and resources to explore new areas as they are simultaneously overwhelmed with their academic responsibilities in teaching, research, and service in their institution. This two-year subcontract of the Mentorship 360 program at Arizona State University sought to instill a new level of entrepreneurial mindset (EM) into their career journey. Previous schools who have adopted EM into their curriculum have seen enthusiastic adopters among the faculty; we hoped to build this into our faculty at NC State so they could use it in their research and teaching.[1-2] The goal of this particular subcontract was to introduce EM and EML to a small cohort of faculty and students to learn what would work at our university and what needed to be adapted from other KEEN partner schools to work better here. The eventual goal at NC State is to build EML into the curriculum across campus.

The entrepreneurial mindset has been much investigated by the KEEN network (Kern Entrepreneurial Engineering Network). The network is a partnership of more than 50 colleges and universities investigating how the entrepreneurial mindset can be developed in engineering graduates and faculty. EM can be difficult to define exactly: in essence the thought is that the same mindset that functions well for an entrepreneur is also good to have in every engineer. Over the course of its existence the KEEN network has come to define an entrepreneurial mindset as "a collection of mental habits that empower you to question, adapt, and make positive change."[3] This collection of mental habits can be taught so that graduates embrace that the network calls the 3 C's: curiosity, connections between concepts, and creating value.

We hope that students develop an entrepreneurial mindset and grow into their careers in a way that leads them always to be looking to make the world a better place. We want students who can connect one class to another and connect their lived experience with the math. We want students who are enthusiastically curious about everything. The network believes that EM can be taught. Intentionally imbuing the classroom with these 3 C's is called entrepreneurially-minded learning (EML). It is crucial to note that we are not expecting all of our students to go off and create start-up companies. The layman's definition of entrepreneur which involves only business does not even satisfy many entrepreneurs.[4] The employers who hire our graduates want their workers to do more than simply repeat the same steps again and again. We do our students a disservice when we allow them to continue to think that engineering involves no innovation, that “getting the right answer” is what they should be about.

EML is more than active learning or project-based learning; it is beyond just asking students to use design thinking. EML asks students to always keep in mind the bigger picture: engineers also need to have the traits that makes an entrepreneur successful.

Mid-career faculty when they are tenure-track can feel quite lethargic when they finally get tenure, something they’ve been shooting for all through their careers. In some cases, the timing of their research has been pointing at that one goal with projects winding down. All faculty (tenure-track or not) can hit the spot where they’ve taught the same course over and over again and feel as if there is nothing new there. We were seeking to find out whether focusing on the entrepreneurial mindset could help faculty reengage with the enthusiasm, to reengage their own curiosity.

We sought to discover whether introducing EM to faculty could encourage faculty to explore a new dimension in their teaching and research in such a way that everyone’s motivation was increased.

Program Description:

The kickoff meeting for this project was in February 2020, less than three weeks before pandemic shutdowns began. Additionally, our original PI Dr. Christine Grant left the university to work at NSF as a program manager for the duration of this subcontract.

During Summer 2020, the remaining co-PI Barbara Smith and Dr. Grant brought in Dr. Anna Howard as a new PI, and we began again. We split the subcontract into two year-long efforts: the first year we focused on tenure-track faculty and their undergraduate research programs. We recruited five mid-career faculty members who had just been promoted with tenure; we provided them seed money, training, and undergraduate researcher help to allow the faculty to try a new avenue of research for the next stage of their career. Faculty and students were provided some training into the entrepreneurial mindset. We assessed the program with student pre- and post-surveys.

During Summer 2021, we pivoted to include teaching in the mentoring recognizing that faculty can also be locked into teaching a certain set of courses a certain way. Each faculty member was provided more training in EM and asked to form a cohort with monthly meetings to bring EM into the curriculum. This paper describes the particulars of this two year journey and a sketch of future work to bring EM into the College of Engineering at NC State. This portion of the subcontract was assessed using faculty interviews. Further assessment using student surveys is ongoing.

