

Reducing the Gender Achievement Gap in Computer Science by Rewarding the Growth Mindset

AYURG | Natural Sciences & Engineering (NSE)

*This cover page is meant to focus your reading of the sample proposal, summarizing important aspects of proposal writing that the author did well, or could have improved. **Review the following sections before reading the sample.** The proposals are also annotated throughout to highlight key elements of the proposal's structure and content.*



Proposal Strengths	Areas for Improvement
Though this proposal tackles a major problem (one too large to fix in a single academic year), the students present a systematic, step-wise approach that takes a reader from the broad issue to the particular doable scope of the project	The end of paragraph 1 does not provide a clear statement about what the project is, this information comes later toward paragraph 3. By the end of the first paragraph, there should be a clear sentence about what the project is, or, in other words, for what are you asking for money?
The students explicitly explain <i>WHY</i> each step of the methodology is being done and <i>HOW</i> that step helps to answer the research question.	In the Background section, evidence is summarized but not interpreted in the context of the project, leaving the reader to “connect the dots” on their own. It is best to make an explicit statement showing why the evidence you present is relevant in supporting your project
The research questions in the proposal clearly relate to the core challenges identified in the background.	The methods section clearly outlines how data will be <i>collected</i> , but it does not include significant indications of how the data will be <i>analyzed</i> . Demonstrating this knowledge is crucial for showing a committee your methods do help you answer the research question
Each group member outlined their unique yet critical role in the project.	The purpose of the survey about colors in Appendix A is unclear



Other Key Features to Take Note Of
This proposal is a group project with 3 people, as such the page limit is 4 pages (2+number of extra people), the budget is \$3000 (\$1000 for each person), and each person outlined their own unique contribution as well as their own unique preparation.
All questions of a survey or interview must be included in appendices, as this proposal does.
Budget should be in an appendix.

As computer programming, or coding, becomes a skill that is seen in almost every industry, people are quickly flooding computer sciences courses in universities and online. Beginning coders face frustration. Computer Science (CS) is a large field, making it difficult to teach every concept. CS also involves combining previously learned concepts to come up with novel solutions, so the answers often times don't exist; they must be created. It is therefore very important to promote learning through failure and comfort with struggling, or a growth mindset.

People who have a growth mindset believe that intelligence can be developed, whereas people who have a fixed mindset believe that intelligence is static. We, Student 1, 2, and 3, believe the initial frustration, in addition to the fixed mindset, increases the barrier to entry in CS, especially for women.

O'Rourke, Dweck, and Good's research has shown that rewarding or promoting a growth mindset in math, another STEM field in which women are underrepresented, has increased user engagement time, users' quality and quantity of problem solving strategies, and users' perseverance when faced with challenge. The growth mindset has also reduced the achievement gap between genders and in general, promoted better learning outcomes. The premise of our research is to build on prior research to promote growth mindsets among novice developers. We seek to do so by adapting the method of rewarding the growth mindset and designing a web based programming environment that rewards effort and good practices with the intention of encouraging users to develop a growth mindset around computer science and seek out new challenges. Writing code in a programming environment is the equivalent to writing an essay in Microsoft Word. A programming environment that promotes the growth mindset doesn't currently publicly exist.

Throughout the next two quarters, we will work with Eleanor O'Rourke to determine how to detect and reward the growth mindset in a programming environment. We predict more students will be excited to take on new challenges if they are rewarded for productive failure through effort, strategy, and progress. We believe that all students would benefit from this product, especially among women who are an underrepresented group in STEM and computer science.

Our work and hypotheses are based off significant research done about the growth mindset, the gender achievement gap in math, and promoting the growth mindset while teaching math. Carol Dweck, a Professor of Psychology at Stanford University, has done extensive research on the growth and fixed mindsets. Through her research, Carol Dweck discovered how the fixed and growth mindsets cause people to react to challenge and effort. A person with a fixed mindset avoids challenge and gives up easily when faced with one because they see the struggle as pointless whereas someone with a growth mindset embraces challenge and sees effort as the path to mastery. Dweck also found that a growth mindset can be learned. Using this knowledge Dweck and O'Rourke, a professor of Computer Science at Northwestern University, hypothesized that promoting a growth mindset could increase excitement about challenge and willingness to put in effort. In an experiment, O'Rourke worked with Dweck to promote the growth mindset with young children learning math. In their research, they built a game called Refraction that taught fractions--and a growth mindset--to children. The game taught a growth mindset by rewarding children for growth mindset behaviors such as productive struggle and trying multiple strategies over just getting the right answer. They did this with "brain points," which were similar to points usually rewarded in a game, but they indicated that the brain was growing stronger. They rewarded brain points for effort, strategy, and progress. They tracked math and move metrics which went into the awarding of brain points as well. They showed that due to the game's brain point reward system, playing this game increased task

