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Graduate Researchers as Educators: How Presenting to First-Year Students Sparks Interest in Teaching Careers

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Since 2018, Nathalie Lavoine has been an Assistant Professor in the Department of Forest Biomaterials at NC State University (Raleigh, North Carolina, US). She received her PhD degree in 2013 from the Laboratory of Pulp & Paper Sciences, and Graphic Arts under the supervision of Dr. Julien Bras and Dr. Isabelle Desloges, in Grenoble, France. She then conducted two postdoctoral research experiences under the supervision of Prof. Akira Isogai at the University of Tokyo, Japan (2014-2016) and Prof. Lennart Bergström at Stockholm University, Sweden (2016-2018). Her research activities center on the development and engineering of advanced sustainable materials from biomass, particularly renewable nanomaterials. She has built a research-education integrated platform towards advancing the commercialization of sustainable packaging and renewable nanomaterials and tackle these important research challenges with the help of students, industrial partners, and researchers. This program fosters entrepreneurial thinking to boost outcomes in sustainable advanced materials meanwhile offering career opportunities and professional development support to undergraduate and graduate students. Dr. Lavoine was recently awarded the 2022 TAPPI NanoDivision Mid-Career award and the 2022 Quanser Sustainability award; both awards recognizing her research and education activities in renewable nanomaterials, sustainability and innovation.

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Introduction

Graduate education in engineering often requires graduate students to balance multiple roles that shape their academic and professional identities. Indeed, in addition to developing their research skills, graduate students are often asked to assume teaching and mentorship responsibilities. These responsibilities are seen as opportunities that can significantly contribute to the student's personal and professional growth [1]. However, these roles are sometimes viewed as secondary when compared to their research within the academic environment, reflecting a broader tendency to prioritize the latter over teaching in STEM opportunities/programs [2]. This limitation has been reported to hinder the development of pedagogical skills in graduate students [3], in addition to constraining the graduate students to a narrowed-down audience for research dissemination and growth. Teaching and mentoring opportunities can enhance skill development by engaging cognitive processes that overlap with research, such as hypothesis formulation and data interpretation, encouraging instructors to reframe and deepen their understanding of their scientific domains, directly benefiting their research performance and conceptual clarity [2]. Studies have also demonstrated that engaging graduate students in educator roles can enhance their teaching confidence and communication skills; two critical skills for any career path [4,5].

STEM graduate programs are also rarely equipped with a structured and organized teaching program that graduate students can enroll in during their graduate studies, which is another reason why teaching and mentoring experiences at the graduate level are not highly promoted. While some institutions offer pedagogical training for graduate teaching assistants (GTAs), this training can be inconsistent. The classroom experience from the instructor's perspective is quite different, demanding the development of learning outcomes, lecture preparation, and assessment creation. As a result, several GTAs may still feel underprepared for the full scope of the classroom activities [3]. As a result, graduate students aspiring to academic positions that heavily emphasize teaching are best prepared for research, but lack experience in teaching upon completing their programs [6,7].

Mentorship also plays a crucial role in graduate education, significantly impacting students' academic and professional trajectories. Faculty members provide essential guidance, helping graduate students navigate their chosen disciplines and enhancing their confidence and readiness for teaching roles [8,9]. Effective mentorship not only promotes academic success but also supports the development of teaching competencies, which are increasingly perceived as essential for future faculty members [4,8].

Programs like the "3 Minute Thesis" (3MT) competition have hence emerged as valuable platforms for graduate students to develop concise and clear communication skills essential for conveying complex research ideas to diverse audiences [10,11], in addition to the teaching assistant and mentoring programs offered by the institution. These initiatives underscore the growing importance of effective communication in both academic and professional settings. While

existing programs concentrate on enhancing communication skills and professional development, they lack the ability to assess the impact of these activities on graduate students' research comprehension and their inclination towards careers in engineering education. While existing research has examined the benefits of skill development programs, it has not adequately investigated how presenting to undergraduate audiences may influence graduate students' academic paths, career goals, and engagement with their research. Graduate students would likely benefit from structured teaching and mentoring programs that foster the development of pedagogical and teaching skills through reflective practice.

This work-in-progress paper thus proposes a novel teaching and mentoring training module, the Peer Mentor Major Exploration (PME) module, that offers graduate students additional opportunities to teach and interact with undergraduate students. Through this module, a group of graduate students is allowed to share their academic journey and research work during the introductory part of an undergraduate-level engineering course. The graduate students are trained to deliver a 3MT format presentation for effective and engaging interactions with a class of engineering first-year students. The PME initiative thus aims to foster a collaborative learning environment that benefits both the graduate students and the engineering first-year population. The graduate student-led presentations promote the exposure of first-year engineering students to a large diversity of engineering disciplines and research projects at the [R1 institution] while expanding their knowledge of future career possibilities and research opportunities at the [R1 institution].

Hence, this research aims to assess the success of the PME module in achieving its intended objectives by evaluating its level of influence on graduate student's understanding of their research through the process of presenting it to an undergraduate first-year engineering audience. Additionally, the module explores how structured dissemination of information about distinct engineering majors impacts graduate students' interest in pursuing further certifications, specialization, or degrees in engineering education. The study also examines participants' overall satisfaction with the module, their likelihood of recommending the experience, and their motivation to seek further training in engineering education.

Methodology

Structure of the PME module

Enrolled graduate students (at both the Master's or Doctoral level) at the [institution] with research interests in engineering-related fields were eligible to participate in this program. Participation in this module was voluntary. During the spring and summer terms, information sessions introduced the graduate students to the PME module, including its benefits to their graduate education and the expected level of commitment involved. Graduate students had to receive permission from their research advisors to participate in this module.

An overview of the deliverables and timeline of the PME module is given in Figure 1. The process started with the information session, as described above. The students were then asked to prepare two presentations:

- A 3-minute presentation on their undergraduate degree using one unique slide (with no animation). This presentation aimed to discuss the key learning elements of the selected engineering major, its most interesting courses, and opportunities for professional development and personal experiences.
- A 3-minute presentation on their current graduate research. Graduate students were asked to follow the format and delivery guidelines of 3MT competitions. They had to tailor their presentation for a general, non-expert audience.

Each presentation was followed by a Q&A session with the undergraduate students to enable graduate students to receive feedback on their presentation's clarity, visuals, content quality, and communication skills.

The graduate students were, indeed, asked to present at least twice these two deliverables. They had then the opportunity to implement the obtained feedback and improve their slides for a second round of presentations.

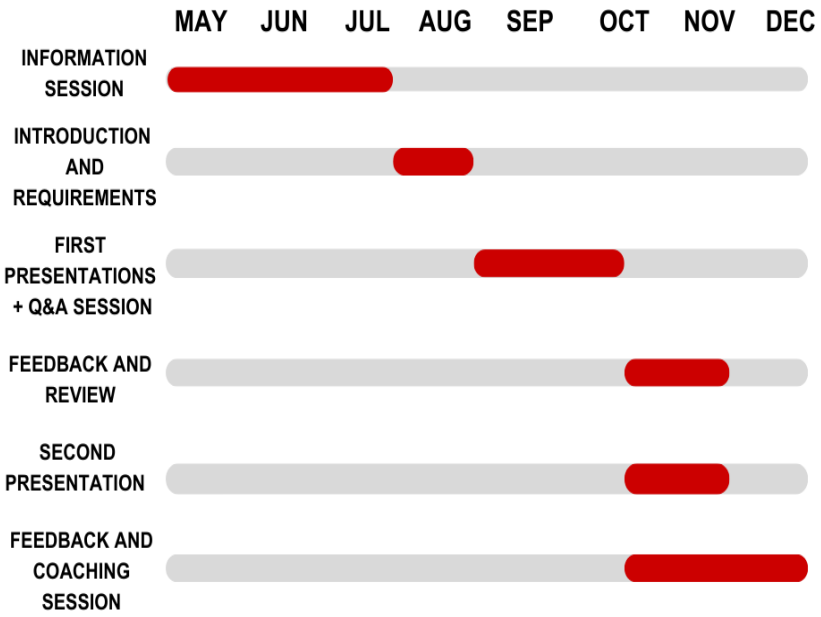

Figure 1. Graphical description of the PME module timeline and structure

Before and after each presentation day, the graduate students were asked to schedule a pre- and post-presentation meeting with two module advisors. The pre-presentation meeting aimed to guide graduate students in the preparation of their presentations and equip them to best interact with an audience of undergraduate students. Students were also allowed to get their slides and talks reviewed. The post-presentation meeting aimed to discuss the received feedback from the undergraduate students, share the recordings of the presentation with the graduate students, and any other general observations on the students' presentations. More importantly, the graduate students had this time allotted to reflect on their experience and receive additional guidance and

support from the advisors.

Implementation of the PME module in the undergraduate engineering curriculum

The PME module was added to the curriculum of an interdisciplinary introductory engineering course at the [R1 institution]. This two-credit-hour hybrid course introduces first-year engineering students to the National Academy of Engineering (NAE) Grand Challenges and explores the relationships between these challenges and the various engineering and computer science degrees offered at the [R1 institution].

The PME module was implemented in five of the 17 sections offered as part of this course. Approximately 70 students were enrolled in each section, so 350 students were exposed to the PME presentations. Three different instructors facilitated the PME module over the fall 2024 semester (first-time offering).

Assessment

The impact and the success of the PME module were evaluated through qualitative and quantitative data gathered from graduate students before and after their participation in the PME module Data collection was conducted under the IRB protocol #27341.

In fall 2024, four graduate students participated in this study. All their responses were collected from the pre-and post-surveys distributed before and after participating in the PME module, respectively. The surveys aimed to assess and monitor any potential changes in the graduate student's level of confidence, perspectives, and interests related to undergraduate teaching.

The pre-PME survey questions focused on the likelihood of graduate students pursuing a career either in research or in teaching, their previous experience with classroom presentations, and their confidence in disseminating their research.

The post-PME survey questions focused on the overall level of satisfaction of graduate students with the PME module, their likelihood of pursuing further training in education and teaching, and the helpfulness of such succinct, but focused presentations in clarifying their research goals [Appendix 1].

Results & Discussion

The results of this study provide insights into the experience of four graduate student participants who engaged in the PME module. These findings highlight key themes related to the impact of teaching and mentoring on research skill development and professional outcomes. The backgrounds of the participants were highly diverse and included Industrial/Mechatronic Engineering, Electrical Engineering, Mechanical & Aerospace Engineering, and Agricultural Engineering. Survey responses were recorded on a five-point scale, ranging from 1 to 5, where 1 signified very low agreement or impact, 2 indicated moderately low agreement or impact, 3 represented a neutral position, 4 reflected moderately high agreement or impact, and 5 denoted high agreement or impact.

Impact of the PME Module on graduate students: confidence, communication, and research clarity

According to **Fig. 2**, participating in the PME module overall increased graduate students' level of confidence in disseminating their research. Participants highlighted significant benefits in learning how to communicate the relevance of their research work to non-experts and emphasized the value of feedback in identifying areas for improvement in their presentations, aligning with the findings of a study conducted by McGoldrick et al. [3]. The data shows, indeed, an increase of 50% in the confidence level after PME.

Regarding the PME module in clarifying students' research interests and goals. Two participants rated the "helpfulness level" highly (rank 5), while the other two rated its helpfulness as neutral (rank 3).

Graduate students who highly ranked the PME Module highlighted the transformative benefits of connecting with undergraduate students and communicating complex research concepts in a more accessible way. One participant shared, "The ability to connect with students and share about all the opportunities my department offers greatly impacted me and hopefully the students." Another noted that "Communicating effectively the relevantness of my research to non-expert in my field was a valuable aspect of the experience". Another participant reflected on how presenting to undergraduate shaped their communication strategies by stating "I believe just giving the presentation to an audience gave me a very good perspective on how I should be communicating to an audience. However, receiving student (and mentor) feedback definitely helped me form a better understanding of aspects of my presentation that could be revised/improved." Additionally, the opportunity to create an engaging learning environment for undergraduate was seen as meaningful, with one participant remarking "I was able to present my research to undergrads and created a learning environment for them."

These results align with the hypothesis that structured outreach opportunities enhance dissemination skills and clarify research interests and goals through preparing and delivering presentations to a non-expert audience [12, 10].

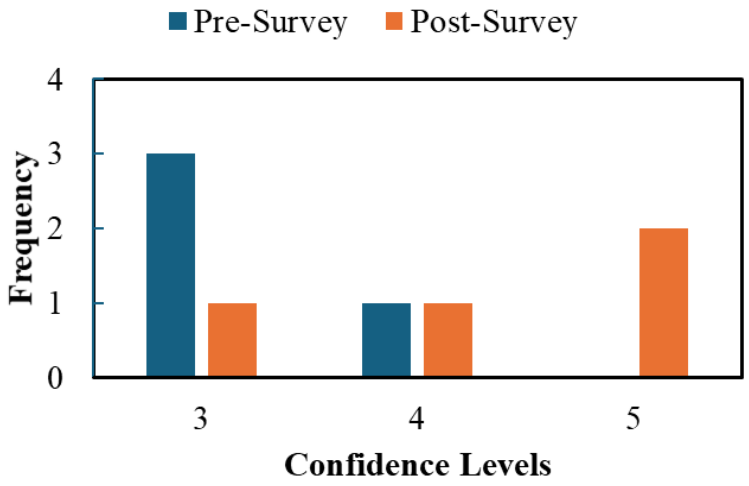

Figure 2. Graduate students' survey responses on their level of confidence in communicating their research topic clearly to an audience.

Impact of the PME module on the perception of graduate students on the complexity of teaching

Figure 3a shows that participating graduate students had initially moderate to high levels (ranks 3-4 out of 5) of comfort in teaching before engaging in the PME module. The post-PME data, however, reveals that graduate students drastically changed their perspectives on t teaching (**Fig. 3b**). The open-ended responses showed that participants grandly underestimated the time and effort that were needed to simplify complex research topics and make them accessible to a general audience.

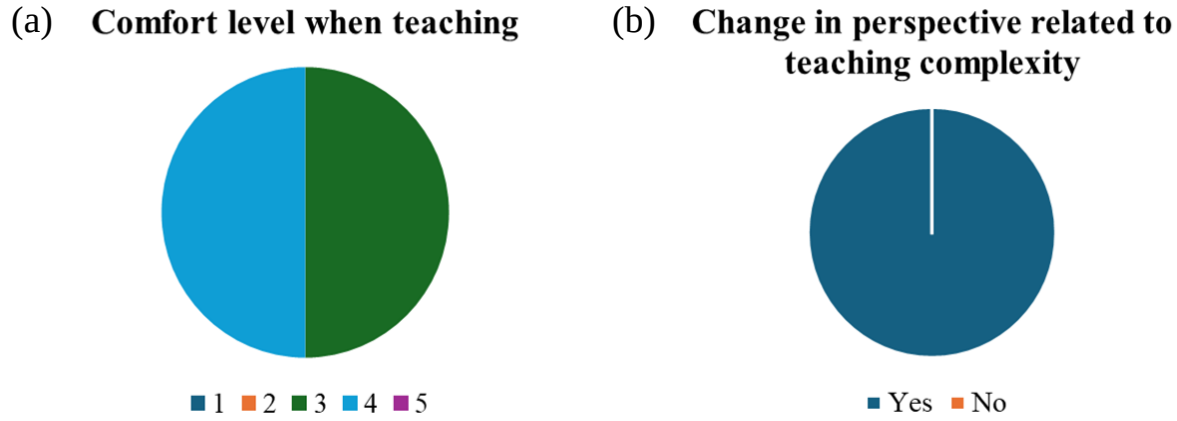

Figure 3. Results from the survey respect (a) overall comfort when teaching and (b) Change in perspective related to teaching complexity after participation in the PME module.

Impact of the PME Module on graduate students' interest in engineering education training

The PME module demonstrated notable shifts in attitudes toward teaching-oriented careers after exposure to the PME module. Before participating in the PME experience, all the participants expressed varying levels of interest in teaching careers (from 2 to 5, **Fig. 4**). Post-survey results, however, show a drastic change in interests: two participants expressed a low interest in additional training in education (rank 2), based on their PME experience, while the other two indicated a moderately high interest in pursuing additional educational opportunities (rank 4).

At this stage, we cannot conclude the reasons why the PME module affected one way or the other the career perspectives of graduate students. More data is needed to validate this split result and understand the *why* behind the observed change.

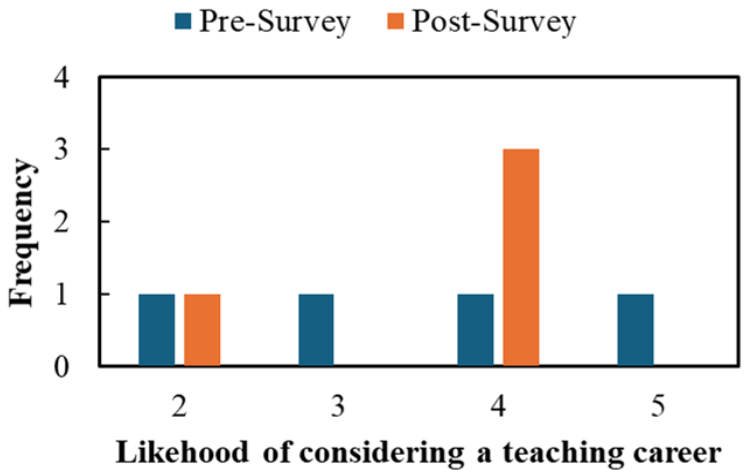

Figure 4. Graduate student's perceptions of the likelihood of pursuing a teaching career before and after the PME module.

Evaluation of the PME module experience from the graduate student perspective

Reduced time commitment opportunities, such as the PME module, offer graduate students impactful ways to practice and enhance their teaching and communication skills while managing their primary research responsibilities.

The overall level of satisfaction among graduate students with their PME experience was high. Post-PME survey results indicated that two participants ranked their satisfaction at 3, while the other two ranked it at 5 (**Fig. 5a**). Participating in PME allowed graduate students to have valuable interactions with undergraduate audiences and effectively communicate intricate research topics to a general audience. These opportunities fostered confidence through structured presentations and feedback from students and mentors, aligning with previous research [1, 5]. When asked about their likelihood of recommending the experience to peers, half of the participants expressed high levels of interest (**Fig. 5b**).

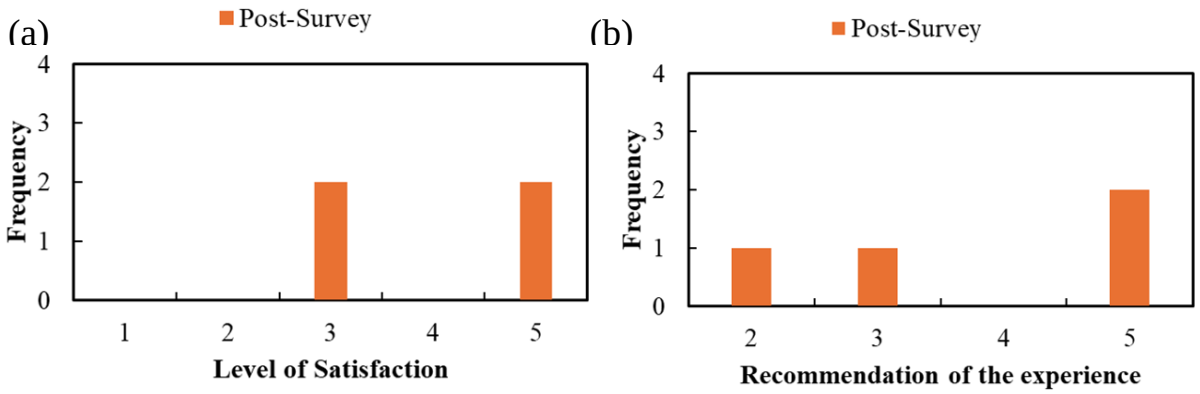

Figure 5. Results from the post-survey for (a) Level of satisfaction with the completion of the PME module, and (b) recommendation for the PME educational module.

Conclusions and future steps

This work-in-progress study highlights the potential of the Peer Mentor Major Exploration (PME) module as an innovative approach to integrating structured teaching and mentoring experiences designed for graduate students to engage with undergraduate students during their first year in an engineering undergraduate program.

The PME module provided graduate students with valuable teaching experiences, which led to improved research communication skills, clearer research goals, and a deeper understanding of the complexities of teaching and learning. Additionally, the module encouraged participants to reflect on their teaching confidence and interest in further educational training. Survey results suggest that while the PME module was successful, some participants may require additional guidance and support to fully benefit from the experience.

While the PME module offered clear benefits, some challenges were associated with its implementation. Without additional incentives (e.g. class credit, economic payment), graduate student involvement is limited. Additionally, further mechanisms of diffusion of this initiative can help foster student interest and their enrollment in this initiative. To further develop this research, the PME module should be expanded to include a larger and more diverse sample of graduate students, which would enhance and diversify survey findings. Further data collection efforts should assess the long-term impact of PME participation on career choices and the pursuit of teaching certifications. Improvements to the PME module, such as enhanced training, advising, and feedback mechanisms, could increase graduate student interest and improve teaching experiences. Gathering a greater amount of perspectives from undergraduate students would also be beneficial in evaluating the perceived benefits and overall impact of the PME program from their perspective.

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Appendix 1: Pre- and Post-Survey Questions

Relevant Pre-Survey Questions:

- How likely are you to consider a research or teaching career after completing your degree:
- Have you given presentations in a classroom setting?
- How would you rank your level of confidence in communicating your research topic clearly to an audience?
- How would you rank your overall comfort level when teaching in a classroom setting?

Relevant Post-Survey Questions:

- How likely are you to consider a research or teaching career after completing your degree:
- Did this experience change your perspective on the complexity of the teaching and learning process?
- How helpful was preparing a presentation to undergraduate students in better clarifying your research interests and goals?
- Based on the experience you had this semester, how likely are you to pursue further training, certificates, or degrees for teaching/education?
- Would you recommend this type of experience to your friends/peers?
- How would you rate your level of satisfaction with the teaching experience you had this semester?