Year One:

The pandemic made the summer of 2020 a difficult time to start a new project. We recruited five faculty for our Year One program from around the university. Faculty who had applied for and been accepted into the College of Engineering Mid-Career faculty Award Recipient Program were invited to join this mentoring opportunity. These faculty hailed from Dr. Andrew Grieshop from Civil Engineering, Dr. Kate Saul and Dr. Scott Ferguson from Mechanical Engineering, Dr. Khaled Harfoush from Computer Science, and Dr. Praveen Kholar from the Department of Biological and Agricultural Engineering. Each faculty member recruited an undergraduate researcher to work with them over ten weeks in Fall 2020. Originally the intent was to have these students in the lab; we all expected to be out of our labs only for a few weeks in Spring 2020. As the summer wore on, all the projects were force to pivot to online-only research.

Student projects included improving the video transmitting techniques for 5G, analyzing the wrist for dart throwing motion, absorption of p-cresol in rice husks, modifying a coffee maker to use K-cups, and building a low-cost black carbon sensor. The variety of these projects helped all the students focus on the research methods which were the same for all the projects. Students met with Dr. Howard to learn about literature reviews, citation management software, project statements, abstract writing, preparing a portfolio, etc.. Students also learned about EM and delved into what curiosity, connections, and creating value meant in the research environment. Undergraduate training in EML amounted to approximately 8 hours over the semester in addition to the instruction students received in their technical research.

The program offered mentoring for the faculty as well as for the undergraduates. For the faculty, our communications were online only. Four mini-briefings were offered for faculty. Each mini-briefing started with an email recap of the concept and its application and included curated video content from Engineering Unleashed and additional readings. The mini-briefings focused on curiosity, creating connections, creating value, and mentoring undergraduate researchers.

Results from Year One:

Students were surveyed pre and post experience to gather information about their experience of EM in their undergraduate research. We developed a survey instrument to assess student expectations and student impressions of their experience to see if attitudes had changed. This survey (found in Appendix A) was loosely based on work by Kennedy and the author's prior experience.[5-6] Questions were based around expectations of the research experience and whether they were met, on students' perception of themselves, and on their career plans post graduation.

Our student cohort was made up of four females and one male; ethnic identities provided by the students were two white, one black, and two of Asian descent. They ranged from their second to fifth years in school (aged 19-22) and came from five different majors.

At the beginning of the research experience, students had very different goals, ranging from gaining confidence in research to simply determining if it was fun. Despite not knowing what the research would be like, when asked if they placed "a high value on the role of research in my future career," four of the five agreed or strongly agreed with that statement. We had universal agreement that "Developing research skills is an important part of my career goals." All five students stated an intention to get a masters degree. We concluded before we even began that it would be impossible to show improvement in convincing the students that research was exciting or intriguing and that they should consider advanced degrees.

Likewise, when we asked the students if they expected the research 1) to be challenging and fun, 2) to provide them with faculty mentorship, 3) to help them understand how to do research, and 4) to encourage them to pursue my own interests, 5) to find research enjoyable, or even 6) to have the potential to change the world someday, not one student was indifferent or disagreed.

These were students who all agreed with the statement that “In the past two years I have imagined a new way to do something.” Students were unfamiliar with applying an entrepreneurial mindset to anything other than becoming a small business owner. There was room for improvement in student understanding of using EM outside of entrepreneurship.

There was some room for improvement in student confidence judging from the pre-survey. Two students indicated that they had no confidence in their knowledge of research methods and one was merely indifferent about their knowledge of research methods. Similar lack of confidence existed for the students’ belief in their abilities to do a literature review or discuss research findings. The post-research survey indicated an improvement in student confidence for all of these.

We concluded that the students who were willing to undertake an undergraduate research study in a pandemic were already motivated to do such research and believed it could bring value. These students were limited in their knowledge of research methods and of their mindset to apply EM.

