# STEMAmbassadors: Developing Communications, Teamwork and Leadership Skills for Graduate Students

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# STEMAmbassadors: Developing Communications, Teamwork and Leadership Skills for Graduate Students


## Abstract

STEM (science, technology, engineering, mathematics) graduate programs excel at developing students' technical expertise and research skills. The interdisciplinary nature of many STEM research projects means that graduate students often find themselves paired with experts from other fields and asked to work together to solve complex problems. At Michigan State University, the College of Engineering has developed a graduate level course that helps students build professional skills (communications, teamwork, leadership) to enhance their participation in these types of interdisciplinary projects. This semester-long course also includes training on research mentoring, helping students work more effectively with their current faculty mentors and build skills to serve as mentors themselves. Discussions of research ethics are integrated throughout the course, which allows participants to partially fulfill graduate training requirements in the responsible conduct of research. This paper discusses the development of this course, which is based in part on curriculum developed as part of an ongoing training grant from the National Science Foundation. Eighteen graduate students from Engineering and other STEM disciplines completed the course in Spring 2019, and we present data gathered from these participants along with lessons learned and suggestions for institutions interested in adapting these open-source curriculum materials for their own use.


## Introduction

Graduate students in STEM (science, technology, engineering, mathematics) gain a wealth of disciplinary knowledge as well as scientific and technological skills during their programs of study. Yet in order to apply this training effectively graduate students must also develop the professional skills and behaviors that foster success in collaborative, multidisciplinary research and practice [1]–[4]. The need for professional (also called "transferrable" or "soft") skills is not new, and there have been varied efforts to study professional skills development in engineering and science education. Some efforts have explored the impact of directly incorporating or measuring professional skills training in an educational setting [5]–[8]. Other researchers have studied the impact of out-of-classroom experiences on the development of professional and technical skills in engineering students, such as service-learning projects [9]–[12] or internships [13]. The National Academy of Engineering (NAE) has also highlighted the importance of developing both technical and professional skills to ensure success in engineering careers. "Best practices include incorporating multidisciplinary team-based projects into curricula to help students develop skills in decision making, leadership, written and oral communication, organization/time management, cultural awareness, and problem solving." [14]

In 2017, a research team from Michigan State University (MSU) received a training grant from the National Science Foundation to develop a modular, flexible curriculum to deliver professional skills training to scientists and engineers [15]. Approximately 10 hours of curriculum materials were developed to help participants develop their skills in communications,

teamwork and leadership – all within the context of collaborative, multidisciplinary science and engineering projects. This curriculum was integrated into a new graduate-level course in the College of Engineering at MSU in the Spring of 2019: "CMSE 890: Communications, Teamwork, Ethics and Leadership Training for Multidisciplinary Research Teams." This course is a graduate elective designed to equip STEM graduate students with the skills needed to successfully communicate and collaborate within diverse, multidisciplinary research teams. No similar courses exist for STEM graduate students at MSU and the College of Engineering decided to create this class to fill a gap in professional skills training for its graduate students.

**Origins of the Curriculum**

The communication, teamwork and leadership skills training materials used in CMSE 890 were developed as part of an NSF-funded project to develop curriculum to train "CyberAmbassadors" to be leaders in facilitating interdisciplinary research [15]. The original grant focused on training CyberInfrastructure (CI) Professionals, who are experts in using advanced computing technology in support of scientific and engineering research. CI Professionals are often asked to support the work of scientists and engineers who are not computational experts, but need to use high-performance "supercomputers" to support work in their area of expertise. The assistance provided by CI Professionals ranges from brief, routine interactions (e.g., providing access to resources and training) to in-depth, long-term collaborations (e.g., creating new technological tools or contributing to multidisciplinary research projects). The CyberAmbassadors project developed interactive training materials to help CI Professionals build skills in communications, teamwork and leadership in order to more effectively contribute to interdisciplinary research [16].

