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Integrative Engineering Leadership Initiative for Teaching Excellence (iELITE)

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Works in Progress: Integrative Engineering Leadership Initiative for Teaching Excellence (iELITE)

Abstract

Beginning in the spring of 2017, a team of engineering faculty, in collaboration with professionals across campus, designed a new teaching and leadership program and successfully offered it as a pilot course for three semesters. Desiring to prepare graduate students for careers in both academia and industry, this program aims to enhance the teaching skills of graduate teaching assistants (GTAs) while simultaneously augmenting their professional skills. The goal is to train the next generation of leaders who will possess technical and academic expertise as well as critical skills such as communication, organization, and relationship building. The team used an integrative approach to design and later modify the course. This paper describes this approach, as well as the results of an investigation into whether the course impacted GTA perceptions of teaching self-efficacy and GTA perceptions of whether teaching skills transfer to other professional contexts.

Introduction

The majority of graduate teaching assistants (GTAs) do not have prior teaching experience when they start their appointments. Although workshops offered by a campus-level teaching center are a quick and efficient way to introduce new GTAs to their roles, follow-up programs are needed to further develop their teaching effectiveness and to train them properly in the specific teaching requirements of their disciplines. Santhanam and Codner reported benefits to tailoring GTA training for particular academic disciplines.[1] Further, Nicklow *et al.* described some specific benefits to discipline-specific GTA training for a Civil Engineering program. Their GTA training resulted in increased motivation among their GTAs to create course-specific educational tools, such as rubrics and learning objectives for laboratory exercises.[2]

Teaching can play a prominent role in the professional development of GTAs. Although nearly half of graduate students will pursue careers outside of academia, a typical PhD program provides little direct training for leadership in a non-academic setting.[3] By learning to teach well, GTAs develop many leadership and communication skills that will transfer well into their future careers. Activities such as organizing and presenting material, working effectively with instructors and fellow GTAs, and communicating effectively with students present an opportunity to develop communication and leadership skills that will be highly valued whether the GTA goes into academia or industry.

For reasons similar to those stated in Nicklow *et al.* and Kenny *et al.*,[2,4] we believed it is valuable to offer pedagogy training beyond the typical two-day, pre-semester training. To maximize the benefits of such training, we chose to format it as a semester-long course for which GTAs would get credit on their transcript.

For the first version of the course, we focused on the design of the program, based on literature and in collaboration with various university education professionals. In the next iteration, we initiated strategic partnerships with various engineering departments, resulting in a dramatic increase in enrollment. We also deepened the connections between teaching skills and leadership skills in the course based on our reflection and feedback from the first version. Our program evaluation uses two surveys: the STEM GTA-Teaching Self-Efficacy Scale[5] and a modified version of Alpay and Walsh's skill-perception inventory.[6]

In this paper, we will describe our collaborative design process, strategic partnerships with various engineering departments, and enhancements of the integrative approach. Additionally, we will discuss students' perceptions of how well the program enhanced their teaching and leadership skills and how much they viewed teaching opportunities as a source of transferable leadership skills.

Program Overview

Our program takes an integrative approach in two ways: 1) incorporating an array of campus resources and 2) integrating both teaching and professional skills for GTAs' professional development. An integrative approach is suggested by literature. For example, Holaday, Weaver, and Nilson[7] suggest that collaborating with campus resources to offer diverse professional development opportunities helps develop the professional skills STEM graduate students will need to be successful in a variety of careers. Porter and Phelps[3] also argue for an integrative program in which doctoral students practice research skills in non-academic settings. However, programs that integrate academic training and professional development are uncommon in the literature. A few examples include teaching training programs that are combined either with professional skills[1,2] or research skills.[8]

We also believe that teaching offers opportunities to enhance transferable skills such as communication skills, interpersonal skills, and problem-solving skills.[9] It is often necessary in professional contexts to convey complex information to diverse audiences as well as to manage diverse teams and projects. Additionally, teachers deal with a host of issues in areas such as oral and written communication, interpersonal communication, and empathy, all of which occur in many other professional settings. It is our assumption that new GTAs may not recognize the ways skills acquired through teaching transfer to other contexts. Further, in an environment where research is valued over teaching, a teaching assignment may be considered to be a diversion from a graduate student's educational objectives.