Our post-research experience data was very disappointing. One student disappeared and stopped participating. One student got Covid and then long Covid and was precluded from undertaking any of the research (though she did participate in some of the student mentoring sessions.) Of the three remaining students, one didn’t take the post survey. No real conclusions can be drawn from such a small sample size.

Year Two, Cohort One:

Our proposal for year two continued our work with mid-career faculty and focused more on the classroom than on faculty technical research. We recruited a cohort of seven faculty: 4 tenured faculty, one tenure-track faculty who had already submitted his dossier for tenure, and 2 professional-track faculty. Cohort One faculty regularly taught core mechanical engineering classes ranging from Engineering Statics to Senior Design.

All faculty were offered admission to a Keen faculty training program during 2021. One took the research workshop, one took the leadership workshop, four took the KEEN workshop “Integrating the Curriculum with EM (ICE) 1.0”, and one is scheduled to take ICE 1.0 in summer 2022. Keen workshops are cohort based and include one year worth of coaching. The cohort members were very grateful for the coaches who were very knowledgeable about EM. One clear takeaway from the workshops attended in year two was that longer, more in-depth training was more valuable than the mini-briefings for instilling the entrepreneurial mindset in the faculty.

Seminar speaker Dr. J.-D. Yoder from Ohio Northern University was invited to speak to the entire Mechanical and Aerospace Engineering department and met with the cohort individually. Dr. Yoder emphasized to the cohort that NC State and the Mechanical and Aerospace Engineering Department (MAE) needed to develop our own goals and emphasis to make EML work for us.[7]

Cohort One met once a month for the 2021-2022 academic year to discuss EML to discern what our goals were to be. After the cohort had attended the trainings, one monthly meeting was spent examining the expanded Keen Student Outcomes from Ohio Northern University.[8] This exercise was very useful for our cohort to focus us on what we were already doing and what we needed to add. At the end of this hour, the cohort felt that the biggest missing piece in our curriculum might be encouraging student curiosity and the next biggest problem was explicitly asking students to connect what they were doing in the classroom to the real world. The cohort decided to begin adding EM to the curriculum by using discussions of real-world applications and by adding open-ended (and possibly ill-defined) projects to the classes. Progress toward these goals and sharing from one teacher to another was our primary monthly task.

The cohort decided to focus on adding projects to each class, specifically open-ended design problems where students could apply their curiosity and their ability to make connections between concepts to solve a problem. Additionally, each faculty member agreed to speak to their class about at least one application in the real world from what they were teaching in the classroom. Two of the classes taught by cohort members were during Fall 2021. The remainder were in Spring 2022. Statics was taught in both semesters.

The combined MAE department has more than 1100 students and is the largest department in the College of Engineering at NC State. Instead of the five students impacted during our first year, during year 2, our cohort reached 912 students in their classes in two semesters.

Year Two Classroom EML:

Dr. Howard teaches MAE 206, Engineering Statics. She attended the Keen workshop Integrating the Curriculum with EM (ICE) 1.0 and later ICE 2.0. Dr. Howard has integrated EM into her course as one mini-project and one larger project. The Flying Forces card from Gaudette and Wodin-Schwartz was adapted as described in McCandless and Howard.[9-11] Class time was devoted to characterizing Engineering as the bridge between the real world and the math: students were explicitly told that “Engineering is the bridge between the real world and the equations. It is your job to decide what is important to include and what isn’t. Neglecting to include something could be a disaster. Including too many thing will leave you unable to solve. This is our jobs, to make the right decisions.” Students were assigned homework to help them make connections between courses and between classroom learning objectives. Sample homework problems and information about the open-ended dam project are found in Appendix B.