As part of the original NSF proposal, the CyberAmbassadors development team worked in collaboration with partners from other national training and professional organizations, such as The Carpentries [17]–[19], XSEDE Campus Champions [20], the Center for the Improvement of Mentored Experiences in Research (CIMER) [21], the National Research Mentoring Network (NRMN) [22], and Tau Beta Pi, the Engineering Honor Society [23]. These collaborators helped to recruit participants and host CyberAmbassador trainings; provided access to existing open-source training materials (many previously funded by the NSF and/or the National Institutes of Health/NIH); and offered feedback and advice on adapting the curriculum to address the needs of STEM students and practitioners outside of the original audience of CI Professionals. The result was a robust, flexible curriculum for "STEMAmbassadors" that can be used with participants from any STEM discipline (and that has been recently adapted for non-STEM participants), as well as an additional "train the trainers" program that helps to prepare volunteers to facilitate the CyberAmbassadors training at their own institutions and workplaces [24].

In addition to the training on communications, teamwork and leadership skills provided by the CyberAmbasadors materials, the CMSE 890 course integrates training for research mentors and mentees developed by CIMER and NRMN. The course covers all of the topics in the "Entering Mentoring" curriculum [25], which is designed to help graduate students, postdoctoral scholars and early-career researchers build skills for successfully mentoring research trainees. Topics include effective communications in research settings (e.g., aligning expectations, gathering and reporting data, developing and communicating about research and mentoring philosophies);

helping mentees become independent researchers and make appropriate plans for their future studies and careers; and fostering an environment that values inclusion, diversity and ethical research practices.

Discussions about ethics are woven throughout the CMSE 890 curriculum, in contexts that range from the best practices for handling outlying data in experimental results to the implications of how unconscious biases about gender might impact opportunities for women in STEM. All graduate students at MSU are required to complete a minimum of 6 hours of discussion-based training in the responsible conduct of research (RCR) prior to graduation. Given the emphasis on ethics within this course and the interactive, discussion-based nature of the curriculum, taking CMSE 890 is one way that graduate students are able to fulfill these RCR training requirements.

**Course Description and Learning Goals**

"CMSE 890: Communications, Teamwork, Ethics and Leadership Training for Multidisciplinary Research Teams" is a highly interactive course that meets once a week for 110 minutes (earning 2 credits in MSU's semester-based system). The choice of one longer meeting, rather than several shorter sessions, was purposeful: the topics and activities of this course encourage discussion and engagement, and the longer class allows students to explore in more depth than a traditional 50-minute session would allow. The focus of the course is on in-class small and large group activities, with supplemental reading materials and resources offered for those students who desire to study the topics in more depth. While each individual topic has its own learning goals, the overarching learning goals for the course are that, by the end of the semester, students will be able to:

1. **Use** techniques for effective one-on-one communication
2. **Apply** effective techniques for speaking in public, including group presentations
3. **Demonstrate** methods to effectively organize and lead team interactions
4. **Evaluate** effective and ineffective leadership and mentoring approaches
5. **Evaluate and Discuss** ethical situations with respect to leadership and research

These learning goals for the course, as well as the individual learning goals for each module within the curriculum, are built using Bloom's Taxonomy of Learning [26]. Table 1 summarizes the topics covered in CMSE 890 with an example of how they could be organized within a semester-long course, with weeks 2-10 focused on materials in communications, teamwork and ethics from the CyberAmbassadors program and weeks 11-14 drawn from the Entering Mentoring materials. Since all of these materials are designed to be delivered in modular, stand-alone trainings, it is easy to reorder the course topics or add/delete topics to fit different timelines. The final class session is reserved for a review, course evaluations, and presenting students with the two national certifications they earn by completing this course: (1) certification as a trained CyberAmbassador, with the communication, teamwork and leadership skills to contribute to collaborative, multidisciplinary research and practice in STEM; and (2) certification as a trained Research Mentor through the National Research Mentor Network (NRMN) and the Center for the Improvement of Mentored Experiences in Research (CIMER).

Grading for CMSE 890 is on a numerical basis (4.0 scale with 0.5 increments, where a 4.0 is equivalent to an "A" grade and a 2.0 is equivalent to a "C"). Grades are earned entirely based on participation and engagement, with all students starting at a 4.0 and points deducted if necessary based on significant, unexcused absences or a sustained lack of participation/engagement during class. Since this is an elective, graduate-level class designed for students in STEM (but open to any major), the expectation is that all students will engage in the course activities and earn a 4.0.