Defining key terms without jargon

Students have been de-identified. You would use your own name

Clearly stated research aim

Identify gap in knowledge

Faculty support clear

Should interpret evidence in the context of your project, go beyond summarizing

persistence and adoption of better problem solving processes. Ultimately, they found that the “growth mindset intervention encourages more low performing students to persist for extended periods of time in Refraction,” (O’Rourke 8).

There is a significant gender achievement gap in CS. Girls account for more than half of all Advanced Placement (AP) test-takers, yet boys outnumber girls 4:1 in computer science exams (Women in Computer Science 1). In 2011, women made up just 18 percent of undergraduate computer science majors (Fessenden 1). There is also a gender achievement gap in math (Total Group Profile Report 1). From 2000 to 2013, males consistently scored at least 30 points higher than women on the math section of the SAT. In contrast, the difference in males’ and females’ average scores in the reading section has been no greater than 10 points. Catherine Good, a professor at the Weissman School of Arts and Sciences, built off of Dweck’s research to show that growth mindset interventions improve math scores for males and females but improve the scores of females more. They also greatly reduce the achievement gap between males and females in math (Good 657). The majority of studies have shown that positive attitudes towards CS can greatly influence the success of a student and whether he or she continues in CS (Berdousis 1162). In addition, females have less confidence in their abilities and individual accomplishments than males do, despite the fact that they often perform at the same levels (Berdousis 1162). These attitudes can be attributed to the growth and fixed mindsets, respectively, and may attest to why females’ continued involvement in CS is so low. These are also reasons for underperformance in math, leading us to believe that education incorporated with the growth mindset in CS could have similar effects to those done in the field of math.

Should interpret evidence in the context of your project, go beyond summarizing

We have two main research questions. RQ1: **How can we develop an interface that support students developing a growth mindset by providing useful feedback, embedded within a student's code editing interface?** RQ2: **Will rewarding the growth mindset in computer science increase women’s interest in computer science?** In order to solve these research questions, we need to tackle two sub challenges. TECH RQ: How can we automatically detect user behaviors that signify effortful actions that are conducive to developing a growth mindset in introductory programming? DESIGN RQ: How can we use detected signals of effortful actions to then provide feedback within the user interface that reward effective actions, as in brain points? We plan on working to answer these research questions until the end of spring quarter. Having three researchers will prove very useful because our knowledge supplements each others’ and we will rotate roles both to catch potential mistakes and become more well-rounded researchers.

Research question is clear and broken down, and this breakdown is used in organizing the methods section

To answer our TECH RQ, we will explore how to automatically detect growth mindset behaviors from behavioral data. To do so, we will conduct a study consisting of 20 participants from introduction to computer science classes (EECS 111 and EECS 211). Participants will collect their keystroke data (e.g. mouse movements, clicks, websites visited, etc.) for an hour while they are completing their homework, using existing keystroke data collecting technology. At three intervals, 10 minutes in, 30 minutes in, and after the hour we will ask the students to complete a questionnaire (Appendix C) to determine if they are currently experiencing a growth or fixed mindset. We can use this information as labels in a machine learning algorithm to correlate patterns between the keystroke data and experiencing a growth mindset while coding. As a result, the final product will use keystrokes to identify when users are experiencing a growth or fixed mindset while coding. With their experience in machine learning, Student 1 and Student 3 will be in charge of running this study and analyzing the resulting data.

Description of methods explicitly show HOW they help answer the research question

Lists who participants are AND how they will be recruited.