Dr. Kate Saul teaches MAE 208, Engineering Dynamics. She attended the Keen workshop on Leadership Unleashed and participated in both the first year and second year EM content for this grant. Dr. Saul focused on creating a new project for Dynamics. Students competed in a design competition in which student teams designed devices to launch racquetballs to a variety of targets. The designs were subject to physical constraints and budget limitations, and required a detailed engineering analysis, professional report to foster technical communication skills, and prototype build. Each group of students compared two designs (rotational and linear actuation strategies) for value, effectiveness, and robustness. In addition, students created snapshot videos to explain a concept in Dynamics to a target audience of high school students; these two-minute videos were intended to be engaging and related mechanical engineering to everyday applications. Students chose topics such as kayaking, billiards, and figure skating to illustrate concepts such as velocity, impact, and angular momentum. For her Leadership Unleashed project Dr. Saul has been developing a card describing methods to accelerate institutional adoption of new learning technology, the barriers to adoption, and the stakeholders that must be engaged in the process. This work draws from prior collaboration between Dr. Saul and Dr. Howard to create adaptive learning course materials for Dynamics, Statics, and other mechanics courses and encourage adoption at NC State and partner universities.[12]

Dr. Scott Ferguson teaches Mae 208, Engineering Dynamics. He attended a virtual ICE 1.0 workshop in the summer of 2021. Throughout the course, he has increased the number of discussion points around real engineering systems with a focus on discussing how design tradeoffs can be modeled by the concepts covered in the course. An in-class intervention is planned for the Spring 2022 semester that is informed by the 3C's of the entrepreneurial mindset. Students will explore the impact of varying the wheel size of a car. This project will require that students connect the effect of changing wheel size on the vehicle's technical performance (turning radius, ride handling, etc.) and considering the scope of wheel sizes that are preferred by customers (creating value). Students will also explore how the modifications impact other design decisions related to the vehicle architecture.

Dr. Grace Landon teaches MAE 214, Solid Mechanics. He was set to attend ICE 1.0 but registrations fell through, so he will attend that workshop in Summer 2022. He has focused his interventions in class around real-life aircraft incidents from his time in industry. For example, during discussions about selecting appropriate factors of safety, he relates the story of repeated structural failures in the flight control linkages of a military aircraft caused by deliberate deployment at high speeds to burn fuel (to reduce landing weight). This anecdote reinforces the concept of careful selection of "worst-case" loading scenarios that are outside of intended use, yet still occur. Connecting learning objectives from class to this kind of real-world experience can motivate students to recall the class material more effectively while also reinforcing its practical importance.

Dr. Marie Muller teaches MAE 310, Heat Transfer Fundamentals. After she attended the EML & Student Research workshop, she made two changes to her course. The first was a guest lecture about heat dissipation in batteries from a local engineer. As one of our EM goals, we wanted to help students connect the topics in their classes to their own lives. Every student in our courses understands that battery life is impacted if your phone overheats, so this guest lecture explicitly asked students to connect what they were learning with the heat transfer calculations in class to everyday experiences in their lives. The guest lecture was extremely well received. Students asked many questions during and after the talk. Some students, who were part of a group focused on implementing microgrid solutions based on solar and renewable generation at a local level, were put in touch with the guest lecturer to continue the conversation.

Dr. Muller also included a Curiosity Project in her class. She asked students to investigate a piece of their lives related to heat transfer, ranging from coffee makers to water cooling in their cars or anything else that caught their interest. Students created two-minute videos describing how the product worked and how it related to the heat transfer related problems from class. Students were explicitly asked to discuss the users of that technology, the market landscape, and the constraints related to the product. Peer-feedback was requested from the students on every video. Finally the students had to create a slide to propose a solution for improving the technology they considered.

Dr. Chau Tran teaches MAE 315, Dynamics of Machines. After he attended the ICE 1.0, he asked his students to design two vibration applications. The first application is an aircraft landing gear and the second is a dynamic absorber. The learning objective in the aircraft landing gear project was for students to see how a passive control system (spring-damper system) actually reduces vibration. Dr. Tran required that students create three feasible solutions, then proposed one based on the created values such as functional performance, technical feasibility, customer comfort, economic viability, etc. The learning objective in the dynamic absorber was for the students to recognize that vibration can be reduced not only by exchanging as done in project one, but also by adding. This is the connection of the N-degree-of-freedom system to a real world application.