Collaborative Program Development

As Holaday, Weaver, and Nilson suggest,[7] collaboration from multiple stakeholders and experts across the college and campus are necessary to create a course that serves the needs of the entire College of Engineering. Our team reflects such collaboration among many campus community members: four teaching faculty from four different engineering departments, two members of the College of Engineering's instructional support unit, a graduate student in engineering education, a member of the campus teaching center responsible for the campus-wide training of GTAs, and another member of the campus teaching center offering support for program evaluation. These team members provided a diversity of ideas, backgrounds, and teaching experience. This group not only collaborated on development, but also on implementation and assessment—an important approach that encourages success.[7]

One benefit of collaboration is the formation of a community of practice where course developers from various disciplines support each other's efforts. Such collaborations have been described in the literature, such as O'Neill and McNamara, who describe a collaborative effort to design a modular GTA training course for six unique STEM and health disciplines. Expert representatives of each of these disciplines formed a community of practice and collaboratively designed their modules and course materials. Each expert tailored their modules to the context of their discipline. They later found that the curriculum-centered modules were easily transferrable to academic staff from each discipline for long-term implementation.[10]

Our team worked closely together in the following areas:

Course Topics. In selecting our topics, we considered the literature, syllabi used for training GTAs at other engineering institutions, and two existing teacher training programs at the university. (Our university has a two-day, campus-wide teaching center program for new GTAs and also a year-long College of Engineering program for new faculty.) With the exception of leadership programming, our new syllabus mirrored other institutions'. We modified the course topics over time based on the authors' reflections and on end-of-semester student feedback. The course topics are listed in Appendix A.

Selection of Speakers. To supplement the sessions led by the authors, we invited experts on campus to present additional topics. After identifying a speaker, the team collaborated to brainstorm examples and activities to implement in class. For example, on leadership topics, we approached the campus leadership center, which provides workshops, certificates, and special programming for students to develop and practice leadership skills. They collaborated with us to tailor their existing training sessions on leadership to be applicable for both teaching and the engineering workplace.

The collaborative and iterative process included moments of disagreement. For example, the instructional development team members preferred more general pedagogy-related topics (such as Bloom's Taxonomy, grading rubrics, active learning), while the faculty members argued for course-specific skills (such as running a lab, working with a design team, proctoring exams). Despite these disagreements, the variety of backgrounds represented by the team helped us develop examples and tasks that would resonate with GTAs from a variety of departments and course assignments, including lectures, discussion sections, and labs. Without a diverse development team, we would have risked missing key topics or connections to authentic GTA duties. This process also ensured that we would cover not just teaching, but also applications to the workplace.

Integrative Approach

An integrative approach has been implemented at the undergraduate level, for example, as shown in Higgs, Kilcommins and Ryan's Irish Integrative Learning Project.[11] In our GTA training, to integrate teaching and professional skills, we intentionally and explicitly linked teaching development with leadership development.

For example, we demonstrated to GTAs that writing learning objectives is similar to setting clear goals for employees, and that interacting professionally with students prepares one to interact professionally with colleagues and employees. The session on grading rubrics was presented to students not just as tools for grading student work, but also as tools for assessing employee performance, and the session on professionalism in communication, which clearly benefits someone seeking a career as a professional in industry, was alternatively presented in the context of enhancing the relationship between the student and GTA, thus motivating our GTAs to practice professional communication skills immediately. Further, because the opportunities and challenges of working with a diverse student body are similar to those of working as part of a diverse team or company, the session on diversity was introduced first as being important to industry, then transitioned to a discussion of the more immediate opportunities for leveraging the diversity of students in classroom contexts.

Our hope was that the explicit references to how teaching skills transfer to leadership skills would encourage GTAs to have more interest in the training.

Strategic Partnerships to Scale

A major goal of our program is to offer the course to students in each department in the College of Engineering. As noted by Finelli, Daly and Richardson,[12] a successful implementation will require some flexibility to accommodate the different needs and ideas that each department would have about how best to train their GTAs. We also considered how quickly we could scale up the program, given that there could be over 300 new GTAs in the College of Engineering every fall. Therefore, our strategy has been to expand the course by adding one department each semester.

The first department to sign on was Mechanical Science and Engineering (MechSE), followed by the Computer Science department (CS). Each of them already required (or used to require) their GTAs to take a teaching training course. One department had a seminar, and the other had a three-credit-hour course. Both had difficulties offering them due to lack of faculty interest. Therefore, our course filled an urgent need for both departments.