**Table 1: Sample Schedule of Topics for a 15-week Semester Offering**

| Week | Topic |
|---|---|
| **1** | Course Overview |
| **2** | Introduction: The CyberAmbassador Program |
| **3** | First Contact: Communicating with Purpose |
| **4** | Let's Talk: Communicating about Problems |
| **5** | It's Complicated: Communicating about Complexity |
| **6** | Teaming Up: Effective Groups and Meetings |
| **7** | Leveling Up: Problem Solving and Decision Making |
| **8** | Effective Presentation Skills (**this module is adapted from [27]) |
| **9** | Leading the Team: Understanding Style and Personality |
| **10** | Leading the Change: Equity and Inclusion |
| **11** | Leading with Principles: Ethics |
| **12** | Mentoring: Aligning Expectations and Maintaining Effective Communications |
| **13** | Mentoring: Promoting Professional Development, Assessing Understanding and Fostering Independence |
| **14** | Mentoring: Mentoring Up |
| **15** | Review, Evaluations and Final Certification |

## Participants

Eighteen graduate students from Michigan State University enrolled in the pilot offering of CMSE 890 in Spring 2019. Several types of evaluation were conducted during the semester, including:

- Pre- and post-test surveys for the CyberAmbassadors training materials
- Post-test survey for the Entering Mentoring training materials
- Post-course survey used routinely to rate classes and instructors at MSU

All of the evaluations were anonymous and optional, with students informed of their rights when participating in research studies associated with the CyberAmbassadors and Entering Mentoring Training. The instructors were not present when the researchers described and administered the evaluations, and the instructors received summary information only after the final grades for the course had been submitted. All 18 students in the course opted to participate in the evaluation processes, and Table 2 summarizes demographic information for the student participants, including their age range; gender; the part of the world where they were educated pre-college (K-12) and as an undergraduate student; their current education level at the time they enrolled in the course; and their work experience. Comparing these results to the 2018-19 demographics of graduate students in the College of Engineering at MSU, the CMSE 890 participants included more male students (87% of participants, versus about 79% of the College); more domestic

students (47% of participants, versus about 35% of the College) and more doctoral students (93% of participants, versus about 74% of the College). The 18 participants came from 5 different engineering majors/departments (out of 8 departments in our College). It is not surprising that 67% of participants were in their first 1-2 years of doctoral study; at MSU these are the years when students are most commonly pursuing coursework requirements, including electives such as CMSE 890.

**Table 2: Demographics for Students in CMSE 890, Spring 2019**

| Demographic | | N | Percentage (%) |
|---|---|---|---|
| Age | 20-24 | 3 | 20 |
| | 25-29 | 5 | 33 |
| | 30-34 | 2 | 13 |
| | 35-39 | 4 | 27 |
| | Missing value | 1 | 7 |
| | | | |
| Gender | Male | 13 | 87 |
| | Female | 2 | 13 |
| | | | |
| Location of Pre-College Education (K-12) | USA | 6 | 40 |
| | Eastern Europe | 2 | 13 |
| | Middle East | 3 | 20 |
| | South Asia | 4 | 27 |
| | | | |
| Location of Undergraduate Education | USA | 7 | 47 |
| | Eastern Europe | 1 | 7 |
| | Middle East | 2 | 13 |
| | South Asia | 3 | 20 |
| | Eastern Europe - Western Asia | 1 | 7 |
| | South Asia - USA | 1 | 7 |
| | | | |
| Educational Level | Current Master's Student | 1 | 7 |
| | Current PhD Student, in first 1-2 years of training | 10 | 67 |
| | Current PhD Student, in 3+ years of training | 3 | 20 |
| | Completed PhD | 1 | 7 |
| | | | |
| Work Experiences | < 1 year | 5 | 33 |
| | 1-2 year | 1 | 7 |
| | 3-5 year | 3 | 20 |
| | 5-10 year | 4 | 27 |
| | 10-15 year | 2 | 13 |
| | | | |
| Prior Training Experience | Yes | 7 | 53 |
| | No | 8 | 46 |