Dr. Cheryl Xu teaches MAE 410, Modern Manufacturing Processes. After she attended the ICE 1.0, she designed a project around different additive manufacturing (AM) processes. She asked the students to do a literature survey regarding new material development, different AM machine capabilities and various application industries, such as aerospace, defense, space explorer, etc. Special focus of this study is on the electrical conductivity of materials and their performance at high temperature. Appropriate additive manufacturing technique for each candidate material is discussed and evaluated. As a hook to encourage student interest in the project, she discussed high temperature electronics in harsh environments using a NASA explorer as an example.

Results and Discussion:

Assessment of mindset is ongoing and difficult: mindset changes tend to be incremental and (we hope) lifelong. This particular subcontract was successful in increasing the understanding of EM in a cohort of faculty who then shared it with almost a thousand. Seven faculty made changes to classes to expressly ask students to create something within the curriculum. In future years we will continue to work with the university Office for Faculty Excellence and the college-level Office for Faculty Advancement to develop ways to assess this program and continue to assess how EM has spread in the ME curriculum.

Several things are very clear: we can reach more students by training the faculty than by training the students explicitly as we touched 5 students in year one and more than 900 in year two. We collaborated with the Friday Institute at NC State to evaluate the experiences of the faculty. A survey was developed and administered as an interview to all seven faculty in Cohort One to ask about the goals of the project and how the faculty felt about EM. One consistent reaction was that the faculty in Cohort One found the entrepreneurial mindset changed the language they were using in the classroom. Five of the seven agreed that the explicit, shared vocabulary around curiosity, connections, and creating value changed their lectures in small ways where faculty pointed out clearly what connections students could make. The open-ended projects from all the classes and the accompanying charge to the students to explore what would make one design better than another helped students see that the engineering tasks went beyond plugging numbers into an equation.

Before Cohort One began its work, more than 300 students from the department were surveyed about what they thought about innovation and mindset. These surveys have been repeated with students who experienced one of the interventions listed above. While the results are still being investigated, one stood out: question 11 asked students how much they agreed with the statement, "My classes have an obvious connection to the real world." The number of students agreeing or strongly agreeing with this statement increased by 8% from 72.1% to 80.8%. Overall this project was very successful at introducing EM into one curriculum and introducing EM to the faculty at NC State.

Future Work:

Next year our team at NC State plans to expand to a second year-long cohort. Recruiting is beginning for faculty who would like to join such a cohort. As we did in year two, we plan to provide training to faculty in active and problem-based learning. We plan a joint effort to provide training on campus with facilitators from Engineering Unleashed. Faculty will continue to meet as a cohort once a month. Initially faculty will be recruited from the same department from aerospace faculty as well as mechanical. We will explore whether we can pair up a faculty member from cohort two with one from cohort one as a mentor. After year two, we hope to expand cohort-by-cohort to the entire college of university, building on what we learn to explore larger cohorts or multiple cohorts per year.

We have submitted a proposal to include entrepreneurial mindset into the next Quality Enhancement Plan for the university; if this is accepted, EM and EML will be explicitly highlighted over the next 6-10 years as the university renews its accreditation. We will continue to explore how EML in the classroom can become enmeshed across campus inside and outside of Engineering.

We are also exploring assessment options across a student's career at NC State to determine how many courses incorporating EML are necessary for a student to take before we can show a difference in our graduates. Concept mapping will be used to find out whether students need only one class with EM content or multiple and if so how many.[13] In the future we would like to expand EML content to every engineering student at NC State University.