MechSE and CS represent two of the three largest departments in the College of Engineering. Our team is presently in talks with the largest of the remaining departments, Electrical and Computer Engineering (ECE) as well as Civil and Environmental Engineering and Bioengineering. Our hope is that the course will develop a reputation for success throughout the college and that the remaining departments will join our GTA training.

Program Evaluation

Aligned with the goals of the program to improve teaching ability and based on the assumption that students may not see the connection between teaching and transferable professional skills, this program evaluation was designed to: 1) measure changes in students' perceptions of their confidence in teaching and 2) estimate changes in students' viewpoints toward teaching as an opportunity to enhance transferable professional skills. To these ends, we administered two surveys before and after the course: the STEM GTA Teaching Self-Efficacy Scale[5] and a modified skills perception inventory.[6] This section discusses the demographics of the students who participated in this evaluation and their responses to the surveys in a nonparametric way.

Methods

Participants

This course, which seeks to integrate teaching and professional skills, has been offered three semesters. In the spring semester of 2017, 13 students voluntarily registered for the pilot version of the course, while in the fall semester of 2017, 79 students, a majority of them from Mechanical Science and Engineering, were required by their department to enroll in the course. Another 54 students were enrolled in the course during the spring semester of 2018; many of these students were from Computer Science and were required to take the course.

Out of 146 STEM graduate students enrolled in the course over the three semesters, 96 participated in this evaluation. These students completed both pre- and post-surveys during the fall semester of 2017 and the spring semester of 2018, when the majority of them were required to take the course.

Table 1 shows the demographics of the students from the fall semester of 2017 and the spring semester of 2018. Sixty-four percent of the students who participated in the evaluation over the two semesters were international students, and 36 percent were domestic students. About half of the students were first-time teachers, and the majority of them were either facilitating laboratory sections or leading discussion sections.

Variables	Fall 2017 $N = 60$	Spring 2018 $N = 36$
Nationality		
International	41 (68%)	20 (55%)
Domestic	19 (32%)	16 (44%)
Gender		
Female	6 (10%)	5 (14%)
Male	54 (90%)	36 (86%)
Length of Teaching Experience		
More than 1 semester	25 (42%)	16 (45%)
First time	31 (52%)	15 (42%)
GTAs' Responsibility		
Facilitating laboratory	36 (60%)	11 (31%)
Leading discussion	12 (20%)	7 (19%)
Grading	1 (1.7%)	6 (17%)
Holding office hours	3 (5%)	6 (17%)
Lecturing	2 (3%)	N/A
Facilitating design projects	2 (3%)	3 (8%)
Others	4 (7%)	3 (8%)

Table 1: Demographics of Survey Participants

Instruments

The STEM GTA Teaching Self-Efficacy Scale evaluates teaching assistants' belief in their ability to teach in STEM fields and consists of 18 items using a 6-point scale (with the higher total score indicating more confidence). This instrument has been validated[5] and the overall scores of 18 items will be reported in the result section. The STEM GTA Teaching Self-Efficacy Scale was selected because of its application to college STEM teaching contexts. Other teaching self-efficacy instruments cover either the broad contexts of college teaching,[13,14] or K-12 science teaching contexts.[15,16]

A modified version of Alpay and Walsh's skills perception inventory assessed whether students perceived that teaching would provide them with opportunities to enhance transferable professional skills and included 18 items rated on a 6-point scale (with the higher total score indicating that students perceive teaching as an opportunity to enhance leadership skills). Alpay and Walsh's original skills perception inventory[6] examined graduate students' perceptions of transferable professional skills, such as time management, self-awareness, communication, and teamwork, after taking part in leadership workshops. We chose this scale because of its context; the original scale was developed specifically for engineering graduate programs that sought to offer workshops on professional skills and measure their impact. Validating the modified inventory used in this evaluation is beyond the scope of this current study. Accordingly, Cronbach's α and the corrected item-total correlations of each item will be reported.

In addition to the survey questions taken from these two already existing scales, the pre-survey included demographic questions, and the post-survey included the following three questions, which directly addressed how this course helped participants:

1. This course has prepared me to successfully complete my teaching assistant responsibilities.

2. This course has provided me with a better understanding of how teaching and leadership skills are intertwined.

3. This course has been effective in improving my professional skills such as communication, teamwork, and time management skills.