**Evaluation of the CyberAmbassadors Curriculum Pilot Study (CMSE 890, Spring 2019)**

This section summarizes the evaluation results for this pilot offering of CMSE 890 in Spring 2019. The data reported here are part of a larger evaluation effort for the grant itself: each offering of the CyberAmbassadors curriculum is evaluated separately, and then data are later integrated across sessions. This approach allows us to capture data that speaks not only to participant satisfaction, but may also highlight changes over time in learning and behavior as the curriculum is refined and participants complete follow-up surveys. While the data offered here for the 18 participants in CMSE 890 during Spring 2019 is a small sample, over time these data will be aggregated with other participants for a more robust statistical analysis and longitudinal data collections. With that context and those limitations in mind, the remainder of this section describes in more detail this evaluation strategy, how it was implemented in this course, and what we gleaned from analysis of the quantitative and qualitative data.

In the pre-test survey, before students had experienced the CyberAmbassadors training, they were asked about their reasons for participating in the course. The open-ended responses indicated that many students were interested in the materials to be covered in the course; hoped to build their professional or "soft" skills; and were eager to earn certification as a CyberAmbassador and to fulfill RCR training requirements. Several students commented that the course focused on essential skills for building successful careers in science and engineering, and that it was a "breath of fresh air" to spend time in a graduate-level course discussing communications, teamwork, leadership and other professional skills.

In the post-test survey, students were asked about their reactions to the CyberAmbassadors training. More specifically, students were asked to rate how relevant they found each topic to their own lives/work, and how satisfied they were with the content and delivery of each topic. Likert scales were used to gather participants' responses, ranging from 1 (completely irrelevant or very dissatisfied) to 5 (completely relevant or very satisfied). Table 3 summarizes participants' responses as to the relevance of and their satisfaction with the CyberAmbassadors training. It should be noted that these results include only the first (of three) leadership modules in the CyberAmbassadors program as the other two segments were delivered as part of the Entering Mentoring training during the Spring 2019 offering of the course.

**Table 3: Relevance and Satisfaction Results for CyberAmbassadors Training**

| Module | N | Relevance | | Satisfaction | |
|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD |
| First Contact | 18 | 3.44 | 1.042 | 4.17 | 1.043 |
| Let's Talk | 18 | 4.00 | .840 | 4.28 | .958 |
| It's Complicated | 18 | 4.00 | .686 | 4.39 | .850 |
| Teaming Up | 16 | 4.38 | .619 | 4.50 | .516 |
| Leveling Up | 16 | 3.88 | 1.088 | 4.31 | .602 |
| Leading the Team | 16 | 4.25 | .856 | 4.13 | 1.088 |

As illustrated by Table 3, students found the "First Contact: Communicating with a Purpose" module to be less relevant and satisfying than the other two components of the Communications skills section of the course. First Contact offers a brief history of and specific approaches for

managing social and professional networking encounters, such as meeting new individuals at a conference, in a class, or at a social event. Understandably, this seemed somewhat less relevant to student's day-to-day work than the other two topics in the communications section: "Let's Talk: Communicating about Problems" and "It's Complicated: Communicating about Complexity." These two modules introduce methods for addressing and resolving interpersonal problems as well as approaches to manage highly complex communications, such as might be encountered in an academic or research setting. Overall, participants reported strong satisfaction with the three communications modules, and felt they were relevant to their personal and/or professional lives.

In the open-ended responses, students offered a number of suggestions for how the communications modules might be improved or expanded in future offerings. There were several suggestions that the section be expanded, either by adding additional activities or allowing more time for students to explore the materials and content during class activities. Several offered suggestions related to communication in more specific contexts, such as explaining research to individuals from different fields; how to communicate effectively with people who have a different native language or different cultural values; or how to manage regular interactions with people who might be difficult to work with or have caustic/challenging personalities. Another suggestion was to cover more deeply the challenges of communicating when there are different power dynamics within the group, while someone else recommended adding a public speaking module to the course (there was a lesson on individual and group presentation skills, but not specifically on "public speaking").