Insufficient description of analysis

To answer our DESIGN RQ, we will adapt O'Rourke's brain points to a college-age audience. In the Refraction game, growth mindset behaviors were rewarded through brain points that popped up during gameplay. We hypothesize that this will be distracting for users while they are programming, so we want to explore other designs for communicating growth mindset feedback to users. We are incorporating three different elements into our new interface. First is colors. Research has been shown that colors have different psychological effects. We have collected preliminary data on colors from a survey (Appendix A). Our second interface concept is implementing a points system and the third concept is incorporating different levels to complete. To see which options users prefer, we will design two paper prototypes and have eight classmates from our DTR class test both so this part of our research does not require compensation (Appendix B). Because of Student 1's and Student 2's experience with design and running usability studies, they will be able to develop effective paper prototypes and seek unbiased feedback.

After, we will combine our results from answering our TECH RQ and DESIGN RQ by developing a prototype of a programming environment, which is where students write code. We will incorporate our algorithm that determines growth mindset from keystrokes with an effective interface that appeals to college students. Our product will be a web based application to allow easy access and prevent testers from having to download anything. We will therefore need a server on which to host the website. Using their previous website development experience, Student 2 and Student 1 will be in charge of designing to site.

Then, to test our MAIN RQ1, if our programming environment encourages a growth mindset for coding, we will conduct a study similar to that of Professor Eleanor O'Rourke. We will recruit 20 college students from introduction to computer science classes by sending emails to professors and announcing the study after classes. Students will be asked to code on our website for an hour and then after there will be a fifteen minute debrief. We will use two versions of our website, one that just rewards getting the correct answer, the same as current programming environments, and the other that rewards growth mindset behavior. The control group will be coding on the version of the website that rewards getting the right answer. The second group will code on our growth mindset platform (where users are rewarded for their process, which is determined by the machine learning algorithms we mentioned earlier). To see if the growth mindset version is most effective at getting participants to overcome challenge, we will again use the same survey in Appendix A and collect responses ten minutes, thirty minutes, and an hour in. We will compare to see if people's growth mindset increases throughout the hour period when using the growth mindset platform rather than the "fixed" mindset platform. Student 1 and Student 3 will use their experience of running studies to run this study and collect unbiased results.

Finally, once we have iteratively tested our website using the previously described study to ensure it promotes the growth mindset, we will address MAIN RQ2, that rewarding a growth mindset will especially benefit women in computer science. We will run a study targeted towards women to determine if designing a programming environment that encourages the growth mindset increases women's interest in computer science. We will recruit 20 women computer science students from introductory classes to conduct a study where the women will be asked to program for one hour with a fifteen minute debrief after. Similar to the last study, half of the women will be in a control group that will perform a series of coding challenges using the version of our website that rewards getting the right answer and the second half will code on our growth mindset platform. We will give them the survey from Appendix D before they begin coding, and after they finish an hour later. Participants' responses to the survey will indicate

Explains WHY each step is being done and HOW it relates to the research question



Need for "unbiased results" is unclear



whether or not our programming environment that encourages the growth mindset makes women more eager to solve computer science problems. The results from the study will indicate if our programming environment succeeds in developing a growth mindset among women and increasing their desire to pursue computer science. Using her experience with psychology and conducting studies, Student 2 will lead this study and analyze the results.

Insufficient description of analysis

Each Student outlines their own preparation that is relevant for their part of the project

Student 1 is a junior majoring in computer science in McCormick and pursuing the Segal Design certificate. She has experience with user centered interface design. She has interned as a User Experience Intern at the US Patent Office, taken and is currently a TA for EECS 330 (Human Computer Interaction), and worked at the CAMI Visualization lab. During these experiences, she has iteratively built products, conducted user testing and used user interviews, feedback, and observations to build better products. Student 1 has also taken EECS 348 (Artificial Intelligence), EECS 349 (Machine Learning), and EECS 399 (independent web-based machine learning project), so she will be able to lead the building of the Machine Learning algorithms for our project. She has worked on teams at school as well as Boeing and Lockheed Martin to design, build, and ship multiple websites and applications, so she will be able to help code the final website product.

Student 2 is a junior computer science major in McCormick with a minor in psychology. This past summer, she worked as a software engineering intern at Chicago food startup Tovala where she was able to serve as a full-stack software developer as well as sit in on design interviews and design meetings, giving input on design decisions for the final product. She has taken classes in artificial intelligence and human centered product design and has been a TA for EECS 111 (Fundamentals of Computer Programming I) and EECS 330. Due to her studies in psychology and work with students in the beginning stages of learning to code, Student 2 understands how to conduct studies and can do so with an understanding of the user. As a full stack developer at Tovala, Student 2 had experience coding all parts of a website, something we will need to do for our research. Because of her experience in the design meetings and EECS 330, she knows how to do that in a way that makes the final product usable.

Student 3 is a junior pursuing a major in computer science through McCormick and the Segal Design certificate. She has taken artificial intelligence and mobile health classes where she had practice analyzing data and developing appropriate heuristics. This will prove very useful when processing and analyzing the keystroke data of participants to determine when a user has a growth mindset while coding. Additionally, she worked as a usability engineer consultant at UserWise where she led user testing to gather unbiased data on different medical device prototypes. This background will be helpful when testing our prototypes. While working there, she also co-wrote a human factors engineering submission for a class II medical device for FDA approval. Furthermore, over the summer, she was awarded a URG to develop a program to determine the pricing of medical supplies, and as a result she has significant experience with what research entails and writing up final results. With her significant experience with research, Student 3 will be an effective leader of our team through the research process by helping us structure our studies to collect valid data and ensure we can draw conclusions.

Appendix A Color Questionnaire



Unclear what this Questionnaire is used for, explanation should be included in methods section

Colors spectrums: Red, orange, yellow, green, dark green, light blue, dark blue, purple, pink

Total responses: 47

1. Which spectrum makes you feel most motivated?
 - a. Light blue 12 (26%)
 - b. Red 11 (23%)
 - c. Violet 7 (15%)
2. Which spectrum makes you feel most anxious?
 - a. Yellow 13 (28%)
 - b. Red 12 (26%)
 - c. Orange 9 (19%)
3. Which spectrum makes you feel most engaged?
 - a. Light blue 11 (23%)
 - b. Violet 10 (21%)
 - c. Green 8 (17%)
4. Which spectrum makes you feel most confused?
 - a. Yellow 14 (30%)
 - b. Dark green 12 (26%)
 - c. Orange 9 (19%)
5. Which spectrum makes you feel most optimistic?
 - a. Light blue 20 (43%)
 - b. Yellow 14 (30%)
 - c. Violet 6 (13%)
6. Which spectrum makes you feel most unmotivated?
 - a. Dark green 17 (37%)
 - b. Dark blue 10 (22%)
 - c. Orange 7 (15%)

Appendix B Paper Prototype Questionnaire

Coding question 1: Write a program that takes in a deck of cards and sorts it.

Coding question 2: Write a program that squares numbers in an array then multiplies them together in your favorite programming environment.

Participants 1 and 2:

- First 10 minutes: Coding question 1 with points reward system
- Second 10 minutes: Coding question 2 with level reward system

Participants 3 and 4:

- First 10 minutes: Coding question 1 with level reward system
- Second 10 minutes: Coding question 2 with points reward system

Participants 5 and 6:

- First 10 minutes: Coding question 2 with level reward system
- Second 10 minutes: Coding question 1 with points reward system

Participants 7 and 8:

- First 10 minutes: Coding question 2 with points reward system
- Second 10 minutes: Coding question 1 with level reward system

Participants will be rewarded for:

- Making the code modular by declaring multiple functions
- Reviewing previously written comments when stuck
- Writing test cases

Post Coding Questions:

1. The levels reward system made you want to continue programming longer. Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

2. The points reward system made you want to continue programming longer. Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

3. You felt successful when you received points.
Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

4. You felt successful when you moved onto the next level.
Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

5. You felt like you were proud of the quality of code you wrote
Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

Appendix C Carol Dweck Questionnaire

1. You have a certain amount of intelligence, and you can't really do much to change it.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

2. Your intelligence is something about you that you can't change very much. Strongly Agree,

Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

3. No matter who you are, you can significantly change your intelligence level. Strongly Agree,

Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

4. To be honest, you can't really change how intelligent you are.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

5. You can always substantially change how intelligent you are.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

6. You can learn new things, but you can't really change your basic intelligence Strongly Agree,

Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

7. No matter how much intelligence you have, you can always change it quite a bit. Strongly

Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

8. You can change even your basic intelligence level considerably.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

9. You have a certain amount of talent, and you can't really do much to change it. Strongly

Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

10. Your talent in an area is something about you that you can't change very much. Strongly

Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

11. No matter who you are, you can significantly change your level of talent.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

