

How to Make Engineering Programs Worse for Women: A Reverse Brainstorming Session with SWE Students

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Abstract

Female engineering students have unique insights for improving engineering programs and yet they often do not feel empowered to suggest changes. This paper will describe the creation and execution of a pilot brainstorming workshop titled, “How to make engineering programs worse for women” which was developed as part of a master’s level creativity and innovation class for a research practitioner. The pilot was run with a small cohort of eight female engineering students from the local chapter of the Society for Women Engineers (SWE) during engineering week in March 2022. The 2-hour workshop employed three proven creativity techniques including reverse brainstorming, a four-field matrix for evaluation, and enrichment tools for elaboration. The catchy title attracted a small outspoken group of participants that were able to create many negative ideas, a good exercise in divergent thinking. Negative ideas are often easier to come up with than solutions, as our analytical brains limit creative potential. The results of this workshop were two-fold. First, the participants were able to vent their current frustrations and they also were able to practice some creative thinking techniques that might be useful in their careers and personal life. Second, the workshop yielded quite a few implementable ideas ranging from short-term to long-term that are being used to improve the campus experience for female engineering students. To date, the researcher has been able to implement three ideas generated by the workshop participants including a new mid-term course survey, women-led makerspace programming, and registration support for parents. Additional ideas such as priority registration for women and gender pairing of academic advisors are in longer-term discussions. This paper will detail the workshop format and supplementing documents, as well as the ideas generated from the pilot workshop. The research practitioner hopes this brainstorming workshop can be used by other program managers to meaningfully engage with female engineering students, implement rapid change, and improve the learning environment for this underrepresented cohort of students.

Introduction

Despite many research efforts and programs encouraging women into the STEM fields, in most engineering disciplines there hasn’t been much progress for the past twenty years. As of data collected in 2020, women earn only 24% of all undergraduate degrees granted in engineering and make up 16% of the engineering workforce [1]. Female engineering students may hold the key to understanding how to improve engineering programs, but how can administrators unlock these great ideas from current female engineering students? This paper will describe the creation and execution of a pilot brainstorming workshop titled, “How to make engineering programs worse for women” which was developed as part of a master’s level creativity and innovation class for a research practitioner. The pilot was run with a small cohort of eight female engineering students from the local chapter of the Society for Women Engineers (SWE) during engineering week in March 2022. The 2-hour workshop employs three proven creativity techniques including reverse brainstorming, a four-field matrix for evaluation, and enrichment tools for elaboration. There were two main results from this workshop. The creativity techniques yielded quite a few implementable ideas ranging from short-term to long-term that are being used to improve the

campus experience for female engineering students. Second, the workshop provided students with additional creativity tools and techniques applicable in engineering classes as well as their personal life.

Creativity is a much-needed professional skill engineering graduates will need to be successful in the 21st century [2]. There are formalized tools, theories, and processes that can promote creativity and can be utilized as a supplement to engineering education. As Michalko quotes “It (creativity) is not a result of some easily learned magic trick or secret, but a consequence of your intention to be creative and your determination to learn and use creative-thinking strategies” [3, p. 26]. There is a great need to provide engineering students with opportunities to develop creativity. Many researchers fear there is not enough emphasis on creativity in engineering education since creativity is not mandated or evaluated through the accreditation process of ABET [4]. Some recent studies have concluded that engineering students are not developing creativity but lose it during their engineering education [5]-[7]. Additional researchers suggest that engineering curriculums are at fault and do not adequately address creative thinking [8],[9]. This reserve brainstorming workshop provided a practical and personal application for creativity development in the students while also unlocking great ideas to enact change.

Site

The site for the study is a private 4-year technology-focused university in the mid-Atlantic region, Stevens Institute of Technology. The site has a total student population of 4061 students with 60% of the students studying engineering. The School of Engineering & Science has around 200 faculty members, with 20% of these being female faculty. The School of Engineering & Science hosts nine departments and 50 academic programs and maintains a rigorous commitment to preparing the next generation of technology leaders by offering a multi-disciplinary, design-based education.