References:

[1] J. Blake Hylton, D. Mikesell, J.-D. Yoder, and H. LeBlanc, "Working to Instill the Entrepreneurial Mindset Across the Curriculum," Entrepreneurship Education and Pedagogy, vol. 3, no. 1, pp. 86–106, Jan. 2020, doi: 10.1177/2515127419870266.
[2] "Entrepreneurial Mindset | 25 Case Studies." https://em.engineering.asu.edu/ (accessed Mar. 28, 2022).
[3] "Entrepreneurial Mindset | Engineering Unleashed." https://engineeringunleashed.com/mindset (accessed Mar.

28, 2022).
[4] "What Does the Word 'Entrepreneur' Mean to You?," SYR-UMT, Mar. 12, 2015. https://onlinegrad.syracuse.edu/blog/word-entrepreneur-mean/ (accessed Mar. 28, 2022).
[5] M. S. Kennedy, H. L. Cox, and S. K. Lanier, "Board # 71 : Tracking Research Self-Efficacy of Participants in an NSF Research Experience for Undergraduates Site," presented at the 2017 ASEE Annual Conference & Exposition, Jun. 2017.
[6] A. K. T. Howard, Undergraduate Research for Composites in Extreme Environments, Second Year Study," Proceedings of the 2018 ASEE Southeast Section Conference, Daytona Beach, FL, March 4-6, 2018.
[7] J. B. Hylton, D. Mikesell, J.-D. Yoder, and H. LeBlanc, "Working to Instill the Entrepreneurial Mindset Across the Curriculum," Entrepreneurship Educ. and Pedagogy, vol. 3, no. 1, pp. 86–106, Sep. 2019.
[8] "Expanded KEEN Student Outcomes (aka e-KSOs) | Engineering Unleashed." https://engineeringunleashed.com/card/618 (accessed Feb. 14, 2022).
[9] G. Gaudette and S. Sarah Wodin-Schwartz, "Flying Forces: Adding Lift to Statics | Engineering Unleashed." https://engineeringunleashed.com/card/2270 (accessed Feb. 14, 2022).
[10] B. A. McCandless, A. K. T. Howard, "Adapting Entrepreneurial Mindset Projects for Large Classes" Proceedings of the 2022 ASEE Southeast Section Conference, Charleston, SC, March 13-15, 2022.
[11] N. Patil, A. K. T. Howard, "Student Projects to Improve Student Proficiency with Three Dimensional Vectors." Proceedings of the 2022 ASEE Southeast Section Conference, Charleston, SC, March 13-15, 2022.
[12] K.R. Saul, A. K. T. Howard, Z. Webster, D. Spencer, "An Adaptive Learning Engineering Mechanics Curricular Sequence." Proceedings of the 2022 American Society for Engineering Education Annual Conference & Exposition, Minneapolis, MN, June 2022.
[13] M. M. Martine, L. X. Mahoney, C. M. Sunbury, J. A. Schneider, C. Hixson, and C. A. Bodnar, "Concept Maps as an Assessment Tool for Evaluating Students' Perception of Entrepreneurial Mind-set," presented at the 2019 ASEE Annual Conference & Exposition, Jun. 2019.

Appendix A: Survey from Year 1

1. I expect this research experience to be challenging and fun.
2. I expect this research experience to provide me with faculty mentorship.
3. I expect this research experience to help me understand how to do research.
4. I expect this research experience to encourage me to pursue my own interests.
5. I expect this research experience to include socialization with students like myself and/or faculty members.
6. I expect this research experience to encourage me to think like an entrepreneur about my research and schooling.
   Please describe any additional expectations that you have in participating in this program.
7. In the past two years I have been involved in a research project.
8. In the past two years I have participated in a Professional Science Conference.
9. In the past two years I have gotten mentoring from someone.
10. In the past two years I have imagined a new way to do something.
11. In the past two years I have imagined myself going into business.
    How long have you been interested in research?
    Why are you interested in doing research?
    What would you say the makes up an entrepreneurial mindset?
12. I am confident in my knowledge of research methods.
13. I am confident in my ability to develop research questions which are interesting and researchable.
14. I am confident in my ability to find research articles.
15. I am confident in my ability to conduct a literature review.
16. I am confident in my ability to discuss research findings.

