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Service learning in science education: a valuable and useful endeavor for biology majors

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Abstract. All college students can benefit from becoming more engaged in their local community. This is especially true for biology majors who can play an active role in enhancing science education opportunities for students in the local K-12 school system. One such service-learning (SL) opportunity is presented where Nova Southeastern University college students work together with local schools by engaging young students in the excitement of hands-on science learning. This type of SL activity is beneficial to all those involved. College students gain valuable public speaking experience while learning how to explain potentially complex scientific concepts in a fun and engaging way. School students gain a varied learning experience and access to role models attending college. Elementary school teachers get some much appreciated support in bringing hands-on science opportunities to their students. College faculty are able to play a positive role providing a community need in their own children's school or a local neighborhood school.

Service Learning (SL) is defined as a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities (Billig and Waterman, 2003). The concept of SL fits well with the three-fold mission of Beta Beta Beta, specifically 1) stimulation of scholarship, 2) dissemination of scientific knowledge, and 3) promotion of biological research. Biology majors and their faculty can find ways to fulfill this three-fold mission while strengthening communities (often their own), particularly in the area of science education. When biology majors and their faculty present science concepts and show grade school students how to be excited about learning science, we are stimulating scholarship, and disseminating knowledge to the students and their teachers. As a result of this process, we are promoting the benefits of biological research and knowledge in ourselves, as well as inspiring younger minds to study and ask questions about the nature of how living things work.

Science education in crisis

Science education has been viewed as being in a state of crisis and the process of how we teach and support young people in the pursuit of science education and potential careers in science is in need of reform. The need to inspire young people, particularly young Americans from all cultural and socioeconomic backgrounds, to become scientists has never been greater (Ramirez, 2013). Having a scientifically literate citizenry is essential for making informed decisions ranging from an individual's daily life to developing sound public policy. Additionally, developing leaders in science is essential for the

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future economic prosperity and well being of the Nation (Marincola, 2006). In order to remain a leader in the global marketplace, the United States needs to maintain a strong program of education in science, technology, engineering, and mathematics (STEM). Over the last decade, the United States has lost ground in its ranking of STEM-related education and has been found by the National Academies to rank 27 out of 29 wealthy countries in the proportion of college students earning degrees in science and engineering (The National Academies, 2011). Likewise, the World Education Forum ranked the United States 48 out of 133 nations in the quality of math and science education (The New York Times, 2010). Science and mathematics curricula are becoming "grinding and unimaginative" due to strict adherence to testing criteria, which may explain why young students are not staying in the field. While this crisis is apparent at the national level, there remains a tremendous need for enhanced STEM education in various states, including Florida grade schools, and Broward County where the authors live and work. Due to recent budget constraints, several Broward County, Florida public elementary schools lost access to science education specialists who delivered 40 minutes of dedicated science education on a weekly basis to classes of grade school students (Web Resources 1). While 40 minutes per week with a dedicated specialist was not enough time, 0 minutes per week on dedicated science education is unacceptable (National Research Council, 1990). Given these pressures, there is a great need for research in the area of science education (Rutledge, 2013). Here is where a SL program that partners college biology majors with local grade schools can help to alleviate this shortfall.

Nationally, partnerships between universities and schools have led to a variety of effective hands-on and exciting learning opportunities for children, their families, teachers, university students, and faculty (Cabe Trundle et al., 2013; Ogens and Padilla, 2012; Paris et al, 1998; Smetana et al., 2012; Thomas and White, 2012). Teach For America provides an especially appealing example of how biology majors can make an impact in education, particularly in science-related fields (Tsang, 2007). The projected effects of loss of specialized STEM education at the grade school level is a decline in science literacy, resulting in lower performance by students at higher grade levels and less understanding and appreciation of science by the public at large. Hands-on learning in small groups, especially when students and their families interact in a positive and fun environment has been shown to be an effective approach to science education, especially to introduce students to more advanced concepts (Smetana et al., 2012). Overall learning of science concepts is enhanced when students engage in hands-on learning before and in conjunction with classroom instruction (Brown and Abell, 2007; Brown and Brown, 2010; Whitaker, 2012). Additionally, when students experience a "sense of wonder" they are more likely to want to learn more and invest their time and energy into more detailed study at an advanced level (Stevenson, 2013).