Development

The researcher was asked by the president of the Stevens Chapter of SWE to participate in Women’s Engineers Week in March 2022 with a presentation or a talk. Due to the creativity classes that were being taken by the researcher, it seemed the perfect opportunity to combine creativity process techniques with practice. The researcher proposed an active workshop that would provide an experience for students to practice and enhance their creative skills while also aiming to solve practical problems for female engineering students.

The researcher chose various tools to usher students through an ideation process that would help generate fresh ideas to enact change on campus for female engineering students. The process started with identifying a need and progressed towards idea generation, evaluation, and then enrichment of a specific idea. The workshop ended with a reflection and an energy and appreciation exercise. The workshop primarily employed negative brainstorming techniques illustrated in *The Idea Agent* [10] and therefore the session was titled ‘How to make engineering programs worse for female engineering students.’

The researcher developed an agenda and workshop documents that included an event flyer, the workshop process, the workshop rules, a positive focus area worksheet, a four-field matrix, an enrichment tool, and instructions for the ten-thousand rose finale. These documents will be discussed in detail, but are also included in Appendix A.

The agenda for the 2-hour workshop is presented below:

- Introduction (Workshop Rules) (10 minutes)
- Positive Focus Area (10 min)
- Negative Focus Area (10 min)
- Negative Idea Generation (15 min)
- Transform into Positive Equivalents (15 min)
- Four Field Matrix (10 min)
- Evaluation of Ideas (15 min)
- Enrichment Tool to Develop Ideas (15 min)
- Reflection on the Process (15 min)
- Ten-thousand Rose Finale (5 min)

The workshop rules were discussed during the introduction. These rules help provide a framework for students and ensure students do not fall into squelching behavior, which can limit creative thinking and brainstorming efforts. The rules were developed based on work by Foursight Consulting [11] which documents practical ways to help promote innovation in the workplace. The workshop rules are listed below:

1. No Squelching – With just one single statement your own creativity or that of another can be destroyed.
2. Take Risks – Give yourself permission to try something new.
3. Write Every Idea Down – Do not self-edit.
4. No Say “no” or “But” – Reframe that with “yes and.”
5. No Analysis – Do not worry about the implementation of ideas.
6. Everyone is an Expert – Everyone gets to speak their mind.
7. Have Fun – Get loud, get animated, move around.

The workshop process document helped students understand how negative brainstorming will be accomplished and how to use the process worksheet. The main premise of negative idea generation is that it is “both easier and more fun to knock down, beat up and backbite than it is to build up” and practically it is easy to implement in any size group [10, p. 117]. In brainstorming, the analytical and practical sides of our brains can limit the creative potential of ideas, but by allowing oneself to go into an imaginative state, new ideas are unlocked. The process worksheet provided students with an opportunity to record all thoughts and ideas, and then share them with the group and build off each other’s ideas.

The four-field matrix is an “extremely common and much-used screening and development tool used to rank the usability of ideas and offers opportunities to enrich ideas” [10, p. 157]. The researcher developed a four-field matrix template to provide participants with the opportunity to apply and practice this evaluation technique. The participants decided on two parameters and two assessment levels for each parameter for the matrix during the workshop. Evaluation is a crucial

step of creative thinking after the initial brainstorming and problem-solving to ensure ideas are original and can be organized in a matter to provide the best solutions going forward [12].

The enrichment tool document asks participants for some basic information about the idea and also provides an opportunity to visualize and quickly sketch the idea. The enrichment tool document has sections where participants document the name of the idea, a brief description of the idea, and indicate why this idea is good. There is a space provided to enable students to draw a picture of the idea, which helps envision what it will look like in practice and an opportunity to communicate the idea to a wider audience. Conceptualization and enrichment of new ideas are important and are akin to agile design and rapid prototyping in innovation [10], [12].

The students were not provided with a formalized worksheet for reflection and instead were given time in the workshop to reflect quietly on the process and encouraged to share their experience with the group. It was noted that in the future, a reflection worksheet would have been helpful for participants. The researcher has included one in Appendix A.

The ten-thousand rose finale activity is based on an energy tool that encourages participants by providing “praise and professional affirmation” of the activities [10, p. 182]. The experience ends on a high note which can encourage and promote future efforts and activities engaging in creativity.