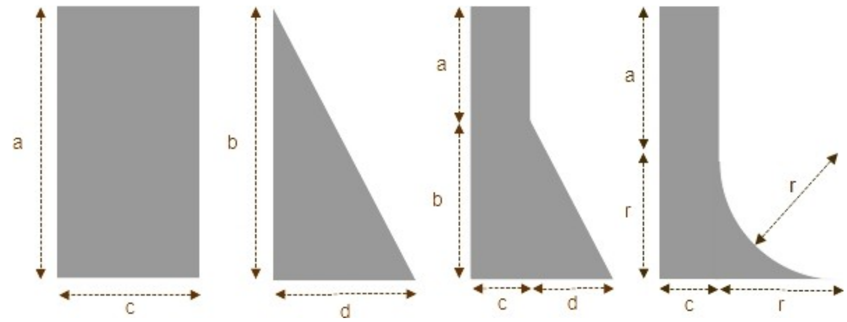
17. I am confident in my ability to work collaboratively with others.
18. I am confident in my ability to work independently.
19. I am confident in my ability to evaluate the quality of a research study.
20. I am confident in my ability to implement new ideas.
21. I think research is enjoyable.
22. I believe what I'm learning could change the world in some way.
23. I believe my ideas are valuable.
24. I have some experience in project management.
25. I can make connections between existing things and new ideas.
26. I am curious about how things relate to each other.
27. I am curious about how my classwork applies to the "real" world.
    Please list your 3 strengths associated with research.
    Please list your 3 weaknesses associated with research.
28. I place a high value on the role of research in my future career.
29. I would be interested in enrolling in more courses related to research.
30. Developing research skills is an important part of my career goals.
31. Developing research skills is an important part of my career goals.
32. I can picture myself innovating in a business.
33. I would be interested in doing research in a university or business setting.
34. I would like to get a patent or two.
35. I would like to obtain a Master's degree in a science field.
36. I would like to obtain a PhD in a science field.
37. I would like a graduate degree not related to science (MBA, Law school, etc.)
38. I am not interested in graduate school.

1. What do you most hope to gain from your participation in this research project?
2. What concerns do you have about participating in this research?
3. Please provide any additional comments, suggestions and concerns you may have regarding this semester.

1. Gender:
2. Age: _______ Years
3. Ethnic Identity: Which of these do you use to describe your ethnic identity? (choose as many as you feel are appropriate)
4. Are you a military veteran?
5. Please indicate the year you will be starting (or continuing in) in fall 2020.
6. What is your academic major?

Appendix B: Example Project from Statics

Statics is a MWF class. The students have one or two homework problems each class day. Homework is completed individually. Throughout the semester, students repeatedly encounter the same shapes in their homework assignments.



On Days 8 and 10, students are asked to calculate when a horizontal force will tip over the dam keeping all the weights equal. On Day 18, the students calculate whether the dams slip or not when height and weight for all four are constant and whether the dams tipped first. On Day 27, students calculate the centroids and area moments of inertia for all four shapes. On Day 30, students calculate the vertical and horizontal force on the dams if there is 21 feet of water on the right-hand side and the dams are 20 feet long (into the page). Students are challenged to consider what would happen if there were 3 feet of mud in addition to the 21 feet of water.

On Day 33 students create their own teams for work with the dam as a team for the remainder of the semester. On Day 34, the team project is assigned. Students are asked to design a dam to hold back 10 feet of silt and 20 feet of water with 5 feet of water on the opposite side. Students were expected to pick between various concretes and show that their dam would not slip or tip. Cost calculations and height calculations were required with a penalty for a dam that was too high (as it irritated the neighbors). Students turned in their projects in three ways: using a Google form which allowed us to check student calculations, as a homework file which included their FBDs and analysis, and as a project report to include reflection, etc. The repetition of the problems help students to connect the different topics in class. The final reflection asks students to comment on what value is created by such a dam.