For the Teamwork and Leadership modules, participants reported high satisfaction levels. "Teaming Up: Effective Groups and Meetings" ranked most highly (averaging 4.5 out of 5.0), followed by "Leveling Up: Problem Solving and Decision Making" (4.31) and "Leading the Team: Understanding Style and Personality" (4.13). The qualitative data (open-ended responses) offers more information to explain these ratings. For example, participants reported that the "Teaming Up" and "Leveling Up" modules were highly relevant to graduate school life and found the examples and activities instructive and realistic. Specific topics that were mentioned as useful included planning and organizing agendas; deciding the length of meetings; and strategies for making decisions and dealing with problems in a meeting. Participants also noted that this module offered practical ways to work effectively within a team, including methods to build relationships and distribute work. They also learned how to identify the strengths of each member in a group and build on this framework to develop an effective team. In the "Leading the Team" module, participants again reported that the topic was useful for their current and future career, and that they valued the introduction to various styles of leadership and the ways that personality may contribute to leadership ability.

Students also recommended a number of additional topics related to communications, teamwork and leadership that might be valuable to include in future offerings of the course. These suggestions included more in-depth discussions of body language (or non-verbal communications) and approaches for communicating effectively with non-native English speakers and/or individuals from different cultural backgrounds. In the context of teamwork, participants wished to learn more about how to maintain respect, handle conflict, handle biases and emotions, as well as personality interactions. With regards to leadership, they were interested

in understanding more about the impact of different leadership styles on the people being led, as well as practical leadership skills like project management, time management, and emotional intelligence (becoming empathetic).

These suggestions are helpful as we think about refining and expanding the curriculum for future audiences and, to us, underscore the value of offering participants opportunities for open ended, qualitative feedback in evaluation. We also interpret the detailed responses as further evidence of students' valuing the curriculum, seeking opportunities for further learning in these areas, and an enthusiasm to engage more around professional development topics like these.

Finally, the post-test survey asked participants to use the same 5-point Likert scale (1=low, 5=high) to rate their overall satisfaction. Participants reported high levels of satisfaction with the overall structure (4.41) and pace (4.41) of the training. Furthermore, the training matched their expectation (4.59), was highly appropriate for their level of experiences (4.59), and participants were very willing to recommend the training to their colleagues (4.4).

As part of the post-test survey, participants in CMSE 890 were asked to consider changes in their knowledge and understanding as a result of the CyberAmbassadors training. Table 4 summarizes the average scores (on a 5-point Likert scale, where 1 is low and 5 is high) for students self-evaluation of their knowledge and understanding before and after the training for key learning goals in each module. Overall, students reported that participating in the training increased their knowledge and understand 1-2 points for each of the key learning goals.

**Evaluation of the Entering Mentoring Curriculum**

CIMER, the Center for the Improvement of Mentored Experiences in Research, currently hosts the evaluation system for the "Entering Mentoring" training program. They conducted a post-test survey of participants in CMSE 890 at the conclusion of the "Entering Mentoring" portion of the course. A unique survey invitation was sent to each participant's email address, and 9 of the 18 students opted to respond. The surveys were anonymous and the raw data is housed at and evaluated by CIMER; a summary report was provided to the course instructors.

The survey instrument for Entering Mentoring asks participants to assess their knowledge, skills and abilities before and after the training (which is similar to the evaluation for CyberAmbassadors). The survey also asks about demographics and experience of the participants. As summarized by Table 5, participants reported gains in all learning goals for each module of the Entering Mentoring curriculum. These results are consistent with the substantial previous research conducted with this training, which show changes in mentors' behavior and improvements in mentees' experiences after completing the Entering Mentoring training [28]–[33].