The Workshop

There were eight student participants from a mixture of engineering programs and class years that participated in the two hour workshop. The researcher first started by introducing herself and learning about the group of students that were in attendance. The researcher re-iterated the rules of the workshop and went over the agenda. Due to the size of the group, students were encouraged to first jot down some ideas for each activity and then to share with neighbors seated next to them, and then to share ideas with the whole group. This format provided plenty of opportunities to expand on ideas, while also coming up with one’s own ideas.

During the negative brainstorming portion of the workshop, 48 negative ideas were generated. These were collected by the researcher on a whiteboard after students jotted down notes and ideas on their worksheets. The students had fun venting and complaining about what would make an engineering program worse for women. There was energy in the room and full engagement with the participants. The next step was to use these 48 negative ideas, as inspiration to create positive equivalents to improve engineering programs for women. The students were asked to jot down notes once again on their worksheets and then share them with the group. There were 19 positive ideas co-created by the eight students. After the session, the researcher collected their worksheets and documented the whiteboard collaborative ideas, and a summary is presented in Fig. 1.



Fig. 1. Ideas generated by negative brainstorming workshop.

The next step was for the students to develop and use the four-field matrix evaluation tool to understand and practice an evaluation process. The students were asked to determine what metric parameters and assessment levels they would like to use. The students determined that they wanted to use impact as one parameter, with the assessment levels of high-impact and low-impact. The second parameter the students selected was approval, and the two assessment levels were if something needed official university approval or not. The students started sorting out

ideas on their matrix worksheets and then shared them with the group. This information was then captured by the researcher on another whiteboard. The four-field matrix enabled discussion of existing ideas and the opportunity to co-create new ideas. From the original 48 negative ideas and 19 positive ideas, ten ideas were sorted in the four-field matrix and three ideas were new. The full results can be seen as a summary in Fig. 2. New ideas are indicated by an asterisk.



*INDICATES A NEW IDEA BASED ON THE CONVERSATION OF EVALUATION

Fig. 2. Four-field matrix evaluation tool.

The next worksheet asked students to pick one of their preferred ideas and practice elaboration by using the enrichment worksheet to add more details to the original idea. A sample, Mother of Sons Training, is included below in Fig. 3. This idea stemmed from a negative idea of how their male colleagues seem not to be able to figure out class schedules or even the laundry machine on

their own. The students concluded that moms had an unhealthy relationship with their sons and refused to let them grow up and become autonomous. They shared outrageous stories of mothers driving to campus once a week to do their son's laundry or how a male classmate's mother called a female student to ask about a big presentation they had for class. Fig. 3 below shows a website with information for parents when their first-year students head off to college.



Fig. 3. Enrichment tool example.

The session concluded with a small time for reflection. Students were asked to sit quietly and think about the session and were asked to share any reflections. The students mentioned feelings of empowerment and stated they felt encouraged that some of their ideas were going to be shared with the administration. This ties into research on self-efficacy promoting persistence in the STEM fields [13]-[16]. The closing exercise, the ten-thousand rose finale, was a great opportunity for first- and second-year students to interact with upper-level students and for students to take the time and congratulate one another, sealing in the benefits of the workshop.

Results

The students identified several opportunities for existing improvement in the experience women face in the engineering curriculum. The researcher has implemented three items thus far and has had preliminary discussions about the feasibility and implications of an additional two items.

Mid-course Surveys

The students identified mid-course surveys as an item that would help provide feedback to male professors about unconscious bias and sexism. Mid-semester feedback surveys are often promoted in centers of teaching and learning and are useful tools for improving student learning while providing instructors feedback to make potential changes in response to the feedback. This was a practice that was implemented during Covid-19, with many courses adopting hybrid and online structures but was terminated when the campus fully opened for in-person learning. This idea did take a fair amount of administrative approval; however, it was deemed an important initiative by the undergraduate academic office. The researcher was able to work with the assessment office to pilot a mid-semester survey in Fall 2022, and a full rollout for all engineering undergraduate courses for Spring 2023. The researcher has no specific measurement of impact of this initiative, but, as this is considered a best practice in the industry, the researcher is confident that this effort was valuable.

