

AC 2007-2234: THE IMPACT OF K-12 OUTREACH PROGRAMS ON GRADUATE AND UNDERGRADUATE EXPERIENCES

Kate Caldwell, North Carolina State University

Kate Caldwell received her B.S. in Mechanical Engineering and is currently a second year master's student in Mechanical Engineering at North Carolina State University. Her research focus is on composites. She has been an NSF-GE Foundation RAMP-UP fellow for the past two years.

Jessica McCoy, North Carolina State University

Jessica McCoy received her B.S. and will complete her master's in Industrial Engineering at North Carolina State University in July, 2007. She is a first year NSF-GE Foundation RAMP-UP fellow.

Lynn Albers, North Carolina State University

Lynn Albers is a second-year NSF-GE Foundation RAMP-UP graduate fellow. She received her B.S. in Mathematics with a minor in Music from MIT in 1992 and her M.S. in Mechanical Engineering with a minor in Nuclear Engineering from Manhattan College in 1996. After working for Nortel Networks and the NC Solar Center, Lynn matriculated at North Carolina State University where she is a Ph.D. candidate in Mechanical Engineering, focusing on renewable energy.

Althea Smith, North Carolina State University

Althea Smith is a PhD candidate in Biomathematics at North Carolina State University. She is also an NSF-GE Foundation RAMP-UP fellow.

Elizabeth Parry, North Carolina State University

Elizabeth Parry received her B.S. in Engineering Management-Mechanical Engineering from the University of Missouri-Rolla in 1983. After working for IBM for 10 years, Ms. Parry left to raise her children and start a science education business. Since 1999, she has directed two major grant programs for the College of Engineering at North Carolina State University. Currently, she is the project director for RAMP-UP (Recognizing Accelerated Math Potential in Underrepresented People), a five year program focusing on outreach to strengthen K-12 math, science and engineering knowledge and funded by NSF and the GE Foundation.

The Impact of K-12 Outreach Programs on Graduate and Undergraduate Experiences

Introduction

The impact of university-initiated educational outreach programs extends beyond K-12 students and teachers to benefit university fellows. A case study done by one such program, Recognizing Accelerated Math Potential in Underrepresented People (RAMP-UP) demonstrates marked improvements in professional skills for both undergraduate and graduate fellows. The inclusion of undergraduates under the supervision of graduate fellows makes RAMP-UP unique among other GK-12 programs. This program also employs a diverse population of fellows. In fall 2006, 66% of these fellows were female and 52% were minority students – percentages that are well above university averages for the primary partner university, North Carolina State University (NCSU). For more information about the demographic breakdown of the RAMP-UP program, see Figure 5 in the appendix. As a result of participation in this program, fellows increase their community involvement, improve their communication skills and explore many post-graduate career opportunities.

The National Science Foundation awarded the first GK-12 grants in 1999. Since then, universities have created dozens of programs across the country to improve student achievement while developing the service and communication skills of future scientists and engineers^[7]. Due to the hypothesized impact on both the K-12 students and the graduate fellows, Rita Colwell as founder of the GK-12 initiative called it a “classic win-win”^[6].

In some programs, the weekly commitment may vary, but undergraduate and graduate fellows have the same roles and responsibilities^{[5][10]}. At least one program pairs undergraduates with graduates, and each pair plans and teaches together in a classroom setting^[3]. Other K-12 outreach programs incorporate a service component into existing engineering courses so that college students can interact with younger students. A range of semester-long projects exists for undergraduates, from developing an informative museum exhibit aimed at elementary school students to leading semi-annual workshops to interest high school students in careers in engineering^{[4][9]}.

In the slightly older tradition of K-12 outreach, researchers have explored the positive influence of service learning on college students. Their results imply that developing curricula for and working with younger students improves the communication skills of college students^{[1][3][10][11]}. Additional studies have suggested that K-12 outreach impacts female students more than their male peers^{[2][10]}. Despite the wealth of knowledge addressing the positive aspects of K-12 outreach to the involved college students, there is concern that the GK-12 initiative was an “overhasty expansion” of NSF resources. At the program’s inception, many university administrators expressed disapproval at the projected costs of the GK-12 program at the expense of the lauded Graduate Research Fellowship program^[8]. The shift from a purely-research focus to a hybrid outreach-research program is also a concern. Trautmann and Krasny counter the argument that graduate fellows involved in GK-12 programs are “sidetracked” from their focus on research with evidence that the nontraditional fellowships improve both the students’ teaching skills and their actual research^[11].

RAMP-UP: Evaluation History

Over the course of RAMP-UP's first three years, the process of collecting data from fellows has evolved to more adequately measure the program's impact. For example, surveys from the first year did not include questions concerning RAMP-UP's impact on the fellows' career plans. The fellows' responses to open-ended questions on these surveys indicated an unanticipated influence. To capture this and other unforeseen results, we adapted the survey questions. These changes are reflected in variations in question content, structure, and rating scale. This paper focuses on the development of the fellows as quantified by pre- and post-surveys; through the use of these surveys, we quantify and support our claims as well as those of previous research. Due to the inclusion of undergraduates and to the growth of the program over the first three years, the RAMP-UP sample size is quite large compared to currently published work and leads to stronger conclusions. Our analysis emphasizes data from the current year because of the inclusion of more relevant survey questions and the larger sample size, although qualitative data collected from open-ended questions prior to this year indicate support of the conclusions we've drawn. Surveys of current undergraduates include a sample size of 42 fellows, while surveys of current and former graduate fellows have a sample size of 8 fellows. Intermittently throughout the year, undergraduate fellows also completed prompted journal assignments to provide more qualitative data about the impact of RAMP-UP on their professional and personal goals.

In addition to observing the impact of K-12 outreach on all involved fellows, we examine the differences in impact on various subgroups: male and female, white and minority, STEM (science, technology, engineering, and mathematics) and non-STEM, undergraduate and graduate. All fellows surveyed (undergraduate and graduate) believe that RAMP-UP is a rewarding experience. Between pre- and post- surveys over the course of the fall 2006 semester, undergraduate fellows recorded a significant increase in their value of public speaking as a result of RAMP-UP; the experiences of the STEM fellows especially drove this difference. During the same time period, the appeal of being a role model increased equally for both white and minority fellows. For NCSU fellows, a much higher percentage of undergraduate fellows plan to attend graduate or professional school, as compared to similar statistics for the entire university undergraduate population. Both undergraduate and graduate fellows believe that they are more prepared for their careers because of their experience with RAMP-UP. We believe that much of these results are due not only to RAMP-UP's goals, which the program shares with other GK-12 programs, but to a fundamentally different structure which affects the impact on all involved students.

RAMP-UP: Structure and Operation

RAMP-UP, a partnership between North Carolina State University Colleges of Engineering and Education, Shaw University (a local HBCU), and the Wake County Public School System, is a five-year program funded by grants from the National Science and GE Foundations. The program consists of 45 undergraduate and 5 graduate fellows in science, engineering or math (STEM) and secondary math education working with 68 teachers in grades K-12 at eight Wake County schools (Figure 1). Under the direction of an engineering project director, graduate fellows supervise teams of undergraduate fellows who work with classroom teachers throughout

the academic year. The undergraduate fellows plan and implement inquiry-based mathematics lessons that demonstrate the practical application of mathematical theory. RAMP-UP fellows are role models and mentors for their students and thereby have the opportunity to make a significant difference for many K-12 students.

RAMP-UP is structured such that the project director manages five graduate fellows. The director and graduate fellows perform many of the organizational and preparation work together – everything from coordinating family math nights to assigning undergraduate fellows to schools. In addition to directly supervising the graduate fellows, the project director mentors them in learning and practicing professional skills (e.g., managerial, administrative). The director also serves as a teacher and mentor for the larger undergraduate fellow population, many of whom have initially never taught before. The undergraduate fellows both learn the basics of developing and implementing lesson plans as well as the professional skills inherent in interacting with teachers and their graduate fellow supervisors.

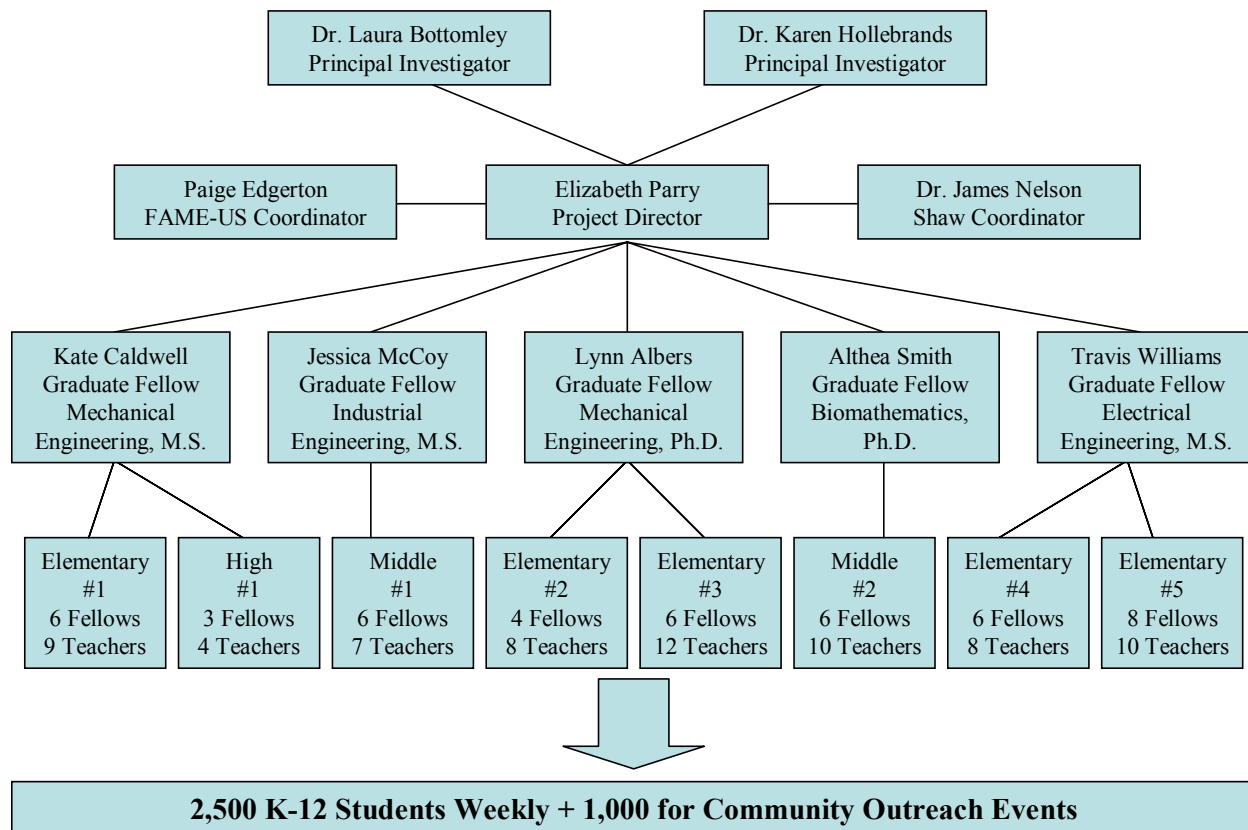


Figure 1: RAMP-UP Organizational Chart

The team of graduate fellows is responsible for helping out on some of the broader aspects of the program such as helping plan lessons for the weekly seminar, creating surveys, and organizing team building events, such as ‘all hands’ meetings and bi-monthly dinners for the fellows. They are also responsible for overseeing much of the daily operation of the program. Each of the graduate fellows applies managerial and mentoring techniques to 6-10 undergraduate fellows at one or two schools. The undergraduates work 10-15 hours a week with up to three teachers at a

specific school. They also help with before and after school math reinforcement programs. The graduate fellow creates each undergraduate fellow's work schedule and is responsible for checking his or her timesheets against online work logs every two weeks. The graduate fellow also ensures that the partnership between the undergraduate fellows and the teachers is healthy, and that the interaction of the undergraduate fellows with the K-12 students remains activity-based.

In addition to managing the undergraduate fellows, the graduate fellows are also responsible for coordinating the team of RAMP-UP teachers at each school. At each school, a staff member serves as the liaison between graduate fellows and teachers to facilitate the daily operations of the program. The graduate fellows meet with the school coordinator and teacher team regularly to make sure the program is being implemented correctly and successfully in their classrooms. They also lead before and after-school programs at their schools, open to students who have been identified as needing extra support. The program targets middle and upper middle ability students who have not been identified by the state of North Carolina as being 'academically gifted' (AG) based on their performance on cognitive ability and basic skills standardized tests administered in third grade. This AG label is necessary for students to be identified for the university math track, unless the student has a strong advocate in middle and/or high school. Traditionally in Wake County, the majority of students currently identified as AG are white and Asian, which is not representative of the overall school and district demographics. RAMP-UP fellows and teachers focus on students who have been identified as 'just below, at or above grade level' but with the potential to achieve greater proficiency with focused intervention.

RAMP-UP goals target three stakeholder groups: K-12 students, the university undergraduate and graduate fellows, and mathematics teachers in grades K-12. All stakeholders support the overall goal of increasing the number and diversity of students who enroll and succeed in higher level math courses, specifically algebra by 8th or 9th grade and calculus by 12th.

For K-12 students, RAMP-UP will enrich learning experiences by:

- Increasing the number and diversity of students pursuing the advanced math track
- Providing university students as role models and mentors
- Working with teachers to decrease the achievement gap between all groups of students
- Assisting in broadening the academically gifted program identification process guidelines
- Forging a strong partnership with mathematics teachers in Wake County and beyond

For university undergraduate and graduate fellows, RAMP-UP will:

- Improve communication and teaching skills
- Deepen their own STEM content knowledge and application skills
- Develop fellows as both formal and informal teachers of STEM disciplines
- Enable fellows to place K-12 education in context with their own career goals
- Encourage life-long involvement in K-12 education
- Increase awareness of research and industry post graduate opportunities

For K-12 teachers, RAMP-UP will:

- Improve content gain, comfort level and professional development opportunities
- Strengthen pre- and in-service teacher understanding and ability to use inquiry as a teaching tool in mathematics and other areas
- Strengthen understanding of engineering as a career and how mathematics and science relate to engineering through daily application of theory to real world problems
- Utilize an engineering approach to provide real life connections in math and science

Impact on the K-12 Community

It is important to note that the focus of this paper is on the impact of the program on university students. Project management has and will continue to publish on the impact of the program on the K-12 teachers, students and parents. Data is being collected from all three groups. Teachers complete math attitude and program impact surveys and fellow evaluations once per semester. In addition, during semi-annual project workshops, teachers provide input on fellow influence on the K-12 students via discussions and plus-delta charts. Overwhelmingly, the aspect of the university student as a positive role model is by far the most important and oft-mentioned benefit of the program. The teachers also cited the benefit of having a student comfortable operating in STEM content areas as a classroom colleague. Consistently, scheduling and communication are the biggest challenges.

Parents are surveyed once each year on their own math influences and attitudes, and are also surveyed about program efficacy during the family math events sponsored by RAMP-UP. K-12 student data is collected via qualitative and quantitative methods, including surveys on math attitudes and reflections on personal perceptions of the program. In addition, we compare RAMP-UP student scores on the North Carolina State End of Grade (EOG) Exams (grades 3-8) and End of Course (EOC) exams (high school) to those of their peers in similar demographic schools without RAMP-UP. First year results show a definite yet inconsistent impact across our eight partner schools except in Algebra I. Students in RAMP-UP classrooms in Algebra I demonstrated a consistent proficiency level in math from 8th to 9th grade vs. their peers at comparison schools, whose proficiency level dropped significantly. Last year's data is currently being evaluated, due to a delay in the state's release of math scores. A preliminary look at the comparison data indicates a strong correlation between length of time working with RAMP-UP students and their academic growth. This data looks very promising and will be published in future work.

RAMP-UP Impact on Undergraduates

Overall College Experience

Throughout the program's three years we have conducted surveys to evaluate its overall impact on undergraduate satisfaction. When fellows were asked if they were more satisfied with their college experience as a result of RAMP-UP their average responses from the first and second years 3.43 and 3.88 respectively (on a Likert scale of 1 = strongly disagree to 4 = strongly agree). Most recently we conducted a survey of 42 undergraduate fellows to support our hypotheses. Significant survey data is available in Tables 2-5 and Figures 6-9 of the appendix.

Undergraduate fellows commit 10 to 15 hours a week to RAMP-UP, which is approximately 25% of their scholastic time¹. For most fellows, RAMP-UP has been a constructive, influential opportunity for development (Figure 2). When asked, "How much has RAMP-UP positively impacted your undergraduate experience?" the average response was a 4.40 on a Likert scale (1 = not at all; 2 = not much; 3 = some; 4 = a little; 5 = a lot). All but one student professed a positive impact. Undergraduate fellows responded similarly that their involvement in the RAMP-UP program is a factor in their satisfaction with their college experience (average 4.38). A white female education major writes:

I would hands-down say that RAMP-UP has been an incredible experience for me so far...Working in this program has definitely presented its challenges to me, but in the midst of that it has helped me to develop my knowledge and experience in my major [Math Education]. The experience I am getting from working with teachers and students is priceless for my future. Also, I have really enjoyed all the interaction with my co-workers in RAMP-UP. I have developed some friendships that go outside of the work realm, which are nice to have. The grad students have also been encouraging and helpful to work with.

Conclusively, *all* undergraduate fellows from all three years contend that RAMP-UP is a rewarding experience; 86% of fellows surveyed this year would recommend the program to classmates and friends. Average responses for the 42 current undergraduate fellows surveyed are displayed in (Figure 2).

In addition to the personal growth inherent in program participation, involvement with RAMP-UP improved fellows' communication skills, increased their sense of community involvement, and impacted career and future plans of the undergraduate fellows. These results are consistent with and more extensive than previous work^{[1][3][10][11]}.

¹ Based on an average semester course load of 15 credits.

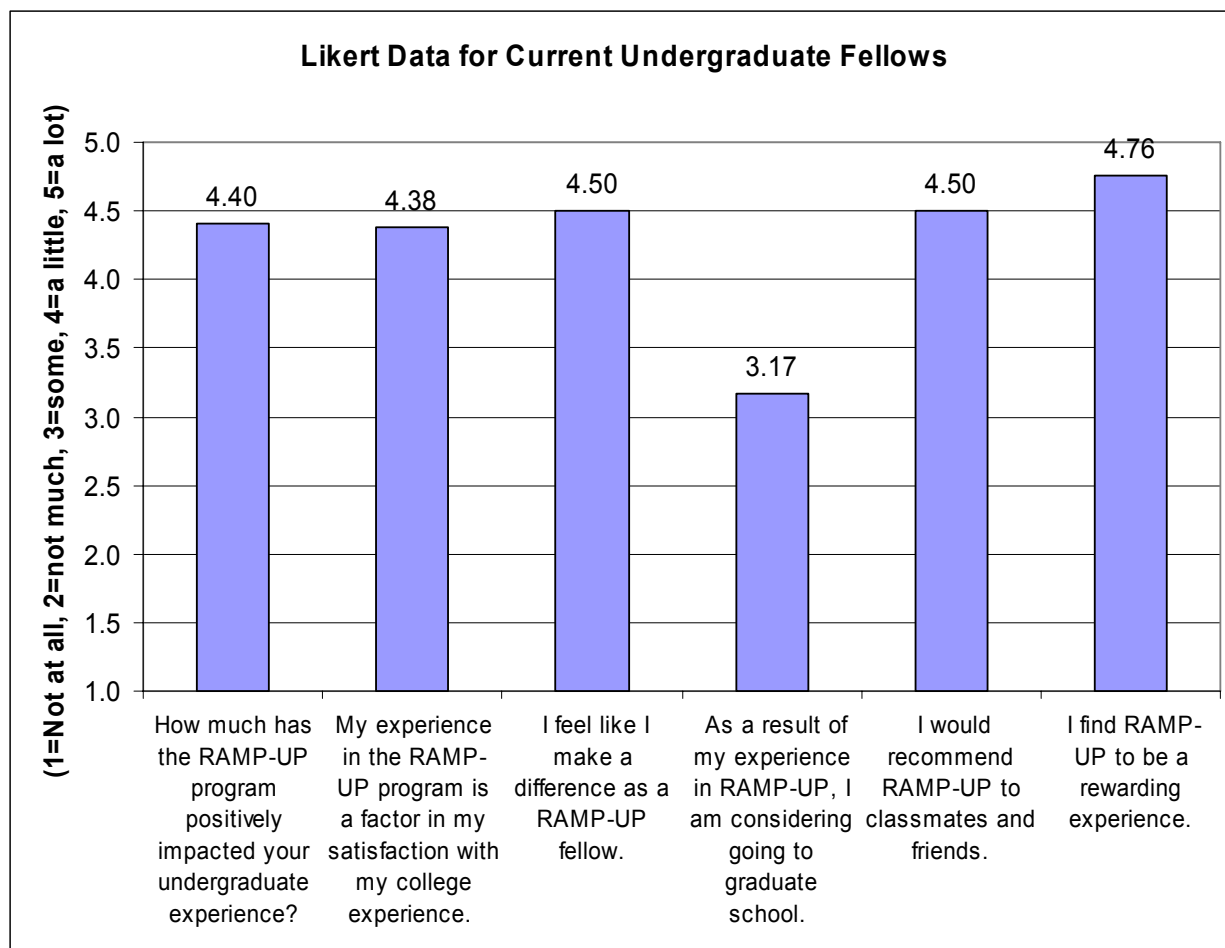


Figure 2: Average survey response of undergraduate fellows.

Communication Skills

The fellows' communication skills improved due to a close working relationship with at least one teacher and frequent implementation of planned lessons in a classroom setting. A comparison of surveys completed before and after the fall 2006 semester reveals that the appeal of public speaking as a component of RAMP-UP demonstrated the most significant increase across the semester. STEM fellows had the greatest effect on this increase; their average valuation of public speaking rose from 3.81 to 4.56, on a scale where 1 = least appealing and 6 = most appealing². A black female fellow in science affirms that:

Participating in RAMP-UP has reassured my interest in teaching for a couple of years before entering medical school. It has also given me the opportunity to deal with a greater variety of people and enhanced my skills to break things down on a lower level, which I feel are valuable skills that I will need in my profession as a doctor.

² Please note that some survey questions are on six-point Likert scale to be consistent with earlier surveys.

A white male fellow in engineering agrees with his belief that “this program has definitely helped me become a better communicator. If you can communicate with 8-year-olds, then communicating with everyone else becomes less of a challenge.”

Ninety-five percent of the undergraduate fellows felt that they learned professional skills (e.g., communication, organizational, time management) from the project director and graduate fellows. In addition, 95% of undergraduate fellows surveyed learned to work with a team of their peers and 98% learned to work with K-12 teachers and students. These improved collaboration skills not only benefit them in college but aid their success in the professional world and could potentially impact their future involvement in K-12 education post graduation. According to a former white female undergraduate fellow in science:

One of the topics that was often discussed and emphasized during the RAMP-UP program seminars was different learning styles and how to communicate to students and the teachers that might see things or learn differently than we did. This has been extremely helpful to me in my daily activities in the work force. Not only have the trouble shooting and communication skills that I learned in the program helped me to succeed in my position, but it has also helped me to understand the thought process of the management staff in order to be better able to contribute to team projects and work with less supervision.

This statement reflects a higher level of awareness than most of her classmates will possess upon entering the workforce. Learning styles are not typically a component in the STEM undergraduate academic program, yet the skills gained from learning about the differences in how people learn and then implementing that knowledge into practice is a valued skill in either industry or academia.

Career Preparation and Future Plans

The RAMP-UP program also has an impact on participating undergraduates' career preparation and future plans. Undergraduate fellows work closely with graduate fellows and are exposed to many post-graduate opportunities through the program. 67.4% of fellows in the program are planning to go to graduate school and 69.2% of STEM fellows are planning to attend graduate school. This is compared to the 46.8% for the

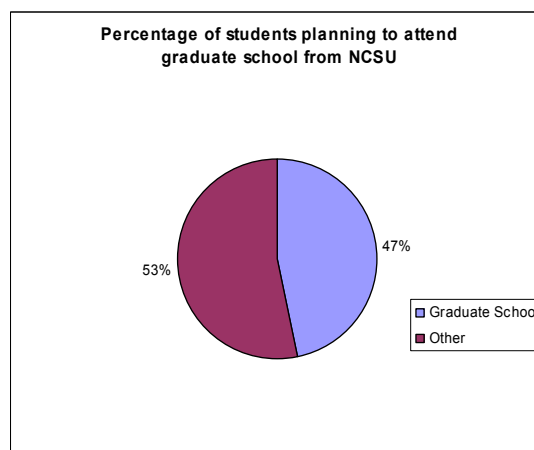
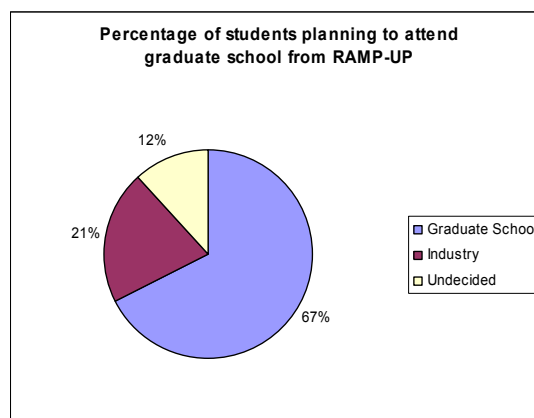


Figure 3: Post-Graduate Plans

total university³ population, 40.8% for the College of Agriculture and Life Sciences, 35.2% for the College of Physical and Mathematical Sciences and 20.7% for the College of Engineering (Figure 3). We recognize that RAMP-UP positions are filled through an application and interview process, and that therefore the fellows are not a random representative sample of the university population. However, we believe that the exposure to post-graduate educational opportunities through RAMP-UP is at least partially responsible for the dramatic difference in the level of interest in graduate school. For more detailed information see Table 1 of the appendix.

Undergraduate fellows who had completed at least one semester with the RAMP-UP program were asked, "How much of a benefit has working with your graduate student supervisor been to you in terms of strengthening your content area skills?" On a scale of 1 to 5, (1 = not at all; 2 = not much; 3 = some; 4 = a little; 5 = a lot), the average response was 3.33. A similar question was asked about the project director's effect, and the average response was 3.4. When this group was broken down into male and female fellows, female fellows averaged 3.57 and 3.75 for the graduate fellows and project director respectively. The male fellows' averages were much lower – 2.86 and 2.71. This shows that the program is having a small impact on undergraduate fellows' comfort with their content area, particularly in female fellows.

Some undergraduate fellows who participate in the program find that RAMP-UP affects their overall career goals. One white male undergraduate fellow in engineering remarked

All of these activities have led me to want to be a university professor. Although, I would still love to be involved with schools in the community through outreach and I would like it even more if I could motivate more undergraduate fellows to become more active members of society by participating in outreach activities.

For education fellows the program provides a unique experience to get significant time in the classroom in addition to the usual one semester of student teaching. Many of the education fellows discover if they are happy with their career decisions after joining the program in their sophomore or junior years. Their peers do not gain classroom experience until student teaching during their last semester of college. One white female fellow in education agreed:

I can honestly say that this program has drastically affected my career choice. I am still intending to obtain a degree in Secondary Math Ed because I am almost finished; but I sincerely think I would enjoy teaching at the elementary level so much more. The kids are wonderful and respectful. They have a desire to learn and are easy to teach. My coworkers have been excellent mentors, and have inspired me to prepare my best lessons each and every time. I feel that they provide me with useful feedback and always answer any questions I have about their profession openly and honestly. When I originally began this program, I did not think that I would be treated as their equal. I thought that I would be viewed

³ Because 38 out of 42 of the students surveyed were from North Carolina State University, data from Shaw University was not used for this comparison. At NCSU, data from the colleges of Engineering, Physical and Mathematical Sciences, and Agriculture and Life Sciences was used to represent the STEM disciplines.

as a TA or just an intern. Instead, I feel welcomed and valued. I firmly believe that no matter what grade level I end up teaching, the experiences I have encountered here will prove useful throughout my teaching career.

Undergraduate fellows in all disciplines say that the program has increased and reinforced their content knowledge. One white female undergraduate fellow in education said

[RAMP-UP] has prepared me in more ways than so many of my peers. I have already learned through experience some of the things that my friends did not learn until their first year teaching. Also, my education classes have so much more meaning because I have a background experience and something to compare to. I have gained so much through this program.

Community Involvement

RAMP-UP provides one way to get college students involved with the community outside of the university and to make them more socially aware. As a result of their participation, undergraduates feel like they are making a difference in the lives of K-12 students and in their community. A white female undergraduate fellow in science remarked, “I love getting out into the community and working with the teachers and students and feeling like you are really at home in Raleigh, not just floating around in a ‘college bubble.’” Another STEM fellow commented that “RAMP-UP has not only made me better at understanding the school system, it made me socially conscious of the issues that the children face today.” Survey data for the question “I feel like I make a difference as a RAMP-UP fellow (1 = strongly disagree, 2 = disagree, 3 = maybe, 4 = agree, 5 = strongly agree)” shows an overwhelmingly positive result, with an overall average of 4.5. In previous years we asked the similar question “I had a positive impact on my students” on a scale of 1 to 4; the responses were 3.57 and 3.5 for years one and two respectively. Yet another STEM fellow commented that RAMP-UP has helped to “inspire me to help and do something for those who need it instead of getting caught up in the selfish thing that can be college life.”

RAMP-UP impacts the greater community through family math events held at schools or churches. These math nights feature 3-4 activities per grade level K-8 which are tied to the math competency goals for that grade. The activities reinforce basic skills and encourage parent involvement. RAMP-UP fellows, circulate throughout the room, advising, directing, instructing and guiding the participants. In the last 18 months, RAMP-UP hosted and staffed thirteen elementary family math nights at schools. Each partner school has an event, and the team travels to other schools in the area with high needs populations and lower parental involvement. In addition, RAMP-UP hosted two community math events at local churches in disadvantaged neighborhoods, inviting parents and students from nearby schools as well as parishioners. In total, nearly 3,000 people attended these events, and feedback has been extremely positive.

The outreach that fellows do during college not only affects their college experience, but also their plans to participate in their communities after graduation. STEM undergraduate fellows were asked the following question: “As a result of my experience in RAMP-UP, I plan to

volunteer in K-12 education after graduation (1 = never, 2 = probably not, 3 = maybe, 4 = probably, 5 = definitely)” with an average response of 3.58. Through their involvement with K-12 outreach, undergraduate fellows also begin to see themselves as role models as evidenced in three years of surveys⁴. Students look to them every day for both help in math and science classes and in their personal lives. A black male undergraduate fellow in engineering notes that “the craziest thing is that a lot of kids that aren't in any of my classes talk to me daily about everything from the football game, to their personal life, and it’s good to know that they feel comfortable coming to me for honest responsible advice.”

RAMP-UP Impact on Graduate Fellows

Graduate fellows, both former and current, cite the opportunity to make a difference in the community, broaden their college experience, and be a role model as reasons for joining RAMP-UP. Current and past graduate fellows surveyed unanimously “strongly agreed” that RAMP-UP has had a positive impact on their graduate experience, and that involvement in the program is rewarding. A former female graduate fellow from engineering summed up the survey data with her belief: “I truly felt that I was a part of something important, and that my contributions made a difference. I can’t imagine my graduate experience without RAMP-UP.” Other questions are displayed below with the average response of graduate fellows (Figure 4).

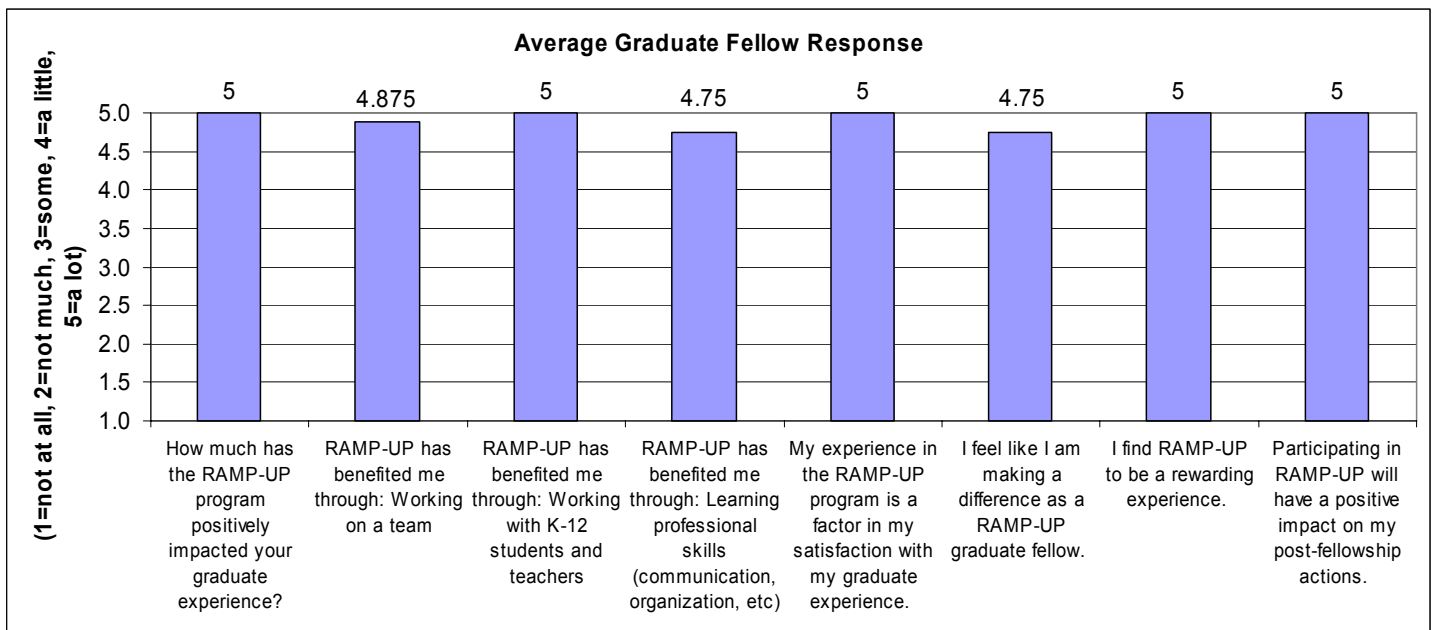


Figure 4: Graduate survey response, on Likert scale.

⁴ With regard to the statement “my students saw me as a positive role model” on a Likert scale where 1=strongly disagree and 4=strongly agree, the average response for the first and second year fellows was 3.86 and 3.88 respectively. Current students find the role model aspect to be very appealing; this year’s average response was 5.55 on a six-point Likert scale where 1=least appealing and 6=most appealing.

While the sample size of 8 graduate fellows is smaller than that of the undergraduate fellow population, many of the same trends apply to the graduate fellows as well. To a greater extent than the undergraduates in the program, graduate fellows exercised time management and other professional skills on a daily basis to coordinate RAMP-UP efforts across most grades at eight different schools, in addition to their academic and research requirements. A female graduate fellow in engineering said that “compared to the other RAs in my department and research group, I am doing the same amount of research work, in addition to my commitment to RAMP-UP. My first semester was a challenging exercise in time management to get everything done on a daily basis.” The responsibilities of the graduate fellows span a wide spectrum of administrative and organization work; a female graduate fellow in engineering lists off “scheduling, verifying time-sheet reporting, facilitating meetings at the schools, mentoring undergraduates, and organizing social team-building events” as regular tasks.

Not only do the graduate fellows work together as a team, but they also facilitate groups of teachers and undergraduate fellows. The hierarchical structure that sets RAMP-UP apart from other GK-12 programs gives the graduate fellows yet another edge on their peers with traditional assistantships: managerial experience. As illustrated in Figure 1, the graduate fellows form an important layer in the structure of the program. A black male graduate fellow in engineering affirms the value of the experience: “I think the managerial aspect will definitely help me in the corporate world and in any future business ownership plans.” Many research assistants are responsible for teaching undergraduates or managing a lab but the relationship graduate students and undergraduate students establish in those environments can be less than mutually respectful. A white female graduate fellow in engineering observes that

Although most other graduate fellows are somehow “in charge” of undergraduates either in a lab setting, or as teachers or TA’s for their classes, their relationships are much less collegial than those developed in the RAMP-UP program. Most graduate fellows are “low on the food chain” so to speak in the departments, and therefore do not treat the undergraduates with respect as their peers like those of us managing the RAMP-UP program.

When a group is motivated toward a common goal, the need for a “boss” is eliminated in lieu of a group facilitator. Graduate fellows in the RAMP-UP program work to maintain mutually respectful partnerships with all of the teachers and undergraduates in the program, as we believe it will take the active participation of all parties to achieve the goals of the program. Former and current graduate fellows found that making a difference in the community, broadening their college experience, and being a role model were reasons for joining RAMP-UP. When these fellows were surveyed, they all “strongly agreed” that RAMP-UP has had a positive impact on their graduate experience, and that involvement in the program is rewarding.

Previous studies have highlighted concerns about “sidetracking” the research focus of students who have GK-12 fellowships as opposed to a more traditional assistantship. The departments where RAMP-UP graduate fellows devote their scholastic hours have varying opinions on RAMP-UP. Some departments expect that the graduate fellows research during all extracurricular hours, and others fully support and publicize RAMP-UP to their students.

Fellows suspect that the departments may not fully understand the program and its benefits. However, one black female graduate fellow in science states:

Both of my advisors in the math and science disciplines have been very supportive in my participation in RAMP-UP. Neither one of my academic advisors have complained about RAMP-UP taking time away from my research. On more than one occasion, my advisors and I discussed our positive and negative experiences with managing undergraduate students.

RAMP-UP also helps graduate fellows put their research into perspective. They learn to put their research in a more general context and to explain their work to people who are not necessarily in their field of study. A white female graduate fellow in engineering elaborates:

RAMP-UP allows me to explore new worlds (quite literally when I attended the ASEE Global Conference in Rio de Janeiro, Brazil), and exposes me to many real world perspectives. So often, graduate students become masters of some very obscure topic and are not trained to see the big picture. In graduate school, I am not only becoming a master of one topic (renewable energy) but through RAMP-UP I am being trained to see the big picture. These are skills that together are invaluable.

Lessons Learned and Future Plans

Over the course of the first three years of RAMP-UP the program has adapted to better meet the needs of the three stakeholder groups: K-12 students, the university undergraduate and graduate fellows, and K-12 mathematics teachers. Many of these developments were implemented to address scheduling problems and improve communication between these three groups. Halfway through our second year we introduced an online system to facilitate communication and time recording. Teachers and fellows complete all surveys and journal assignments online and correspond on various message boards. Fellows also report all of their RAMP-UP time on a weekly basis; this is available to their graduate fellow supervisors for accountability purposes. The project director uses the data to inform schools each month of their fellow usage in terms of teaching, tutoring, planning, etc. This move to a paperless system has streamlined data collection and made data more instantaneously accessible.

To increase productivity the program expectations and guidelines have become more well defined in the past three years. At the beginning of each year, teachers and fellows are asked to sign a contract that outlines their responsibilities in the partnership. In the first year fellows were paid by a semester stipend and training was offered quarterly. Currently fellows are paid by the hour, which permits more efficient scheduling and resource allocation. To give fellows more community support and training, a seminar is now held once a week. It is difficult to schedule one class for the entire program, but those who are enrolled find it beneficial. Fellows appear to be most successful when working within one grade level at one school to maximize planning and meeting time as well as lesson development efficiency. The majority of RAMP-UP fellows work with one to three teachers.

Some keys to enabling graduate fellows to be successful managers include tailoring the workload to each graduate fellow's availability. For example, graduate fellows at the thesis stage of their degree have less time to commit to the program outside of their research. In our experience it is reasonable for a graduate fellow to manage 5-10 fellows in no more than two schools.

Departmental support is vital; advisors should be aware and supportive of graduate fellows' commitments beyond research. Graduate fellows can also be mentors to each other as they will likely be in different stages of their degrees. We recommend appointing both masters and PhD candidates to provide this mix of experience and to stagger the graduation years of the fellows.

Obviously a program of this magnitude is well suited to grant funding but from the standpoint of institutionalization it's not practical. Therefore, our goal at the end of our funding in December, 2008, is to have defined a more efficient and sustainable model of prolonged and meaningful K-12 partnerships between universities and the communities they serve.

Conclusion

This paper seeks to analyze and explain specific benefits of sustained K-12 outreach on the college student participants. The analysis of limited survey data from the first two years of the program and extensive survey data of 50 RAMP-UP fellows in fall 2006 indicates a significant positive impact on both undergraduate and graduate students. In the hierarchical structure of our university's program, the involved graduate fellows gain management experience that distinguishes them from their peers that have traditional research assistantships. In addition to benefiting thousands of students in the local public school system, RAMP-UP has impacted and continues to impact the involved college students. All participants agree that RAMP-UP is a rewarding experience, and the opportunities to learn and hone professional skills abound within the unique structure of the program. Many fellows feel that they are more prepared for their respective careers after working with RAMP-UP. Based on our analysis, a more detailed study on a larger scale would be beneficial to funding agencies and universities alike. K-12 outreach truly is, in the words of founder Rita Colwell, a "win-win situation."

Acknowledgements

The authors would like to thank all of the RAMP-UP fellows, former and current, who participated in this study and who continue to dedicate themselves to K-12 outreach.

References

1. Tori L. Bailey, Alexander T. Tung, and Beth L. Pruitt, *Integration of K-12 Outreach with Design Projects in an Introductory Mechanical Engineering Course*, Proceedings of the 2005 American Society for Engineering Education/Institute of Electrical and Electronics Engineers Frontiers in Education Conference, October 2005.

2. Gayle A. Buck, Diandra L. Leslie-Pelecky, Yun Lu, Vicki L. Plano Clark, and John W. Creswell. *Self-Definition of Women Experiencing a Nontraditional Graduate Fellowship Program*. *Journal of Research in Science Teaching* 43.8 (2006): 852–873.
3. Erin Cejka, Melissa Pickering, Kaitlyn Conroy, Lisa Moretti, and Merredith Portsmouth. *What do college engineering students learn in K-12 classrooms? Understanding the development of citizenship & communication skills*, Proceedings of the 2005 American Society for Engineering Education/Institute of Electrical and Electronics Engineers Frontiers in Education Conference, October 2005.
4. Ayyana Chakravartula, Barbara Ando, Cheng Li, Shikha Gupta, and Lisa Pruitt. *Undergraduate Students Teaching Children: K-8 Outreach within the Core Engineering Curriculum*, Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exposition: Excellence in Education, June 2006.
5. Janet deGrazia, Jacquelyn F. Sullivan, Lawrence E. Carlson, and Denise W Carlson. *Engineering in the K-12 Classroom: A Partnership that Works*, Proceedings of the 2000 Annual American Society for Engineering Education/Institute of Electrical and Electronics Engineers Frontiers in Education Conference, October 2000.
6. Cathy Lundmark. *Inquiry in K-12 Classrooms: Graduate Students and Teachers Team Up*. *BioScience* 54.4 (2004): 295.
7. Jeffrey Mervis. *Grad Students Head to Class as New NSF Teaching Fellows*. *Science* 286.5441 (1999): 895.
8. Jeffrey Mervis. *Sharp Jump in Teaching Fellows Draws Fire from Educators*. *Science* 288.5465 (2000): 428.
9. Bozena Pasik-Duncan and Dominique Duncan. *Undergraduates' Partnership with K-12*, Proceedings of the 2002 American Control Conference, May 2002.
10. Melissa Pickering, Emily Ryan, Kaitlyn Conroy, Brian Gravel, and Merredith Portsmouth. *The Benefit of Outreach to Engineering Students*, Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, June 2004.
11. Nancy M. Trautmann and Marianne E. Krasny. *Integrating Teaching and Research: A New Model for Graduate Education?* *BioScience* 56.2 (2006): 159-165.

Appendix

Table 1: Graduate and Professional School Intentions: RAMP-UP vs. NCSU

	RAMP-UP			NCSU	
	Graduate School	Industry	Undecided	Graduate School	Other
All	67.4%	20.9%	11.6%	46.8%	53.2%
Male	53.3%	20.0%	26.7%	23.7%	76.3%
Female	75.0%	21.4%	3.6%	29.9%	70.1%
White	57.1%	28.6%	14.3%	25.1%	74.9%
Black	80.0%	15.0%	5.0%	36.3%	63.7%
STEM	69.2%	15.4%	15.4%		
CALS				40.8%	59.2%
PAMS				35.2%	64.8%
COE				20.7%	79.3%
Non-STEM	61.5%	38.5%	0.0%		
CED				11.5%	88.5%
COM				19.5%	80.5%

A higher percentage of students employed by RAMP-UP are considering graduate or professional school than the university-wide percentages. The colleges that house the STEM disciplines at NCSU are the College of Agriculture and Life Sciences (CALs), the College of Physical and Mathematical Sciences (PAMS) and the College of Engineering (COE). All of the students who are not in STEM fields study in either the College of Education (CED) or the College of Management (COM).

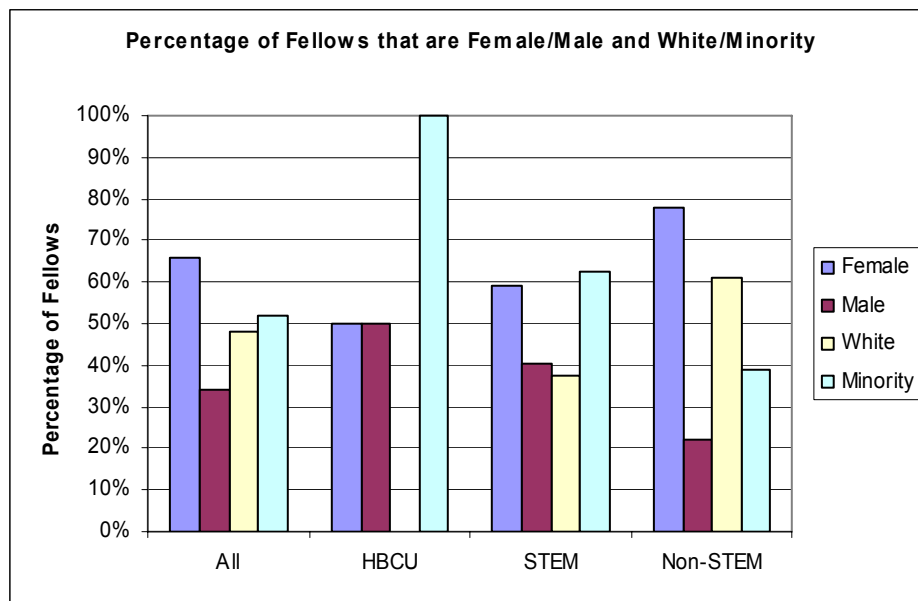


Figure 5: Demographics of the RAMP-UP Program

“HBCU” is Shaw University, the partner Historically Black College or University.

Table 2: Average differences⁵ in Likert data from August to December

Use the scale to indicate the how appealing the following aspects of RAMP-UP are (1= least appealing, 6= most):		supportive community	public speaking
All Undergraduate Fellows (N = 42)	Average	-0.6190	0.7619
	Standard Deviation	1.7937	1.5588
	p-value	0.0308	0.0029
Female (N = 28)	Average	-0.3571	0.7143
	Standard Deviation	1.9093	1.6966
	p-value	0.3311	0.0344
Male (N = 14)	Average	-1.1429	0.8571
	Standard Deviation	1.4601	1.2924
	p-value	0.0117	0.0275
STEM (N = 24)	Average	-0.2917	0.7083
	Standard Deviation	1.7315	1.1602
	p-value	0.4177	0.0065
Non-STEM (N = 18)	Average	-1.0556	0.8333
	Standard Deviation	1.8302	2.0073
	p-value	0.0256	0.0962
White (N = 21)	Average	-0.4762	0.7619
	Standard Deviation	1.5040	1.5781
	p-value	0.1623	0.0387
Minority (N = 21)	Average	-0.7619	0.7619
	Standard Deviation	2.0713	1.5781
	p-value	0.1074	0.0387

This table illustrates only the two questions of the survey that demonstrated the most statistically significant differences between the August and December surveys. To look at the change in fellows' assessment of RAMP-UP over time, we performed paired t-tests on the average Likert data for each question. Even when using a two-sided t-test and an α -level of 0.05, several of the results are significant (bold in the above table). When split into different demographic groups, conclusive correlations appear. Above, male fellows appear to be the cause of the significant drop in valuation of supportive community, and STEM fellows appear to be driving the significant increase in the valuation of public speaking.

⁵ Note that the data presented here are differences of the average Likert data, and are no longer on a scale from 1 to 6.

The following four graphs investigate the August and December surveys in greater detail. Figure 6 compares before and after data for all undergraduate fellows, and Figures 7-9 explore the comparison for STEM/non-STEM fellows, male/female fellows, and white/minority fellows.

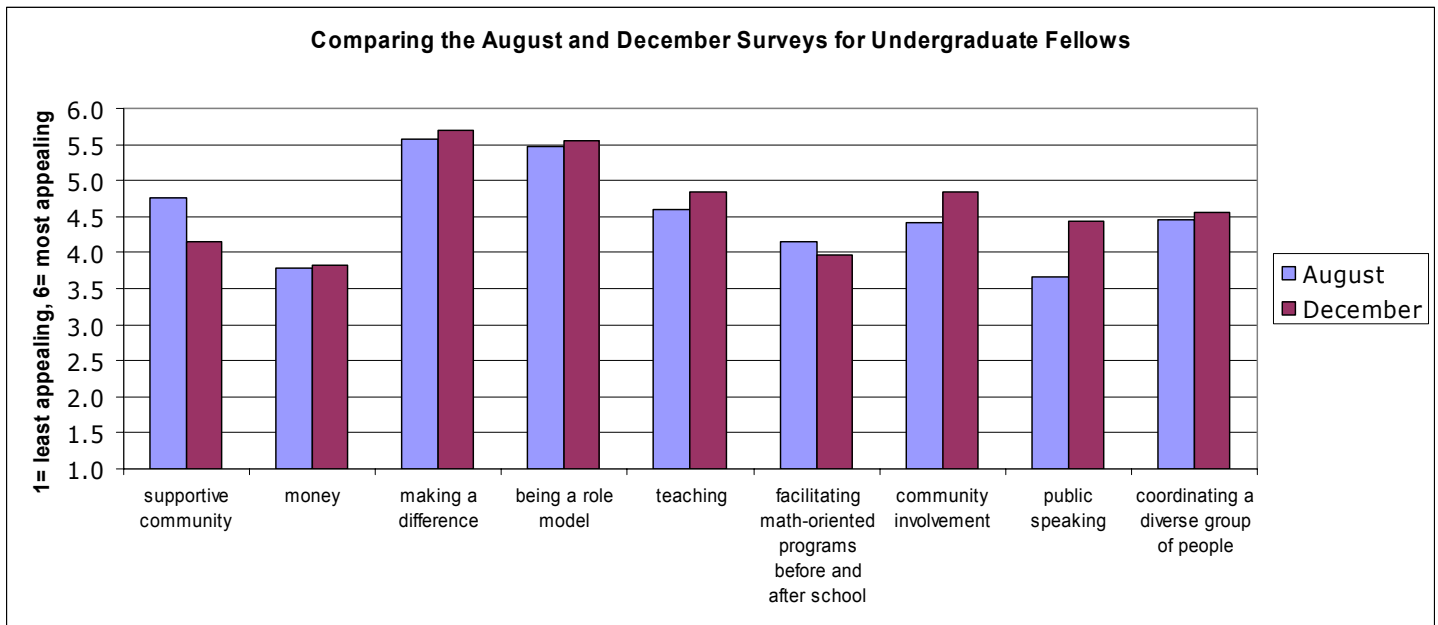


Figure 6: Comparison of the August and December surveys about what aspects of the RAMP-UP program undergraduates find most appealing

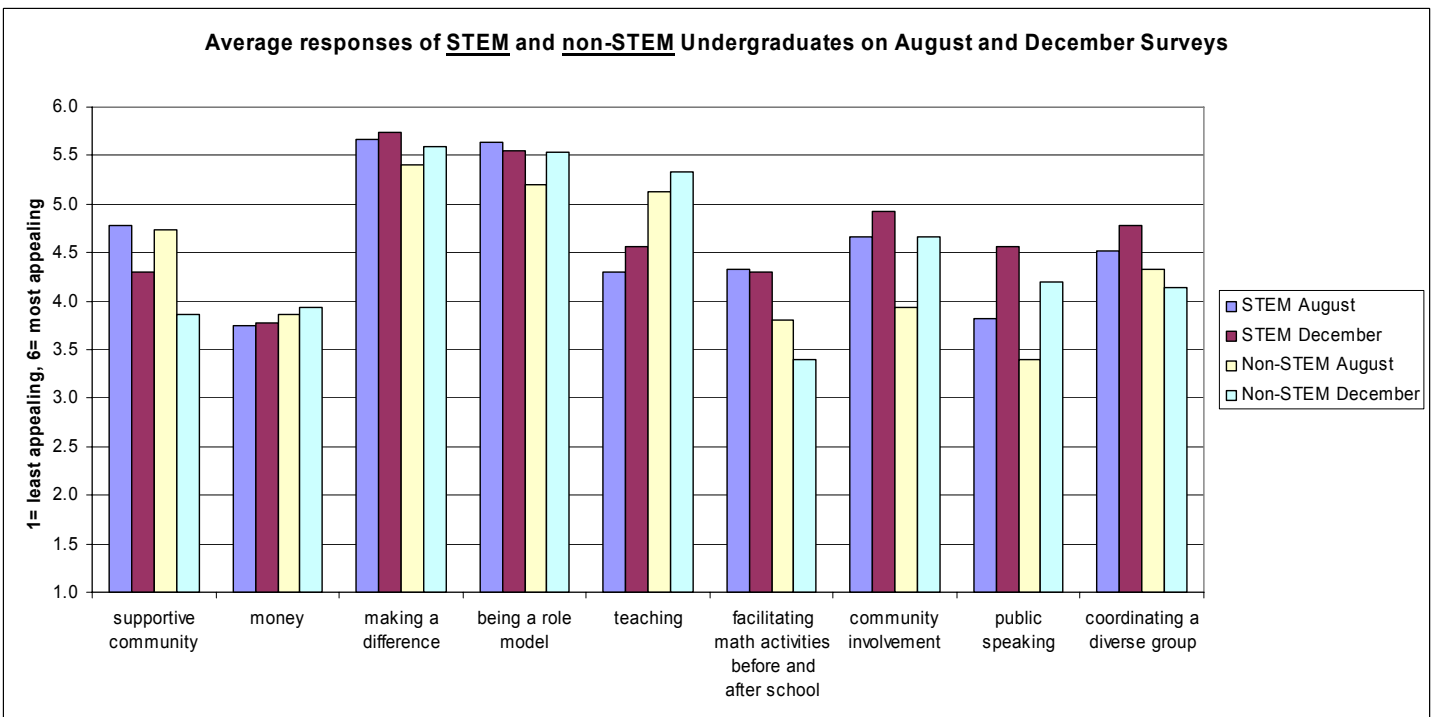


Figure 7: Comparison of the August and December surveys for STEM and non-STEM fellows about what aspects of the RAMP-UP program undergraduates find most appealing

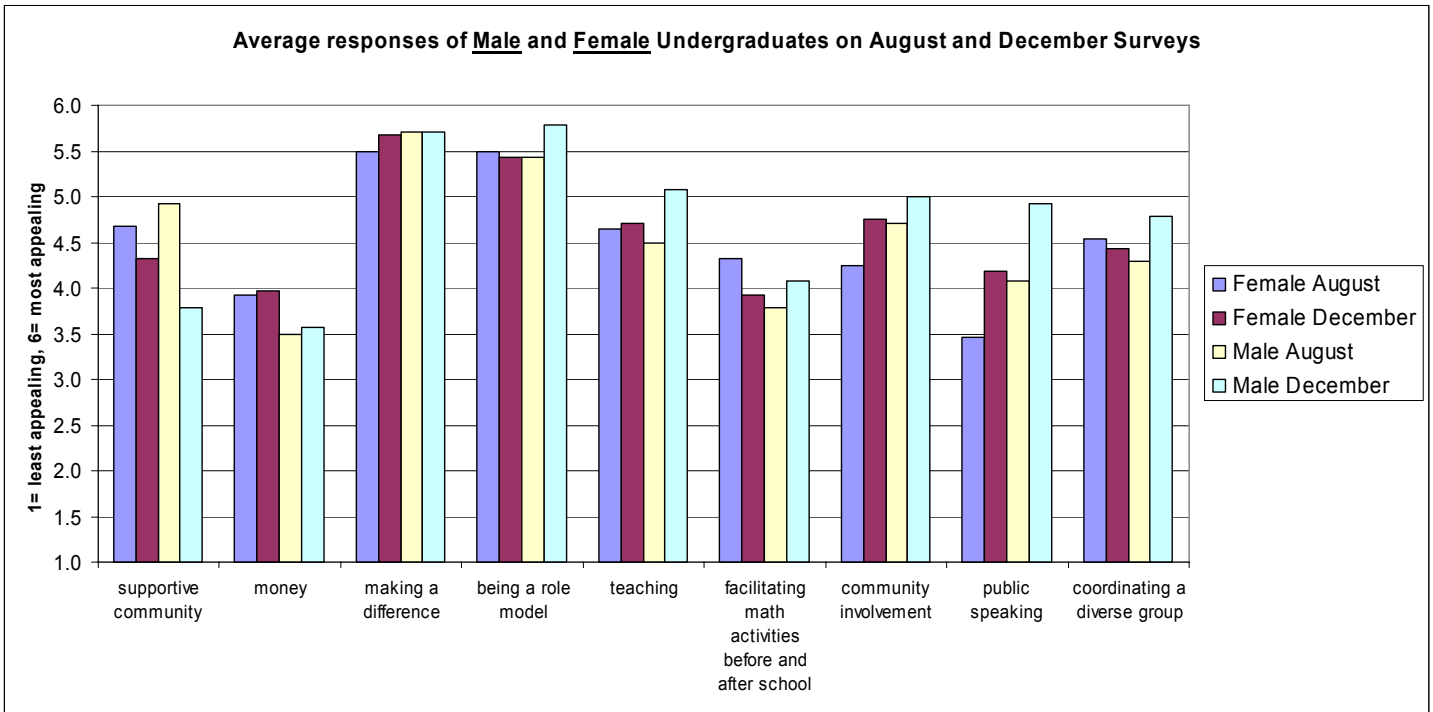


Figure 8: Comparison of the August and December surveys for male and female fellows about what aspects of the RAMP-UP program undergraduates find most appealing

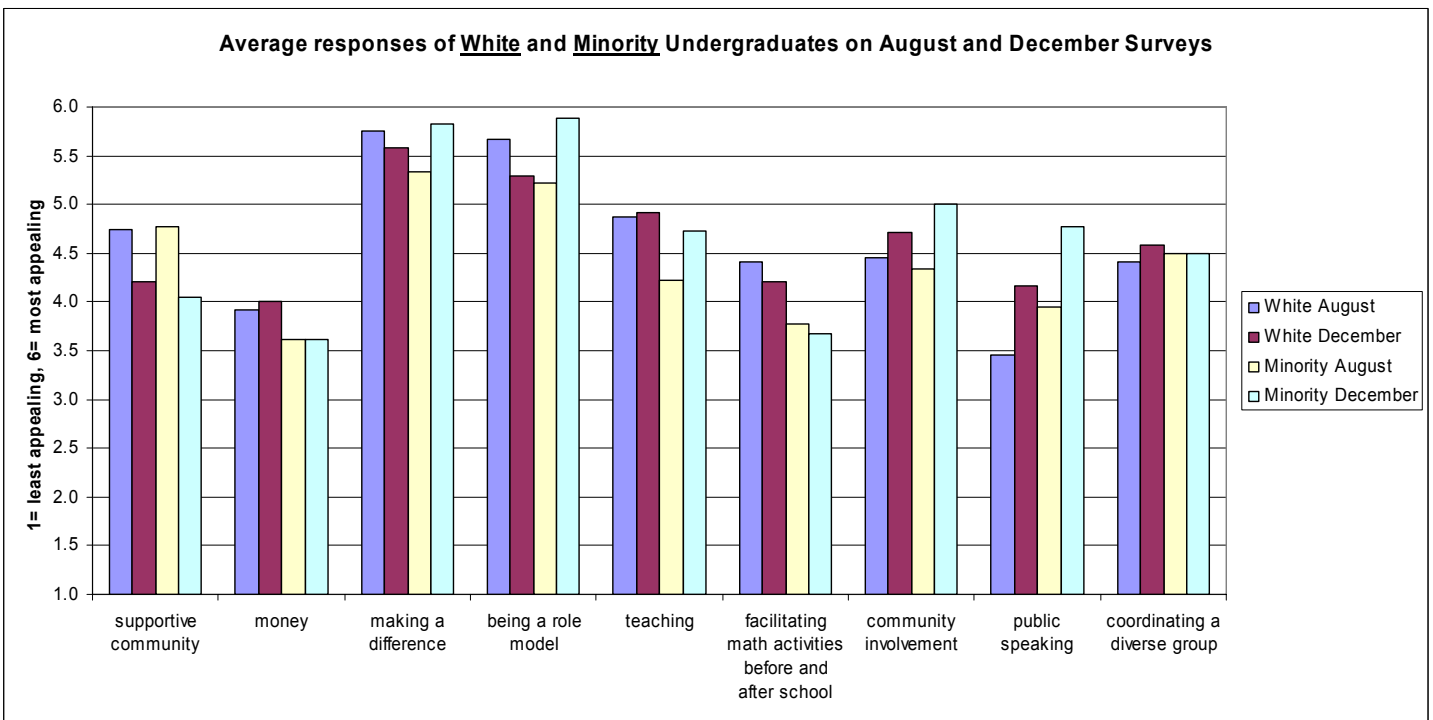


Figure 9: Comparison of the August and December surveys for white and minority fellows about what aspects of the RAMP-UP program undergraduates find most appealing

Table 3: December Survey Data (Fall 2006 Program Undergraduates) Divided by Discipline

Question Number	Question		STEM (n=24)		Non-STEM (n=18)		Two-Sample t-test	
			Average	Standard Deviation	Average	Standard Deviation	t-statistic	p-value
1		How much has the RAMP-UP program positively impacted your undergraduate experience? (1=not at all, 2=not much, 3=some, 4=a little, 5=a lot)	4.50	0.59	4.28	0.96	0.87	0.40
2	How much of a benefit has working with your graduate student supervisor been to you, in terms of:	learning about post bachelor degree opportunities	3.08	1.18	2.67	1.46	1.00	0.33
3		becoming familiar with research opportunities	2.54	1.32	2.28	1.18	0.68	0.50
4		learning professional skills (communication, organizational, time management, etc)	3.75	1.11	3.94	1.26	0.52	0.61
5		working on a team	3.83	1.20	3.72	1.45	0.26	0.79
6		working with K-12 students and teachers	4.38	1.01	4.17	1.04	0.65	0.53
7		strengthening your content area skills (math and science in particular)	3.46	1.18	3.17	1.38	0.72	0.48
8		How much of a benefit has working with your project director been to you, in terms of:	learning about post bachelor degree opportunities	3.13	1.19	2.72	1.41	0.98
9	becoming familiar with research opportunities		3.04	1.23	2.83	1.34	0.52	0.61
10	learning professional skills (communication, organizational, time management, etc)		4.25	0.74	4.22	1.17	0.09	0.93
11	working on a team		4.29	0.81	3.94	1.35	0.97	0.35
12	working with K-12 students and teachers		4.54	0.59	4.39	0.85	0.65	0.52
13	strengthening your content area skills (math and science in particular)		3.54	1.28	3.22	1.17	0.84	0.41
14			My experience in the RAMP-UP program is a factor in my satisfaction with my college experience.	4.54	0.72	4.17	1.10	1.26
15		I feel like I make a difference as a RAMP-UP fellow.	4.63	0.58	4.33	0.69	1.46	0.16
16		As a result of my experience in RAMP-UP, I am considering going to graduate school.	3.38	1.53	2.89	1.41	1.07	0.30
17		I would recommend RAMP-UP to classmates and friends.	4.75	0.74	4.17	1.10	1.95	0.07
18		I find RAMP-UP to be a rewarding experience.	4.83	0.48	4.67	0.59	0.97	0.34

Illustrated in Table 3 are December survey questions with Likert responses averaged over STEM fellows and non-STEM fellows.

Table 4: December Survey Data (Fall 2006 Program Undergraduates) Divided by Race

Question Number	Question		White (n=21)		Minority (n=21)		Two-Sample t-test	
			Average	Standard Deviation	Average	Standard Deviation	t-statistic	p-value
1		How much has the RAMP-UP program positively impacted your undergraduate experience? (1=not at all, 2=not much, 3=some, 4=a little, 5=a lot)	4.29	0.85	4.52	0.68	1.01	0.33
2	How much of a benefit has working with your graduate student supervisor been to you, in terms of:	learning about post bachelor degree opportunities	3.10	1.22	2.71	1.38	0.95	0.36
3		becoming familiar with research opportunities	2.76	1.22	2.10	1.22	1.77	0.09
4		learning professional skills (communication, organizational, time management, etc)	3.67	1.32	4.00	1.00	0.92	0.37
5		working on a team	3.57	1.43	4.00	1.14	1.07	0.30
6		working with K-12 students and teachers	4.19	0.98	4.38	1.07	0.60	0.55
7		strengthening your content area skills (math and science in particular)	3.33	1.24	3.33	1.32	0.00	1.00
8			learning about post bachelor degree opportunities	3.10	1.30	2.81	1.29	0.72
9	How much of a benefit has working with your project director been to you, in terms of:	becoming familiar with research opportunities	3.05	1.28	2.86	1.28	0.48	0.63
10		learning professional skills (communication, organizational, time management, etc)	4.10	1.09	4.38	0.74	0.99	0.33
11		working on a team	3.90	1.26	4.38	0.80	1.46	0.16
12		working with K-12 students and teachers	4.33	0.80	4.62	0.59	1.32	0.20
13		strengthening your content area skills (math and science in particular)	3.33	1.24	3.48	1.25	0.37	0.71
14		My experience in the RAMP-UP program is a factor in my satisfaction with my college experience.	4.38	0.86	4.38	0.97	0.00	1.00
15		I feel like I make a difference as a RAMP-UP fellow.	4.52	0.68	4.48	0.60	0.24	0.81
16		As a result of my experience in RAMP-UP, I am considering going to graduate school.	3.00	1.58	3.33	1.39	0.73	0.48
17		I would recommend RAMP-UP to classmates and friends.	4.33	0.91	4.67	0.97	1.15	0.26
18		I find RAMP-UP to be a rewarding experience.	4.71	0.56	4.81	0.51	0.57	0.57

Illustrated in Table 4 are December survey questions with Likert responses averaged over white fellows and minority fellows.

Table 5: December Survey Data (Fall 2006 Program Undergraduates) Divided by Gender

Question Number	Question		Female (n=28)		Male (n=14)		Two-Sample t-test	
			Average	Standard Deviation	Average	Standard Deviation	t-statistic	p-value
1		How much has the RAMP-UP program positively impacted your undergraduate experience? (1=not at all, 2=not much, 3=some, 4=a little, 5=a lot)	4.39	0.74	4.43	0.85	0.13	0.90
2	How much of a benefit has working with your graduate student supervisor been to you, in terms of:	learning about post bachelor degree opportunities	2.93	1.30	2.86	1.35	0.16	0.87
3		becoming familiar with research opportunities	2.46	1.14	2.36	1.50	0.24	0.82
4		learning professional skills (communication, organizational, time management, etc)	3.96	1.10	3.57	1.28	0.98	0.35
5		working on a team	3.93	1.21	3.50	1.45	0.95	0.36
6		working with K-12 students and teachers	4.36	0.95	4.14	1.17	0.60	0.56
7		strengthening your content area skills (math and science in particular)	3.57	1.10	2.86	1.46	1.61	0.13
8		How much of a benefit has working with your project director been to you, in terms of:	learning about post bachelor degree opportunities	3.00	1.36	2.86	1.17	0.35
9	becoming familiar with research opportunities		3.11	1.20	2.64	1.39	1.07	0.31
10	learning professional skills (communication, organizational, time management, etc)		4.32	0.90	4.07	1.00	0.79	0.44
11	working on a team		4.25	0.93	3.93	1.33	0.81	0.43
12	working with K-12 students and teachers		4.54	0.64	4.36	0.84	0.70	0.50
13	strengthening your content area skills (math and science in particular)		3.75	1.00	2.71	1.38	2.49	0.03
14			My experience in the RAMP-UP program is a factor in my satisfaction with my college experience.	4.36	0.99	4.43	0.76	0.26
15		I feel like I make a difference as a RAMP-UP fellow.	4.46	0.69	4.57	0.51	0.56	0.58
16		As a result of my experience in RAMP-UP, I am considering going to graduate school.	3.32	1.44	2.86	1.56	0.93	0.37
17		I would recommend RAMP-UP to classmates and friends.	4.46	1.04	4.57	0.76	0.38	0.71
18		I find RAMP-UP to be a rewarding experience.	4.71	0.60	4.86	0.36	0.96	0.36

Illustrated in Table 5 are December survey questions with Likert responses averaged over female fellows and male fellows.