Actualizing Graduate Student Identity, Belonging, and Feelings of Competence in STEM via Personal Story-telling

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1. Introduction

This *work-in-progress, evidence-based practice paper* reports on Year 1 activities of a multi-year, National Science Foundation (NSF) funded research to practice project that aims to develop and assess a storytelling intervention to support science, technology, engineering, and mathematics (STEM) graduate student retention. In academically challenging STEM graduate degree programs, students' lack of professional identity, isolation, and feelings of incompetence (i.e., impostorism) have been shown to catalyze incidents of student drop-out and degree non-completion [1-2].

2. Purpose

To address the pressing challenge of STEM graduate student retention, we explore the use of a workshop-style, personal storytelling intervention to transform graduate student self-beliefs and perceptions about their professional identity, belonging, and personal competence in STEM. We hypothesize that, through writing, sharing, and publicly performing a true personal story about a STEM experience, graduate students can undergo a shift in thinking that fosters their professional identity development, promotes their sense of belonging, and negates the effects of impostorism. In this project, we seek to answer the overarching research question: *"How does development and performance of a personal narrative about experiences in STEM graduate education relate to changes in professional identity, sense of belonging, and feelings of being an impostor?"*

3. Background

Stories have tremendous potential, as research methodology and as teaching pedagogy, to generate deeper and more diverse understandings of experience [3]. Engineering education researchers are gaining recognition for use of narrative as a research tool [4] [see e.g., 5-7]; emerging use of narrative as an instructional strategy in engineering is also noted [4]. Scholars define Narrative Pedagogy (NP) [8], or Story Driven Learning (SDL) [9], as an approach wherein students go beyond reading narratives to write and interpret their own narratives. NP has been implemented in engineering in several ways, including having students write personal and/or creative narratives. Examples of NP personal narrative assignments include writing stories about problem solving [10], giving up technology for a day [10], learning thermodynamics [11], and transformational events [8]. Examples of creative writing assignments include writing science fiction narratives related to emerging technology [10] and narratives of everyday events and their connections to course content (i.e., renewable energy) [12]. Storytelling has been integrated into existing engineering courses to improve teaching and learning efficiency [10, 13] and built as new, required courses for undergraduate students to explore their identities and/or improve their self-concept [9, 11]. To the authors' knowledge, our storytelling workshop format and public performance aspect are novel.

4. Methodology

Our work is grounded in theories of narrative identity [14], reflection [15], and cognitive consistency [16]; our focal outcomes are guided by three basic human needs of Self-determination Theory (SDT): autonomy (identity), relatedness (belongingness), and competence (imposter feelings) [17]. We employ a mixed-methods sequential explanatory design [18] and follow principles of Design-based Research [19-20] with input from multi-institutional/disciplinary faculty, non-profit partners from The Story Collider, and STEM graduate student participants.

In this project, we iteratively develop, evaluate, and refine a storytelling curriculum tailored for STEM graduate students. Each project year, graduate student participants enroll in a one-day (8-hour) collaborative workshop where they are introduced to story craft and practice workbook activities. These activities focus on identifying and developing a personal story related to one of three SDT themes and our focal constructs: discovery of their STEM-related passion (professional identity; autonomy), fitting into STEM graduate education (sense of belonging; relatedness), and relieving personal doubts about their abilities as a STEM professional (impostorism; competence). During the workshop, participants share their emerging stories and listen to others' stories in small groups. After completing, refining, and submitting their drafts after the workshop, at least five participants are invited to perform their stories at a public, live show event. Participants who do not perform live submit in video form and are invited to attend an informal storytelling meetup, where they share stories in an open-mic format with other workshop participants.

Methods. Mixed-methods data, including responses from a tailored pre/post Likert scale survey (quantitative) developed from three existing instruments, the Graduate Engineering Identity scale (7-point Likert scale) [21], Wanton and Cohen's Sense of Belonging scale (5-point Likert scale) [22], and the Clance Impostor Phenomenon instrument (5-point Likert scale) [23]; transcripts of semi-structured interviews (qualitative); and participant-constructed narrative stories (qualitative) are generated using procedures approved by the review boards at both participating institutions. During Year 1, we collaboratively developed and implemented the storytelling intervention with two cohorts of STEM graduate students (approximately 50 graduate students in total) enrolled at the lead institution. Ongoing analyses of survey and interview data provide insights on intervention design, implementation, and impact and support iterative improvement and project assessment.