Results

Each of the STEM GTA Teaching Self-Efficacy Scale and the modified skills perception inventory had high reliabilities for both pre- and post-tests. With the STEM GTA Teaching Self-Efficacy Scale, pre-test had Cronbach's α = .95 and post-test had Cronbach's α = .93. With the modified skills perception inventory, pre-test had Cronbach's α = .97 and post-test had Cronbach's α = .93. Corrected item-total correlations for each of the items in the modified skills perception inventory were greater than .40 and are reported in Appendix B.

Descriptive statistics of pre- and post-scores of both scales are listed in Table 2. These two cohorts of students started slightly higher in their perception of teaching as enhancing transferable professional skills than in their confidence in teaching.

Surveys	Minimum	Maximum	M	SD
Self-efficacy pre (96)	2.27	6	4.84	.71
Self-efficacy post (96)	3.66	6	4.99	.59
Skill perception pre (96)	1	6	4.91	.99
Skill perception post (96)	3.11	6	5.02	.59

Table 2: Descriptive statistics for pre- and post-scores of the STEM GTA Teaching Self-Efficacy Scale and the modified skills perception inventory

Question 1: Differences in Confidence in Teaching

Nonparametric statistical processes were performed as the Shapiro-Wilk normality test results of pre- and post-surveys did not show normal distribution. Pre- and post-scores were compared with the Wilcoxon signed-rank test. Table 3 shows that, overall, there was a statistically significant difference ($z = 2.51, p = 0.01$) between the pre- ($Mdn = 4.89$) and post- scores ($Mdn = 5.03$) of STEM GTA Teaching Self-Efficacy Scale, which demonstrates an increase in their confidence in teaching. Looking at the sub-groups closely, the program would likely help female students and international students increase self-efficacy, but their significance levels were not at $p = 0.01$.

As non-parametric tests were performed multiple times, the significant alpha level in this study is considered to be $p = 0.01$.

Groups (n)	Median of pre/post tests	Positive Rank (n)	Negative Rank (n)	Ties (n)	z	p
Overall (96)	4.89 / 5.03	57	35	4	2.51	0.01**
Female (11)	4.72 / 5	7	3	1	2.19	0.02*
Male (85)	4.89 / 5.06	50	32	3	1.88	0.06
International(61)	5.0 / 5.06	39	20	2	2.19	0.02*
Domestic (35)	4.83 / 4.94	18	15	2	1.21	0.22

**p <.05, **p <.01*

Table 3: Results of the Wilcoxon signed-rank test for pre- and post-scores of the STEM GTA Teaching Self-Efficacy Scale

The students in our course developed confidence in their teaching, and 98 percent (see Figure 1) also agreed that this course prepared them to successfully complete their teaching assistant responsibilities, within varying degrees.

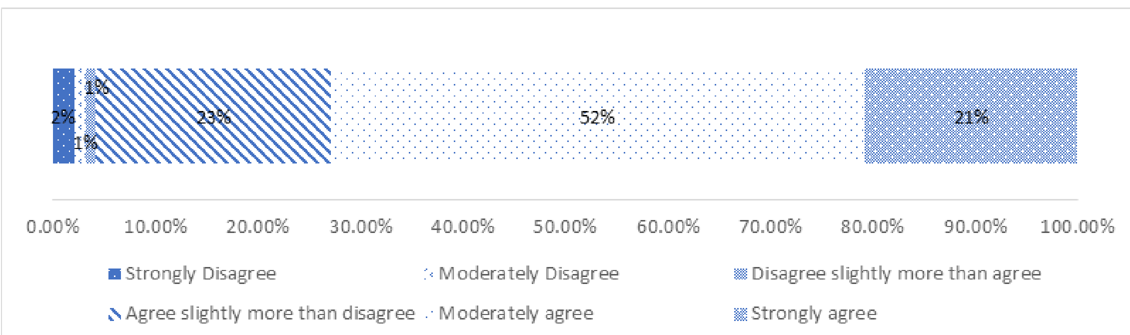

Figure 1: Perception of how well course prepared GTAs

Question 2: Differences in Viewpoint toward Teaching as Enhancing Transferable Professional Skills

We also conducted a nonparametric statistical process, the Wilcoxon signed-rank test, to compare pre- and post-scores of each of the 18 items in the modified skills perception inventory. Table 4 shows that students did not change their perceptions toward teaching as an opportunity to enhance transferable skills, except for one area, giving constructive feedback.

This may be because the pilot cohorts started the semesters already believing that teaching skills would transfer to other contexts, so there was not much room for the course to effect much improvement in that regard. Compared to the means in self-efficacy at 4.84, the means in the skills perception inventory was slightly higher at 4.91 (see Table 2).

Another possibility is that the course still has room to improve in terms of integrating teaching and professional skills. In contrast to the large percentage of agreement (98) that this course helped them complete their teaching assistant responsibilities, the students agreed less that this course provided them with a better understanding of how teaching and leadership skills are intertwined (see Figure 2) and that it was effective in improving their professional skills (see Figure 3). Only approximately 80 percent of participants agreed in these two regards.

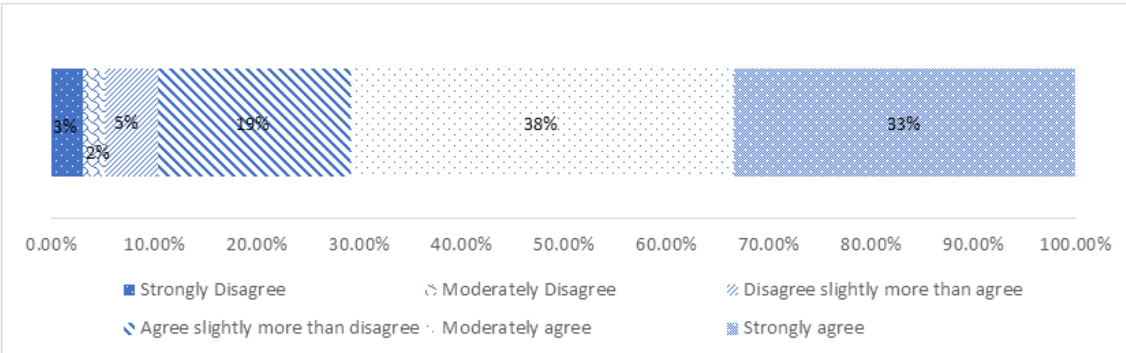

Figure 2: Perception of relationship between teaching and leadership skills

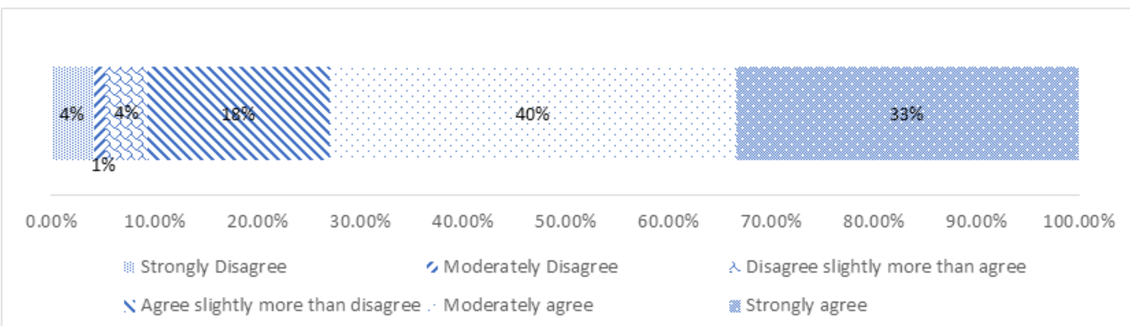

Figure 3: Perception of leadership skill improvement

Conclusion

As the literature continues to emphasize the importance of offering teaching training programs tailored to engineering education and report the positive results of such programs, we designed our program by leveraging existing campus resources and by integrating training for teaching and professional skills. The results of the pilot study indicate that participants in the course experienced an increased sense of self-efficacy as teachers. This finding is encouraging in that GTAs are polishing and developing their teaching skills, which has ripple effects for undergraduate education[17]. This finding also reiterates the significance of tailoring GTA training to engineering education as a continuum of general training.[1,2,18] However, in terms of connecting