How the college community can help

At least 30% of approximately 6.7 million college students surveyed nationwide report having completed some form of SL in their college curriculum (Beattie, 2004). In fact, many institutions of higher education have entire departments dedicated to the maintenance and tracking of SL opportunities and community partners. An increased number of institutions of higher education, including Nova Southeastern University (NSU), have been classified as Carnegie Community Engagement Institutions (Web Resources 2). Being involved in SL programs, particularly in one's major field of study, has been shown to improve the overall college experience for students leading to greater engagement and overall retention and satisfaction (Gallini and Moely, 2003; Simonet, 2008). College students benefit by becoming more actively engaged in their own learning process and directly experiencing the relevance of their own education, possibly even investigating future career paths or interests (Kovarik, 2010; Prentice and Robinson, 2010). The community partners benefit by gaining an

excited and motivated workforce of volunteers, as well as long term relationships with universities (Mead and Kennedy, 2012). All aspects of society stand to benefit by these SL educational opportunities. This is especially true for SL projects linked to K-12 science education, where there is high demand for "concept-based science outreach at the elementary school level" (Othmer and Sealfon, 2010).

The *Science Alive!* example

The *Science Alive!* program at NSU started as a conversation between a faculty member (E.S.) and the teachers at her child's elementary school when the child was in Kindergarten (2009-2010). The faculty member wanted to make a difference in her community using her profession in a meaningful way and this program was recently featured in a TEDx Talk (Web Resources 3). This process was somewhat unique in that the college faculty member was in dialog with the elementary school faculty and leadership simply asking the question, "In what way can college faculty and students assist this school in science learning and fun?" It was suggested by school leadership and teachers that the college students and faculty organize a science family community night. The concept behind family nights is to provide a structured environment where hands-on exploration is made possible for children working together with their families (Heil et al., 1999; Jackson et al., 2011; Ogens and Padilla, 2012). A science family night was created at this elementary school (Welleby Elementary in Sunrise, Florida) and was called "*Science Alive!*" That first family science night in 2010 included 13 college students facilitating the elementary school students and their families (approximately 400 participants) to experience six different hands-on science activities ranging from exploring the strength of natural arches such as egg shells, lifting ice cubes using salt, extracting DNA from onion juice, and exploring characteristics of polymers using sodium polyacrylate (found in disposable diapers). The following year the science family night was expanded to include 38 college students (graduate students and a few alumni) to conduct a similar evening of science fun with six new hands-on science activities including making ice cream, and using strawberries, wires, pennies and nails to make an LED glow for the school community of about 400 people. The following school year (2011-2012) the program expanded to include the large-scale family night and two separate grade level science lab activities led by the college students and faculty for the second grade on the topics of states of matter and forces, motion, and energy. Throughout that school year approximately 800 students and their families were reached and 77 college volunteers participated. Last year (2012-2013) the program expanded to include eight faculty members working with their community K-12 schools. There were specific grade level events for second graders on states of matter, and forces, motion, and energy. For third graders there were specific grade-level events on the themes of classification of living things and plants: form and function. In total for the 2012-2013 school year, there were 13 events at seven different schools with an involvement of 120 college volunteers (Figs. 1-4). We expect the program to continue to expand, fulfilling an important need for both the college and grade school communities.

Figure 1. Biology I student L. Odom demonstrates her SL project "Blobs in a bottle" to college classmates in March 2012.

For the winter 2012 and 2013 semesters, the college biology major students were specifically engaged in SL projects as part of their

Figure 2. Biology major K. Donovan demonstrates how to convert a liquid to solid by making flubber with second grade students at Welleby Elementary School in Sunrise, Florida.

Figure 4. NSU biology majors with D. Boruch, principal of Welleby Elementary School, preparing to engage third graders in plant-science discovery.