Quantitative data analysis. Year 1 workshop participants were asked to complete the survey (Appendix A) via the Qualtrics platform one week before the start of the storytelling workshop (Pretest, or Time 0). Participants were asked to complete the survey again within one week after their completion of the overall storytelling assignment, representing our measure of immediate posttest (Posttest, or Time 1). Year 1 quantitative results report on survey data gathered from 38 STEM graduate student participants (36% female, M_{age} = 29.42). Reliability analysis using Cronbach's alpha demonstrated strong internal consistency, with values ranging from 0.81 to 0.95. We conducted paired-samples t-tests to compare participant data from pre- and post-tests.

Qualitative data analysis. Fourteen Year 1 participants engaged in post-workshop, one-on-one virtual (ZOOM) interviews (Appendix B). Interviews were recorded and transcribed in ZOOM, verified and de-identified by a single research team member, and then independently coded by three research team members using inductive qualitative content analysis techniques [24-25]. Consensus was built among the three researchers via three collaborative coding meetings to ensure the reliability and validity of the data analysis. Consensus driven codes were iteratively combined into thematic categories [25] relating to workshop design, implementation, and impact.

5. Results

Quantitative. Results from paired sample t-tests indicate that Year 1 participants experienced slight, yet statistically significant (a) improvements in STEM and researcher identities (expected), (b) declines in social fit (unexpected), and (c) declines in impostorism (expected).

Table 1. Survey Pretest and posttest t-test results across Year 1 participants

Construct	Likert scale	Pretest M(SD)	Posttest M(SD)	*t*(37)
STEM Identity	7-point (4 neutral)	5.78 (1.00)	6.01 (.98)	1.56*
Researcher Identity	7-point (4 neutral)	5.43 (1.14)	5.72 (1.11)	1.83**
Sense of Belonging	5-point (3 neutral)	3.79 (.56)	3.71 (.48)	1.40*
Impostor Phenomenon	5-point (3 neutral)	3.30 (.91)	3.14 (.86)	1.89**

Note: *$p < .10$, ** $p < .05$

Table 1 summarizes t-test results for survey constructs for Year 1 workshop participants.

Qualitative. Thematic categories developed during qualitative analysis of participant interview transcripts included workshop (1) environment and organization, (2) challenges, (3) activities, (4) impacts, and (5) recommendations as presented in Figure 1.

Figure 1. An overview of resultant thematic categories constructed using mindmeister.com

Analysis showed that, despite a welcoming and useful foundation provided by the workshop *environment and organization* overall, participants described encountering *challenges* in most aspects of story development process, including writing, telling/sharing and (especially) performing their personal stories. However, participants largely felt that they could overcome many challenges to developing their stories through participation in *workshop activities* and with more time and practice spent after completion of the workshop.

Participants also described personal, professional, and broader *impacts* of workshop participation (Table 2). Many participants described how the workshop activities required them to look back on and consider their journeys in ways they had not done so before. *Writing* held participants develop professional communication skills and reflect on their personal journeys to find a deeper sense of belonging within the STEM community. Connection and belonging were further strengthened by *listening* to other participants share their stories in small groups, helping them empathize by realizing that they have similar feelings and stories, regardless of differences in gender, nationality, or technical background, as the other workshop participants.