Women-led Makerspace Workshops

A very simple idea that took a mere e-mail to set up was proposing the idea of women-led makerspace workshops. Women are traditionally underrepresented in makerspaces and do not take advantage of these resources [17]. The Director of the makerspace loved the idea and had a student in mind that would be perfect for running some women-led training sessions. The first workshop was held in November 2022. The impact of this workshop was a write-up on the website and in the student newspaper, with photos from the event. This impact is more subjective and qualitative in nature but has led to two additional workshops held in March and April. These women-led workshops are a great example of something that required very little administrative permission, zero dollars to implement, and has the potential to be highly impactful for female students on campus.

Mother of Sons Training

Another idea that was identified as not needing permission from administration was supporting the Mother of Sons Training. This idea was developed as an extension of the elaboration tool in Fig 3. The students identified they did not want to have to remind their male colleagues about registration and help them sort out their schedules. They were extremely frustrated that they needed to “mother” their male colleagues. The researcher was on a large Zoom Meeting with many representatives from the student affairs department and admissions department to touch base on first-year orientation, when the opportunity arose to implement this idea. There were a few minutes left in the meeting and the researcher mentioned that registration was coming up for the Fall semester and asked if registration information could be sent to parents. It was revealed that there was already a Facebook group for parents to stay connected with news on campus and that student affairs would be able to post information about registration and academic advisor appointments. The goal was to get parents, academic advisors, and students all on the same page during registration and reduce the burden from female students. The admissions and student life departments were extremely happy to collaborate on content to send to parents. Hopefully, this

helped many of our female students from having to “mother” their male colleagues and also helped parents feel connected to the college experience as well.

Priority Registration for Women

The most creative and ingenious idea of the session was the idea of priority registration for women. It came up when women said that if men had priority registration, it would make things worse. The students indicated they would prefer classes with female professors, and priority registration would help them achieve that since only 20% of engineering faculty are female. This is an idea that has not yet been implemented but has yielded some interesting discussions around scheduling and priority registration for female students. Hopefully, in the next few semesters, we might see some engineering design sections that are women-only sections or have reserved seats with female professors for female students.

Gender Pairing of Academic Advisors

Another riff off this idea was thinking about how female students could have more contact with female faculty in a structured way. This led to the idea of pairing entering female students with female faculty members as their faculty advisors. The faculty advisor is typically assigned based on the current major and is a formal mentorship program common throughout higher education. Faculty advisors provide career advice and may also help students understand academic requirements for graduation-specific majors or minors. It is the first professional relationship a student gains when in college, and yet students are not provided the opportunity to choose an advisor at the undergraduate level, they are assigned at the entry to a program. This formalized system has been largely the same for the last 30 years, but in recent years staff positions in academic advising have started to supplement the traditional faculty advising role. These staff members provide guidance on study plans, pre-requisites, and other logistical degree requirements to help facilitate graduation, but often do not develop deep human relationships with students the way a faculty-advisor relationship can develop [18]. A recent study by Gaule and Piacentini [19] found that female Ph.D. students in chemistry paired with female advisors were both more productive and more likely to become faculty themselves. This seems to be an interesting strategy to combat the under-representation of women in science and engineering and break the cycle of attrition of female students. The researcher has plans to pilot the gender pairing of advisors for the Fall 2023 cohort of students.

Limitations

This workshop was a pilot that was performed with only eight students and therefore the results are not generalizable to other schools or programs. The researcher acknowledges that this workshop should be repeated to confirm validity. The researcher also acknowledges that it is very difficult to quantify the impact of these initiatives and is instead providing stories and examples to help others who many serve in similar roles. However, the researcher is very optimistic that this process, of allowing students to tap into their potential by formalized brainstorming, is worth more investigation and warrants repetition. The eight students were able to generate 48 ideas in just under 25 minutes. Faculty, program directors, and other administrators spend many more hours debating how to improve engineering programs in weekly

meeting all semester. In just under two hours, some concrete actionable items were created and implemented in under a year.