## Table 4: Learning Evaluation for CyberAmbassadors Curriculum

| Module \| Learning Goal | Before M(SD) | After M(SD) | Difference(M) |
|---|---|---|---|
| **First Contact: Communicating with Purpose** | | | |
| Understanding the parameters of "First Contact" | 2.24(1.200) | 4.06(0.748) | 1.82 |
| Understanding the challenges of balancing independence and involvement | 2.53(0.800) | 3.82(0.809) | 1.29 |
| Understanding the effective communication skills for "First Contact" | 2.82(0.951) | 3.88(0.857) | 1.06 |
| Ability to introduce yourself in the "First Contact" | 3.06(1.088) | 3.82(0.883) | 0.76 |
| **Let's Talk: Communicating about Problems** | | | |
| Understanding the key components of effective communication | 2.88(0.697) | 4.24(0.562) | 1.36 |
| Understanding the difference in "jargon" | 2.88(1.258) | 4.50(0.632) | 1.62 |
| Ability in providing constructive feedback | 3.35(0.702) | 4.12(0.600) | 0.77 |
| Ability to be an active listener | 3.12(0.857) | 4.35(0.606) | 1.23 |
| Ability in identifying and accommodating different communication skills | 3.12(0.928) | 4.00(0.707) | 0.88 |
| Ability to communicate clearly in a variety of context | 3.12(0.993) | 3.83(0.809) | 0.71 |
| **It's Complicated: Communicating about Complexity** | | | |
| Understanding the types of problems in communications | 2.94(0.659) | 4.24(0.664) | 1.30 |
| Understanding the cause of problems in communications | 2.76(0.562) | 4.06(0.748) | 1.30 |
| Ability to communicate problems | 3.06(0.966) | 4.18(0.529) | 1.12 |
| **Teaming Up: Effective Groups and Meetings** | | | |
| Understanding the keys of effective meeting | 2.37(0.719) | 4.19(0.544) | 1.82 |
| Ability in structuring a meeting | 2.56(0.892) | 4.13(0.342) | 1.57 |
| Ability in facilitating a meeting | 2.94(0.994) | 4.31(0.479) | 1.37 |
| Ability to keep meeting on task | 2.81(0.911) | 4.19(0.655) | 1.38 |
| Understanding the science of team formation | 2.81(0.834) | 3.81(0.911) | 1.00 |
| **Leading the Team: Understanding Style and Personality** | | | |
| Understanding various leadership styles | 2.87(1.025) | 4.50(0.632) | 1.63 |
| Understanding various types of STEM leaders | 2.38(0.885) | 4.00(0.894) | 1.62 |
| Awareness of personal "leadership pizza" | 2.13(1.246) | 4.20(1.014) | 2.07 |
| Understanding personality in leadership effectiveness | 3.06(0.772) | 4.06(0.772) | 1.00 |
| Self-personality awareness | 3.44(0.964) | 4.38(0.633) | 0.94 |

## Table 5: Learning Evaluation for Entering Mentoring Curriculum

| Topic \| Learning Goal | Mean BEFORE | Mean AFTER | Diff. |
|---|---|---|---|
| **Aligning Expectations** | | | |
| Working with mentees to set clear expectations of the mentoring relationship | 3.6 | 5.7 | 2.1 |
| Aligning your expectations with your mentees' | 3.8 | 5.8 | 2.0 |
| Considering how personal and professional differences may impact expectations | 3.8 | 5.7 | 1.9 |
| Working with mentees to set research goals | 3.7 | 6 | 2.3 |
| Helping mentees develop strategies to meet goals | 4.3 | 5.9 | 1.6 |
| **Maintaining Effective Communication** | | | |
| Active listening | 4.3 | 5.8 | 1.5 |
| Providing constructive feedback | 4.2 | 5.4 | 1.2 |
| Establishing a relationship based on trust | 4.8 | 5.9 | 1.1 |
| Identifying and accommodating different communication styles | 4.2 | 5.6 | 1.4 |
| Employing strategies to improve communication with mentees | 3.9 | 5.8 | 1.9 |
| Coordinating effectively with your mentees' other mentors | 4.1 | 5.6 | 1.5 |
| **Promoting Professional Development** | | | |
| Helping your mentees network effectively | 4.8 | 5.9 | 1.1 |
| Helping your mentees set career goals | 4.7 | 6.1 | 1.4 |
| Helping your mentees balance work with their personal life | 4.9 | 5.7 | 0.8 |
| Understanding your impact as a role model | 5.3 | 6.2 | 0.9 |
| Helping your mentees acquire resources (e.g. grants, etc.) | 5.0 | 6.1 | 1.1 |
| **Assessing Understanding** | | | |
| Accurately estimating your mentees' level of scientific knowledge | 4.3 | 5.6 | 1.3 |
| Accurately estimating your mentees' ability to conduct research | 4.4 | 5.6 | 1.2 |
| Employing strategies to enhance your mentees' knowledge and abilities | 4.0 | 5.9 | 1.9 |
| **Fostering Independence** | | | |
| Motivating your mentees | 4.9 | 5.9 | 1.0 |
| Building mentees' confidence | 4.8 | 5.9 | 1.1 |
| Stimulating your mentees' creativity | 4.4 | 5.7 | 1.3 |
| Acknowledging your mentees' professional contributions | 5.3 | 6.0 | 0.7 |
| Negotiating a path to professional independence with your mentees | 4.1 | 5.8 | 1.7 |
| **Promoting Mentee Research Self-Efficacy** | | | |
| Defining the sources of self-efficacy | 5.1 | 6.0 | 0.9 |
| Recognizing deficits in mentees' confidence for research | 4.8 | 5.8 | 1.0 |
| Building mentees' confidence for research | 4.9 | 6.1 | 1.2 |
| Employing strategies for building mentees' self-efficacy in research | 4.2 | 5.8 | 1.6 |
| Assessing mentees' confidence for research | 4.9 | 6.0 | 1.1 |
| **Cultivating Ethical Behavior** | | | |
| Articulating ethical issues I need to discuss with my mentee(s) | 5.1 | 6.0 | 0.9 |
| Role modeling ethical behavior | 5.3 | 6.0 | 0.7 |
| Teaching mentees about ethics in research | 5.1 | 5.9 | 0.8 |

## Discussions and Future Work

"CMSE 890: Communications, Teamwork, Ethics and Leadership Training for Multidisciplinary Research Teams" was successfully piloted at MSU during Spring 2019. Students completed pre- and post-course evaluations, which asked about their expectations and reasons for participating in the course at the outset and examined their experiences and learning at the end. Overall, students reported that the course content was highly relevant to their daily work and that they were highly satisfied with the content of all major focus areas (communications, teamwork, leadership, mentoring). Participants also reported that the structure and the pacing of the course were appropriate, and that the experience had met their expectations. The results related to changes in students' knowledge indicate that the course was effective in increasing participants understanding of and ability to employ professional skills for communications, teamwork, leadership and mentoring.

Based on student feedback, a number of refinements were made to the CyberAmbassador curriculum. For example, the structure of CMSE 890 was altered for Spring 2020 so that the CyberAmbassador materials were presented first and the Entering Mentoring materials second. Twenty students from engineering and other STEM majors enrolled in this second offering of the course in Spring 2020, including a few advanced undergraduates who requested to enroll based on recommendations from their mentors or friends.

The NSF-funded CyberAmbassadors project is entering its final year of funding, having served more than 400 participants and trained about 50 facilitators in the last 18 months. Continuity plans were built into the original grant proposal, and we expect that the curriculum will be jointly hosted and managed by MSU, Tau Beta Pi (the Engineering Honors Society) and CIMER (Center for the Improvement of Mentored Experiences in Research) after the funding runs out. The CyberAmbassadors materials are open-source and freely available to interested educators by contacting the PI, Dr. Dirk Colbry (colbrydi@msu.edu). The Entering Mentoring materials are also freely available through CIMER, which provides support for training and evaluating both mentors and mentees.

As the project shifts from curriculum development and pilot testing to sustained implementation, the CyberAmbassadors team is developing follow-up survey instruments in an effort to track the longer-term impacts of this training. A number of the students who enrolled in the course in Spring 2020 reported that they did so at the urging of a classmate from the Spring 2019 cohort. There is also some anecdotal evidence of positive impacts from the training of facilitators – several of whom have been able to integrate these skills in their own workplaces and are noting positive changes in the behaviors of their teams as a result of the CyberAmbassador training. While it may not be possible to isolate the impact of the CyberAmbassadors program itself, our follow up surveys will attempt to assess retention and implementation of the training materials.

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