Table 2. Connection of workshop activities to impacts

Workshop activities	Impacts		
	Professional skills (Identity)	**Belonging**	**Impostorism**
Writing	Communication	Reflection, "Therapy"	
Listening	Empathy	Connection	
Telling/Sharing	Communication Empathy	Strengthen connections	Self-Confidence Self-efficacy
Performing (audience)	Public speaking Memorizing Emotional expression		Challenge confidence Substantial gains in confidence if challenges overcome

After these more personal and introspective activities, participants then faced the potential effects of impostorism at two different levels. *Sharing/telling* personal stories in small groups within the safe workshop environment helped participants strengthen their self-confidence and increase their self-efficacy in STEM, which reduced their impostorism. At a higher level, the participants' efforts reached their peak when they performed their stories in public. There, they had to struggle and push themselves to overcome all the difficulties, especially the feeling of being an impostor, to *perform* the story effectively from memory and with adequate emotional expression to receive validation from the audience. Some participants shied away from this opportunity and chose to perform their stories in a private setting with participants or only via video. For some, the idea of story performance led to decreases in self-confidence and further entrenchment of impostorism.

6. Discussion and Conclusion

Overall, preliminary results provide evidence that storytelling as a workshop-style intervention has potential to positively influence STEM graduate students' self-beliefs, helping them to develop a professional skills and identity, connect with the student STEM community, and re-evaluate STEM self-efficacy to fight impostorism. Multi-method findings combine to identify and explain increases in professional identity and skills. While quantitative results showed slight decreases in belonging and social fit, qualitative data highlighted participants' perceptions that workshop interactions (i.e., sharing/telling and listening to others' stories) supported their feelings of belonging. Qualitative results suggested that some students might experience decreases in self-confidence and increases in impostorism during the story performance phase. Qualitative results indicated that participants perceived the performance phase to be the most challenging part of the intervention, partially due to individual personality characteristics (i.e., introversion) and language barriers among international students. Recommendations suggest that some participants would benefit from additional practice and coaching, especially in advance of public performance, and a longer, multi-day workshop. Recommendations also highlight the potential to expand the storytelling program to faculty, undergraduates, non-STEM fields and professional organizations.

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Appendix A

Graduate Engineering Identity scale

Scientist items

Q: To what extent do you disagree or agree with the following statements:

(Recognition Items)

1. I see myself as a SCIENTIST.
2. My department faculty see me as a SCIENTIST.
3. My peers see me as a SCIENTIST.
4. I have had experiences in which I was recognized as a SCIENTIST.
5. I want to be recognized for my contributions to SCIENCE.
6. My advisor(s) see me as a SCIENTIST.
7. Other scientists see me as a SCIENTIST.

(Interest Items)

8. I find satisfaction when learning SCIENCE concepts.
9. I am interested in learning SCIENCE concepts.
10. I enjoy learning SCIENCE.

(Performance/Competence Items)

11. I can overcome setbacks when learning SCIENCE.
12. I am confident that I can understand SCIENCE in class.
13. I am confident that I can understand SCIENCE outside of class.
14. I can perform well when my SCIENCE knowledge is tested (for instance, in exams or defenses).
15. I understand concepts I have studied in SCIENCE.

Researcher items

Q: To what extent do you disagree or agree to the following statements:

(Recognition Items)

1. I see myself as a RESEARCHER.
2. My department faculty see me as a RESEARCHER.
3. My peers see me as a RESEARCHER.
4. I have had experiences in which I was recognized as a RESEARCHER.
5. I want to be recognized for my contributions to RESEARCH.
6. My advisor(s) see me as a RESEARCHER.
7. Other researchers see me as RESEARCHER.

(Interest Items)

8. I find satisfaction when learning about my RESEARCH topic.
9. I am interested in learning more about how to do RESEARCH.
10. I enjoy conducting RESEARCH.

(Performance/Competence Items)

11. I find satisfaction when doing RESEARCH.
12. I can publish RESEARCH results in my field.
13. I can present RESEARCH related topics to relevant audiences.

14. I am confident that I can network with other RESEARCHERS.
15. I understand the concepts needed to analyze and interpret data.
16. I am confident that I can design a RESEARCH study

STEM attitudes

Personal and social implications of STEM
It is important to know science in order to get a good job
It is important to know engineering in order to get a good job
It is important to know digital technologies in order to get a good job
It is important to know mathematics in order to get a good job
Science, technology, engineering, and mathematics make our lives better
Science, technology, engineering, and mathematics are very important in life
Having a job that involves science, mathematics, engineering, or technology would help me to be successful in life
Science, technology, engineering, and mathematics are good for the future of our country
The benefits of science, technology, engineering, and mathematics are greater than any harmful effects that they may have
I would like to have a job that involves science, mathematics, engineering, or technology
To learn engineering, I have to be good at science and mathematics
When something new is discovered, I like to learn about it quickly
Learning of science and engineering and the relationship to STEM
I enjoy learning engineering
I am good at engineering
I am interested in taking more classes that involve engineering
I enjoy learning science
Learning engineering helps me learn science, mathematics, or technology
I am interested in taking more classes that involve science
I am good at science.
Learning science helps me learn mathematics, engineering, or technology.
Learning mathematics helps me learn science, engineering, or technology.
Using technology helps me learn science, mathematics or engineering.
Learning of mathematics and the relationship to STEM
I enjoy learning mathematics.
I am good at mathematics
I am interested in taking more classes that involve mathematics
Learning and use of technology
I am good at using technology
I enjoy learning to use technology
I am interested in taking more classes that involve technology

Sense of Belonging

To what extent do you see yourself as a member of your STEM graduate program?
To what extent do you feel you are a part of your STEM graduate program?
To what extent do you feel a sense of belonging to your STEM graduate program?

Impostor Phenomenon Scale

1. I have often succeeded on a test or task even though I was afraid that I would not do well before I undertook the task.
2. I can give the impression that I'm more competent than I really am.
3. I avoid evaluations if possible and have a dread of others evaluating me.
4. When people praise me for something I've accomplished, I'm afraid I won't be able to live up to their expectations of me in the future.
5. I sometimes think I obtained my present position or gained my present success because I happened to be in the right place at the right time or knew the right people.
6. I'm afraid people important to me may find out that I'm not as capable as they think I am.
7. I tend to remember the incidents in which I have not done my best more than those times I have done my best.
8. I rarely do a project or task as well as I'd like to do it.
9. Sometimes I feel or believe that my success in my life or in my job has been the result of some kind of error.
10. It's hard for me to accept compliments or praise about my intelligence or accomplishments.
11. At times, I feel my success has been due to some kind of luck.
12. I'm disappointed at times in my present accomplishments and think I should have accomplished much more.
13. Sometimes I'm afraid others will discover how much knowledge or ability I really lack.
14. I'm often afraid that I may fail at a new assignment or undertaking even though I generally, do well at what I attempt.
15. When I've succeeded at something and received recognition for my accomplishments, I have doubts that I can keep repeating that success.
16. If I receive a great deal of praise and recognition for something I've accomplished, I tend to discount the importance of what I've done.
17. I often compare my ability to those around me and think they may be more intelligent than I am.
18. I often worry about not succeeding with a project or examination, even though others around me have considerable confidence that I will do well.
19. If I'm going to receive a promotion or gain recognition of some kind, I hesitate to tell others until it is an accomplished fact.
20. I feel bad and discouraged if I'm not "the

Appendix B

Interview Protocol

Thank you for coming to this focus group today. The purpose of this focus group is to better understand your perceptions of the Story Collider workshop you participated in, your overall experience of the workshop, and how it impacted you.

1. Please describe your overall experience of the workshop.
o What did you like about it?
o What didn't you like about it?

2. What was the process of developing your personal story like for you?
o What aspects did you like about it?
o What aspects did you find challenging?

3. We want to better understand how developing your story influenced your view of yourself.
o Do you think it had any impact on how you think of yourself, in general?
o Do you think it had any impact on how you think of yourself, as a grad student?
o Do you think it had any impact on how you think of yourself, as a future STEM professional?

4. We want to better understand the impacts of performing (telling) your story to others.
o What was the experience like, for you?
    What did you like about it?
    What aspects did you find challenging?
o What impact, if any, do you think telling the story to others had on you?
    In terms of how you see yourself?
    In terms of how you think others see you?
    In terms of your communication skills?

5. Would you recommend that others participate in this workshop?
o If so, why? / If not, why not?
o Who, in particular, do you think could benefit from the activities in this workshop?

6. Is there anything else you'd like to share with us about your experience?