Concluding Remarks

Attracting and retaining more female students interested in engineering is an extremely important initiative for the 21st century. There is an increasing need to look more in-depth at female students' existing experiences. This focused approach of brainstorming with underrepresented student groups may help to create a more equitable environment that could yield a more diverse workforce while also providing students an opportunity to practice creative thinking. The pilot workshop hosted by SWE on March 2022 yielded incredibly promising results. The catchy title attracted an outspoken group of participants that were able to create many negative ideas which ultimately yielded a few impactful solutions that will help improve the campus experience for female engineering students.

This experience was a first step in increasing the dialogue with students on campus. This exercise could be replicated with other underrepresented student groups on campus that may not feel heard and would like to feel empowered to brainstorm about potential changes. The format of the workshop enables students to learn creativity techniques and provides the opportunity to practice these techniques. All workshop documents are provided in Appendix A for use.

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NEGATIVE BRAINSTORMING SESSION

HOW TO MAKE ENGINEERING AND
TRADE PROGRAMS WORSE FOR FEMALE
STUDENTS

FACILITATOR: SANDRA CLAVIJO, P.E.



AGENDA

- **INTRODUCTION & GROUP FORMING (10 MIN)**
- **POSITIVE FOCUS AREA (10 MIN)**
- **NEGATIVE FOCUS AREA (10 MIN)**
- **NEGATIVE IDEA GENERATION (15 MIN)**
- **TRANSFORM INTO POSITIVE EQUIVALENTS (15 MIN)**
- **FOUR FIELD MATRIX (10 MIN)**
- **EVALUATION OF IDEAS (15 MIN)**
- **ENRICHMENT TOOL TO DEVELOP IDEAS (15 MIN)**
- **REFLECTION ON PROCESS (15 MIN)**
- **TEN-THOUSAND ROSE FINALE (5 MIN)**



WORKSHOP PROCESS

STEP 1: SET POSITIVE FOCUS AREA

EXAMPLE: HOW CAN WE ENSURE MORE FEMALE STUDENTS JOIN THE ENGINEERING & TRADE PROFESSION

STEP 2: TURN IT NEGATIVE

EXAMPLE: HOW TO MAKE ENGINEERING AND TRADE PROGRAMS WORSE FOR FEMALE STUDENTS

STEP 3: BRAINSTORM:HAVE FUN

GENERATE SOLUTIONS FOR THE NEGATIVE ISSUES - I.E. GET RID OF ALL FEMALE BATHROOMS

STEP 4: REVERSE IT

TAKE THOSE NEGATIVE IDEAS AND TURN THEM INTO POSITIVE EQUIVALENTS

GOALS:

VENT ABOUT CURRENT FRUSTRATIONS
UNLEASH CREATIVE POTENTIAL
EMPOWER YOU TO SOLVE PROBLEMS
TRY SOMETHING NEW
HAVE FUN WITH PEERS



WORKSHOP RULES

1. NO SQUELCHING

WITH JUST ONE SINGLE STATEMENT YOUR OWN CREATIVITY OR THAT OF ANOTHER CAN BE DESTROYED.

2. TAKE RISKS

GIVE YOURSELF PERMISSION TO TRY SOMETHING NEW

3. WRITE EVERY IDEA DOWN

DO NOT SELF-EDIT

4. NO SAYING "NO OR BUT"

REFRAME THAT WITH "YES, AND"

5. NO ANALYSIS

DO NOT WORRY ABOUT IMPLEMENTATION OF IDEAS.