Question items	Median of pre/post Tests	Positive Rank (n)	Negative Rank (n)	Ties (n)	z	p
communicate with people of different cultures	5.5 / 5	16	26	54	-.89	.375
effectively prioritize work to minimize distractions	5/5	29	32	35	-.38	.7
give constructive feedback to peers and other students	5/5.5	28	15	53	1.96	.05*
use effective strategies to manage time	5/5	30	27	39	.28	.77
have ideas listened to by others	5/5	33	24	39	1.21	.22
develop a realistic awareness of how one is perceived by others	5/5	31	24	41	.98	.32
understand the different roles within a team	5/5	25	27	44	.07	.93
communicate with people one does not know very well	6/5	22	31	43	-.53	.59
coordinate teamwork	5/5	24	21	51	.28	.77
understand how one's own and others' personality types affect work interactions	5/5	29	19	48	1.85	.06
make use of feedback opportunities in the planning of my work	5/5	30	21	45	1.54	.12
describe the facets of positive team development	5/5	24	27	45	.05	.95
network with fellow scientists or engineers	5/5	25	24	47	.11	.91
develop cooperative relationships	5/5	27	25	44	.12	.89
receive feedback and handle criticism	5/5	25	25	46	.66	.51
develop an awareness of one's strengths and weaknesses	5/5	28	18	50	1.02	.30
enthuse a non-expert about science	5/5	33	27	36	1.24	.21
non-technical professional skills such as communication, teamwork, interpersonal skills, etc.	6/6	23	23	50	.13	.89

$p<.05$, $**p<.01$

Table 4: Results of the Wilcoxon Signed Rank Test for pre- and post-scores of the modified skills perception inventory

teaching and leadership, the pilot results show no noticeable change in the participants' perception that skills gained through teaching transfer to other contexts.

Implication and Future Work

It is our intention to use program evaluation as feedback so we can iteratively improve the design and teaching practice of the program. We have discussed how the course will incorporate case-based design to improve the integration of teaching and professional skills. Cases will include not only classroom settings where GTAs polish their teaching skills and interact with students, but also social/professional settings of higher education, where they analyze workplace conflicts and organizational culture, and hone professional skills.

It is also important to note that the current study was a pilot study with a small number of participants; therefore, results should be interpreted with caution. However, results of the current study inform next steps for further exploration. To understand engineering students' general perception of transferable professional skills, a future study will include larger samples across educational departments, and also use those who do not enroll in this course as a control group. A larger sample will allow us explore the factors within the modified skill perception inventory and understand students' perceptions in the thematic areas highlighted in the original study, including communication, interpersonal skills, etc.

We have also identified a few other interesting areas of future research. Given the large percentage of international GTAs in our cohorts, it would be interesting to investigate whether international students have a different initial outlook on the value of teaching skills. We would also be interested in following one or more cohorts as they progress through their graduate school experience to see if any improvement as a result of our course persists. Ultimately, we plan to investigate whether our course improves teaching effectiveness of GTAs by directly hearing feedback from their students in addition to GTAs' perceptions of self-efficacy.

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Appendix A Course Topics

Week	Topic in the spring of 2017	Topic in the fall of 2017
1	Intro Session, Learning Objectives (Bloom's Taxonomy)	Intro Session, Professional & Transferable Skills
2	Bias, Equity, and Access	Learning Objectives (Bloom's Taxonomy)
3	Exam Management	How to write exam and homework questions
4	Informal Early Feedback, Introduce the Project	Rubrics
5	Rubrics	How to Give Feedback
6	IEF Review / Project-based learning	Informal Early Feedback
7	Student Motivation	Presentation Skills
8	Presentation Skills	Active Learning
9	Teaching with Technology	Leadership Part 1 – Strength Finder
10	Classroom Management	Leadership Part 2 – Interview Skills
11	Interacting with Students	The Diversity Bonus
12	Active Learning	Interacting with Students
13	Professional Skills	Motivation
14	Student Presentation	Course Recap

Appendix B Corrected item-total correlations of the modified skills perception inventory

Question items	Item-total correlations (pre/post)
communicate with people of different cultures	.82 / .61
effectively prioritize work to minimize distractions	.76 / .68
give constructive feedback to peers and other students	.84 / .63
use effective strategies to manage time	.82 / .68
have ideas listened to by others	.79 / .68
develop a realistic awareness of how one is perceived by others	.82 / .66
understand the different roles within a team	.83 / .55
communicate with people one does not know very well	.83 / .60
coordinate teamwork	.84 / .70
understand how one's own and others' personality types affect work interactions	.84 / .66
make use of feedback opportunities in the planning of my work	.82 / .70
to describe the facets of positive team development	.83 / .69
network with fellow scientists or engineers	.79 / .50
develop cooperative relationships	.87 / .72
receive feedback and handle criticism	.86 / .72
develop an awareness of one's strengths and weaknesses	.75 / .61
enthuse a non-expert about science	.78 / .46
non-technical professional skills such as communication, teamwork, interpersonal skills, etc.	.82 / .60