12. To be honest, you can't really change how much talent you have.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

13. You can always substantially change how much talent you have.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

14. You can learn new things, but you can't really change your basic level of talent. Strongly

Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

15. No matter how much talent you have, you can always change it quite a bit.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

16. You can change even your basic level of talent considerably.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

Appendix D: Women's view of computer science (Blouin 103)

1. I am very confident in my ability to program.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

2. I enjoy programming.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

3. Programming is far too complicated for me.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

4. I feel less competent than my classmates at programming.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

5. I get anxious when starting assignments.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

6. I consider myself a more skilled at programming than most of my classmates. Strongly

Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

7. I am good at programming.

Strongly Agree, Agree, Mostly Agree, Mostly Disagree, Disagree, Strongly Disagree

Works Cited

- Berdousis, Ioannis. "Gender Differences and Achievement in Computer Science: A Case Study." *Procedia - Social and Behavioral Sciences*, vol. 191, pp. 1161-1166, <http://www.sciencedirect.com/science/article/pii/S1877042815024933>. Accessed 14 Feb 2017.
- Blouin, Janet Seeley. "High School Seniors' Computer Self-Efficacy and Interest in Computer Science Careers." (2011): 103. University of Georgia, May 2011. Web. 14 Feb. 2017. https://getd.libs.uga.edu/pdfs/blouin_janet_s_201105_edd.pdf.
- Dweck, Carol. *Mindset: The New Psychology of Success*. Random House, 2006.
- Fessenden, Marissa. "What Happened to All the Women in Computer Science?" *Smithsonian*, 2014, <http://www.smithsonianmag.com/smart-news/what-happened-all-women-computer-science-1-180953111/>. Accessed 14 Feb 2017.
- Good, Catherine. "Improving adolescents' standardized test performance: An intervention to reduce the effects of stereotype threat." *Journal of Applied Developmental Psychology*, vol. 24, no. 6, 2003, pp. 645-662, <http://www.sciencedirect.com/science/article/pii/S0193397303001126>. Accessed 14 Feb 2017.
- O'Rourke, Eleanor. "Brain Points: A Growth Mindset Incentive Structure Boosts Persistence in an Educational Game." *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, https://psychology.stanford.edu/sites/all/files/brainpoints_chi.pdf. Accessed 14 Feb 2017.
- "Total Group Profile Report." *College Board*, 2013, <http://media.collegeboard.com/digitalServices/pdf/research/2013/TotalGroup-2013.pdf>. Accessed 14 Feb 2017.
- "Women in Computer Science." *Computer Science*, <http://www.computerscience.org/resources/women-in-computer-science/>. Accessed 14 Feb 2017.

GRANT APPLICATION BUDGET BASICS

A. RESEARCH-RELATED EXPENSES (DATA COLLECTION; ANALYSIS)

TYPE	COST	NOTES
1. Consumable Materials		
2. Non-Consumable Materials		
3. Equipment/Durable Goods		
4. Research Subject Compensation	\$3000	\$20 * 75 experts + \$20 * 75 learners
5. Fees		
6. Transcription Services		
7. Tuition/Mandatory Fees		
8. Instructional Materials		
9. Living Expenses		
10. Other		

B. TRAVEL-RELATED EXPENSES

TYPE	COST	NOTES
1. Airfare (round trip)		
2. Housing		
3. Food		
4. Local Travel Expenses		
5. Other		

C. INTERNATIONAL-RELATED EXPENSES

TYPE	COST	NOTES
1. Entry Visa or Visas		
2. Required Vaccines		
3. Recommended Vaccines		
4. Travel Health Insurance (HTH)		
5. Passport		
6. Other		

GRANT APPLICATION BUDGET BASICS

TOTAL EXPENSES

TYPE	COST	NOTES
Total Research Expenses (A)	\$3000.00	
Total Travel Expenses (B)	\$ 0.00	
Total International Expenses (C)	\$ 0.00	
TOTAL EXPENSES	\$3000.00	

D. POTENTIAL FUNDING

SOURCE	AMOUNT	NOTES
URG Grant	3 * \$1000	For 3 team members
TOTAL FUNDING	\$3000.00	

The amounts in Total Expenses and Total Funding should match.

If you or your family plan on covering the difference between your expenses and the grant amount for which you are applying, add that amount as a source of potential funding (D).