6. EVERYONE IS AN EXPERT

EVERYONE GETS TO SPEAK THEIR MIND

7. HAVE FUN

GET LOUD, GET ANIMATED, MOVE AROUND



1. POSITIVE FOCUS

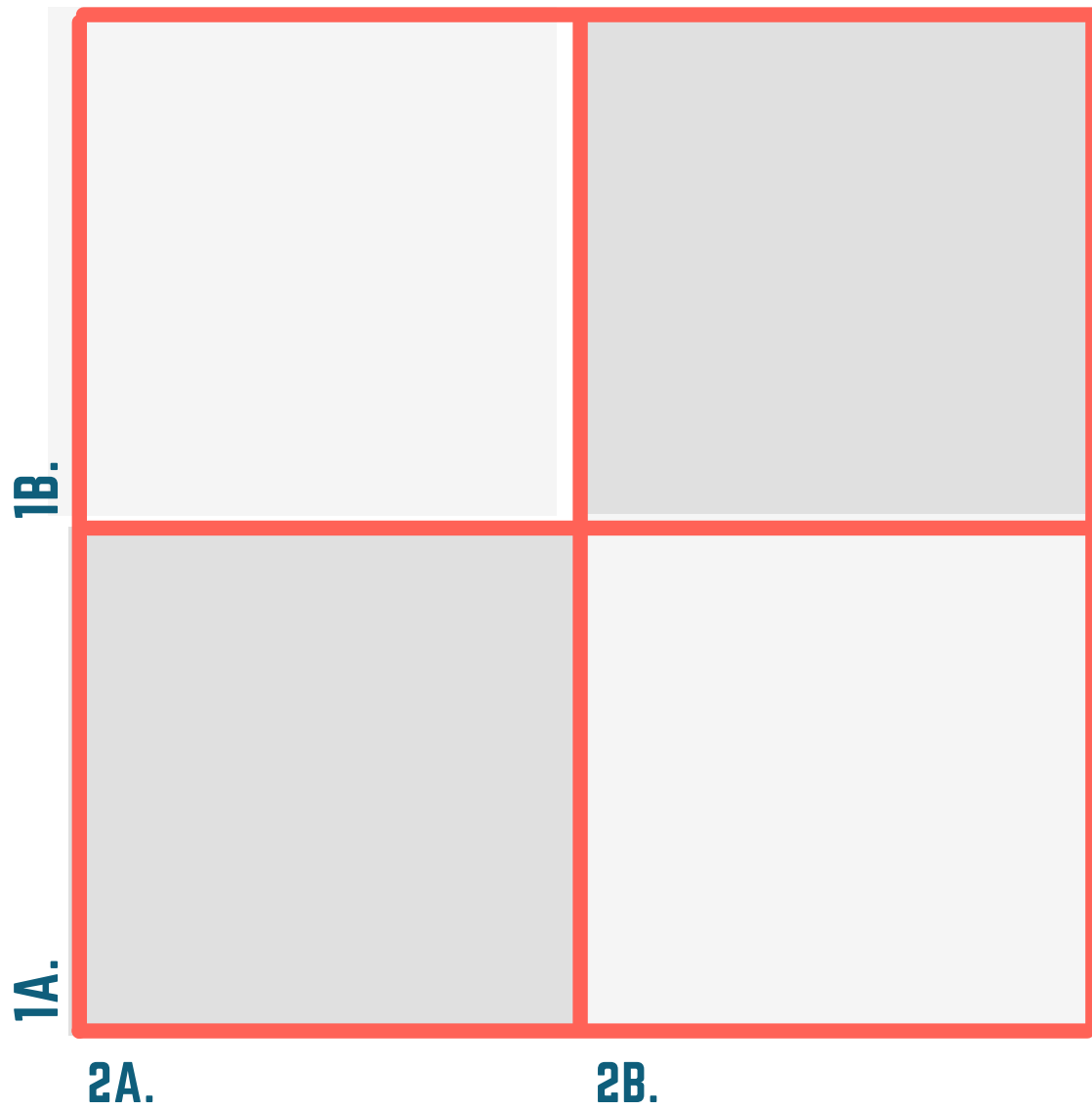
2. NEGATIVE FOCUS

4. POSITIVE IDEAS

3. NEGATIVE IDEAS



**FOUR-FIELD MATRIX - EVALUATION TOOL
USED TO RANK THE USABILITY OF IDEAS**



NAME OF IDEA:

BRIEF DESCRIPTION OF IDEA:

WHY THIS IDEA IS GOOD:

VISUALIZE / SKETCH THE IDEA

END OF WORKSHOP REFLECTION

WHAT WORKED WELL IN THIS WORKSHOP AND WHY?

WHAT DID NOT WORK WELL AND WHY?

WHEN DID YOU FEEL PARTICULARLY ENGAGED? WHAT WERE YOU DOING?

KEY NOTES: