The Creation, Evolution and Impact of a GK-12 Outreach Model

Ms. Lynn Albers, North Carolina State University

Lynn Albers is a Ph.D. candidate in the Mechanical and Aerospace Engineering department at North Carolina State University with a passion for Renewable Energy, Energy Efficiency and K-20 Engineering Education. Albers has been active in ASEE since 2008 when she presented her first conference paper with Althea Smith in the K-12 and Pre-College Division. Since then, she has authored or co-authored nine ASEE conference papers spanning the K-12 and Pre-College, Mechanical, Minority, and Energy Conversion and Conservation Divisions; presenting all of them with the exception of one paper in 2010 when she was double-booked. Lynn most recently held the position of project coordinator for the ARRA funded Student Energy Internship Program in the Mechanical and Aerospace Engineering department at NCSU. She mentored and coordinated 60+ interns with energy professionals in the private and public sectors and recruited interns to volunteer at Family STEM Nights. Prior to this experience, she was a National Science Foundation Graduate Fellow in K-12 Education working under the direction of Liz Parry, Dr. Laura Bottomley and Dr. Karen Hollebrands in the RAMP-UP program at NCSU. During this tenure she created Energy Clubs for students in grades 3-5. Lynn is passionate about experiential learning and strongly encourages the inclusion of hands-on activities into a curriculum. Her dissertation spans the Colleges of Engineering and Education and quantifies the effects of hands-on activities in an engineering lecture.

Elizabeth A Parry, North Carolina State University

Dr. Laura Bottomley, North Carolina State University

Dr. Laura Bottomley received a B.S. in Electrical Engineering in 1984 and an M.S. in Electrical Engineering in 1985 from Virginia Tech. She received her Ph.D. in Electrical and Computer Engineering from North Carolina State University in 1992. Dr. Bottomley worked at AT&T Bell Laboratories as a member of technical staff in Transmission Systems from 1985 to 1987, during which time she worked in ISDN standards, including representing Bell Labs on an ANSI standards committee for physical layer ISDN standards. She received an Exceptional Contribution Award for her work during this time. After receiving her Ph.D., Dr. Bottomley worked as a faculty member at Duke University and consulted with a number of companies, such as Lockheed Martin, IBM, and Ericsson. In 1997 she became a faculty member at NC State University and became the Director of Women in Engineering and K-12 Outreach. She has taught classes at the university from the freshman level to the graduate level, and outside the university from the kindergarten level to the high school level. She is currently teaching courses in engineering, electrical engineering and elementary education. Dr. Bottomley has authored or co-authored more than 40 technical papers, including papers in such diverse journals as the IEEE Industry Applications Magazine and the Hungarian Journal of Telecommunications. She received the President’s Award for Excellence in Mathematics, Science, and Engineering Mentoring program award in 1999 and individual award in 2007. She was recognized by the IEEE with an EAB Meritorious Achievement Award in Informal Education in 2009 and by the YWCA with an appointment to the Academy of Women for Science and Technology in 2008. Her program received the WEPAN Outstanding Women in Engineering Program Award in 2009. In 2011 she was recognized as the Women of the Year by the Women’s Transportation Seminar in the Research Triangle and as the Tarheel of the Week. Her work was featured on the National Science Foundation Discoveries web site. She is a member of Sigma Xi, past chair of the K-12 and Precollege Division of the American Society of Engineering Educators and a Senior Member of the IEEE.
GK-12 Outreach Program

RAMP-UP (Recognizing Accelerated Math Potential in Underrepresented People) was a GK-12 outreach program at North Carolina State University (NCSU) that began in 2004 with a grant from the National Science Foundation and supplemental funding from the GE Foundation. The program at NCSU was unique from the other 300+ programs across the country in that it contained a hierarchical system whereby a project director mentored graduate students who in turn managed and mentored a team of undergraduate students. The graduate student and their team of undergraduates would travel to local, inner-city K-12 schools and work directly with teachers in the classroom by preparing and leading activities that helped the students learn science, engineering and math; three of the components of the STEM (Science, Technology, Engineering and Math) initiative. The program was a win-win-win situation for the three key stakeholders: the K-12 students, the K-12 teachers and the university students. The university students brought fresh ideas and intellectual property from the university to the K-12 environment which benefitted both teachers and students, the teachers taught the university students how ‘to teach’ and improve their communication skills, and the K-12 students, inspired and motivated by the university students, responded more positively to their studies.

The graduate student, as a part of the hierarchy, received valuable experience through interacting with the project director and from managing the pairs of undergraduates and teachers. This managerial experience is something that could not have been obtained by sitting in a lecture and reading a textbook. The director led by example and provided valuable feedback to improve management techniques that effectively benefited the program, the university students, the K-12 teachers and ultimately the K-12 students.

The Model

The initial model underwent several iterations during the next six years to help maximize the university’s impact and ability to disseminate intellectual capital to the surrounding community without increasing the current workload of K-12 students and teachers. To the benefit of all involved, the flow of intellectual capital was not unidirectional. K-12 teachers reciprocated by helping undergraduates and graduates improve their soft skills as well as develop successful out-of-school time (OST) programs. The partnership that was created between NCSU and the K-12 community has not only benefited the three initial stakeholders but has also benefited the university and the K-12 school.

The permission to fund undergraduates with the grant was grandfathered into the program from a pre-existing condition. Also, with additional funding from GE, the program was able to hire undergraduates from the College of Education. Mixing undergraduates from the College of Education with the College of Engineering proved to be a win-win situation in itself. The Education majors, whose focus was math and science, helped the Engineering students with teaching techniques and proper presentation of mathematical material. For example, a math
education major enlightened the team by stressing that in an equation with an equivalent variable on each side of the equal sign, the variable doesn’t ‘cancel’ but instead, ‘they sum to zero’. Her contribution was a more correct way of explaining the math and was appreciated by all the engineering majors. Likewise, the engineering majors helped the science and math education majors by explaining such concepts such as Bernoulli’s equation and why Oobleck is a Non-Newtonian (shear-thickening) fluid. It was an excellent symbiotic relationship that helped both sides grow intellectually.

With the addition of undergraduates, the program not only utilized the intellectual capital of the graduate students but also gave them managerial experience. This forced the graduate students to develop people skills and cultivate leadership skills; two skillsets that are not necessarily developed in the confines of a graduate research lab.

In return, the College of Education undergraduates received invaluable classroom teaching experience before their student teaching semester thereby increasing their success as a student teacher. The College of Engineering undergraduates were given the opportunity to improve their presentation and communication skills. As one, male, engineering undergraduate commented, “If you can explain something to a third grader, you can explain it to anyone.”

Another positive effect of using so many undergraduates was that we could impact more K-12 students (than if the program had been comprised of graduate students only). K-12 students were impacted either by having a university student in the classroom with them during the school day or by working with a university student in an out-of-school time (OST) activity such as science fair projects, Energy Clubs, FAME, tutoring, or Family STEM Nights. For example, Energy Clubs were an opportunity for students in grades 3-5 to learn about renewable energy, energy efficiency and recycling. The graduate student prepared original activities or utilized those prepared by the Engineering is Elementary team from the Museum of Science in Boston. The two most popular activities were building windmills from milk cartons, Popsicle sticks and index cards (an EiE idea) and building solar cars to participate in the Junior Solar Sprint at the university’s campus. In preparation for the solar cars, the graduate student prepared activities that demonstrated how gears work and how solar panels collect the sun’s energy (photons) and convert it into electricity. Another example, Family STEM Nights were typically held in the evening for 1-2 hours and were an opportunity for parents and their children to engage in activities together that demonstrated the STEM principles. The goal of the evening and the activities was to remove the fear-factor associated with science, technology, engineering and math, to teach parents the concepts so that they could help their children, and to inspire children to love STEM.

The initial model for academic years 2004-2005 and 2005-2006 was similar to that shown in Figures 1 and 2 for years 2006-2007 and 2007-2008 respectively. The model was essentially the same for the first three years with the exception that the number of participants increased each year and reached it’s maximum size by the third year (2006-2007) when 37 undergraduates mentored by 4.5 graduate students worked in 8 schools (one high, two middle, and 5 elementary) with 70 teachers and impacted 3,500 K-12 students. This number was nearly double that impacted during the first year of the program.
**Figure 1**: 2006-2007 Organization Hierarchy

**Figure 2**: 2007-2008 Organization Hierarchy

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### 2,500 K-12 Students Weekly + 1,000 for Community Outreach Events

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### 1250 K-12 Students Weekly + 1,000 for Community Outreach Events
After three years, resources dictated that we modify the model and our project director implemented new ideas to maximize the remaining resources. As a result, we were able to extend funds (of a five-year grant) to six years (using a no-cost extension).

The number of graduate students naturally decreased from 4.5 to 2 due to graduation. Similarly, the quantity of undergraduates decreased from 37 to 26. With fewer university students, we also decided to reduce the number of schools from 8 to 6 (two middle and four elementary). Even with the decreased numbers, we were still able to impact 2,250 K-12 students.

A marked change occurred in the fifth year where our project director decided to divide the responsibilities of the undergraduates into two roles, that of either an in-classroom fellow or of an out-of-school time (OST) partner. The fellow would still work with the teacher in the classroom and help with OST events as their schedule allowed. Partners’ primary responsibility would be helping with Family STEM Nights first and then other OST events as their schedule permitted.

The creation of separate Undergraduate Fellow and Partner positions allowed us to maintain a presence in the same number of schools (6) and impact 2,000 K-12 students while incurring fewer payroll hours.

By the sixth year, through graduation, the number of undergraduates had decreased to twelve (less than half the number from each of the previous two years) and the number of schools decreased from six to four (three elementary and one middle) but we were still able to impact 1,450 K-12 students or 72.5% of the previous year’s amount using half the resources.

Table 1 shows the number of university students involved in the program for each year and the respective number of K-12 students impacted. The column containing the number of university students includes the total of undergraduate plus graduate students. The column for the number of K-12 students is the combined total of those impacted by a university student in a classroom setting or an OST setting. The final column shows the number of K-12 students impacted per university student.

<table>
<thead>
<tr>
<th>Academic Year</th>
<th># University Students</th>
<th># K-12 Students Impacted</th>
<th>Impact Ratio of K-12 to University Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-2005</td>
<td>30</td>
<td>1,800</td>
<td>60</td>
</tr>
<tr>
<td>2005-2006</td>
<td>40</td>
<td>3,000</td>
<td>75</td>
</tr>
<tr>
<td>2006-2007</td>
<td>41.5</td>
<td>3,500</td>
<td>84</td>
</tr>
<tr>
<td>2007-2008</td>
<td>28</td>
<td>2,250</td>
<td>80</td>
</tr>
<tr>
<td>2008-2009</td>
<td>29</td>
<td>2,000</td>
<td>69</td>
</tr>
<tr>
<td>2009-2010</td>
<td>14</td>
<td>1,450</td>
<td>104</td>
</tr>
</tbody>
</table>

It is interesting to note that from years three to four, we were able to reduce our staff by 32.5% while only reducing our impact ratio by 4.76%. By the sixth year, we had discovered a formula that impacted 104 K-12 students per university student thereby maximizing our resources and the dispersal of the university’s intellectual capital.
In conclusion, the evolution of the model was, in part, genius. We have created a model that works, that creates a win-win-win situation for each of the three stakeholders: the K-12 students, the K-12 teachers and the university students, and that can maximize resources. This is a way to not only disperse intellectual capital from a nearby university into the community but is a way to inspire the next generation to love STEM and potentially pursue careers in the fields of science, technology, engineering and math.

Acknowledgements

The authors would like to thank the entire RAMP-UP team for their dedication, support and commitment to K-20 STEM outreach. Special appreciation is extended to Mrs. Elizabeth Parry, Project Director of RAMP-UP, for her outstanding foresight and managerial skills.

References:


Resources:


presented at the 117th Annual Conference and Exposition of the American Society for Engineering Education (ASEE 2010), Louisville, Kentucky. K-12 and Pre-College Engineering Division


Appendix

Table 2 shows the program numbers for six years beginning with academic year 2004-2005.

Table 2: The program by the numbers.

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6*</th>
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<tbody>
<tr>
<td># of Schools</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td># of Undergraduate Fellows</td>
<td>24</td>
<td>35</td>
<td>37</td>
<td>26</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td># of Undergraduate Partners</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td># of Graduate Fellows</td>
<td>6</td>
<td>5</td>
<td>4.5</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td># of K-12 Students Impacted Weekly</td>
<td>1,600</td>
<td>2,350</td>
<td>2,500</td>
<td>1,250</td>
<td>900</td>
<td>450</td>
</tr>
<tr>
<td># of K-12 Students Impacted by Community Outreach Events</td>
<td>200</td>
<td>650</td>
<td>1,000</td>
<td>1,000</td>
<td>1,100</td>
<td>1,000</td>
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