Introduction to Biology laboratory courses. SL was incorporated in an effort to increase student engagement and accomplishment in the general biology course sequence (Biology I and II). For the SL component, students developed curricular units on self-selected course topics to present for elementary school students and their families potentially as part of the ongoing *Science Alive!* program. Students created informational and activity-based handouts as well as interactive, hands-on demonstrations (with explanatory handouts) which they presented to their classmates for peer-evaluation.

Approach and assessment

The SL component was 5% of the overall course grade in Biology I and Biology II. Students could complete the project in a small group or individually. Students then had the option to present their activities at various *Science Alive!* events at the local school. Pre- and post-surveys regarding biology student attitudes toward science education and the SL process, and specifically whether or not doing the SL project gave them an added sense of relevance to their coursework and improved their overall understanding of course-related materials, were administered. Additionally, the biology students were required to write a one-page reflection essay documenting their SL experience. Pre- and post-science education event surveys were also given to the grade school children, their parents, and teachers, as well as other college faculty participating in the hands-on science events (Table 1).

Figure 3. NSU students teach elementary school students at the Boys and Girls Club of Hollywood, Florida about enzymatic reactions.

Elementary school students were given pre- and post-surveys on the subject matter presented at specific grade level *Science Alive!* days. In addition their teachers were given a survey regarding program effectiveness. College volunteers were also surveyed to document their opinions of the program. Additionally, students, and parents were surveyed regarding the program effectiveness at the end of the *Science Alive!* family nights (Table 2).

All surveys consisted of statements to which the respondent would either strongly agree (1), agree (2), be neutral (3), disagree (4), or strongly disagree (5). Responses were tallied with the average numerical response for each statement reported.

Table 1. Summary of pre- and post-survey results regarding outcomes of the SL experience in Biology I and II (undergraduate courses).

Questions	Bio I pre avg (SD) [1] n=21	Bio I post avg (SD) [1] n=17	Bio II pre avg (SD) [1] n=26	Bio II post avg (SD) [1] n=29
1. Community service should not be required for a particular grade.	2.9 (1.8)	3.1 (2.1)	2.9 (4.2)	3.6 (2.9)
2. Preparing a science demo helps (helped) me understand concepts in my biology course better.	2.3 (3.6)	2.4 (1.9)	2.3 (2.9)	1.7 (6.8)
3. It is pointless to go and teach young children because they are not appreciative or interested.	4.9 (8.3)	4.8 (7.1)	4.6 (7.9)	4.9 (11.4)
4. The only way for a child to learn difficult topics pertaining to science is through tests and assessments. Hands-on learning experiences are not effective teaching tools.	4.5 (6.6)	4.1 (4.3)	4.8 (10.0.)	4.6 (9.2)
5. Children love science and enjoy learning as much as they possibly can.	2.6 (3.2)	2.1 (3.5)	2.8 (4.1)	2.1 (4.9)
6. When asked "what do you want to be when you grow up?" most of the students respond "a scientist!"	4.0 (3.6)	3.6 (1.6)	4.0 (4.1)	3.6 (3.8)
7. Science is not fun, regardless of how it is presented.	4.4 (5.6)	4.9 (5.7)	4.7 (8.4)	4.7 (8.8)
8. Young kids are difficult to control regardless of how many times you ask them to behave; they probably will not listen to you because you are not a teacher or any sort of disciplinarian.	3.3 (4.1)	3.8 (2.3)	4.1 (4.5)	4.2 (6.5)
9. Parents will be more interested in the experiments than the children.	3.3 (3.8)	3.7 (2.9)	3.9 (5.1)	3.9 (6.9)
10. I am anticipating a fun night of science activities at the *Science Alive!* event. I am excited to see how the children react to my presentation.	2.1 (4.2)	2.2 (2.4)	1.9 (4.7)	2.4 (4.5)
11. A project like this one should be a group project for BIOL I/II students.	3.0 (4.5)	2.8 (1.7)	2.5 (3.1)	2.0 (5.3)
12. BIOL I/II students should have the option to either work independently or in a group, as they choose.	2.4 (5.0)	1.7 (4.0)	1.8 (5.9)	1.2 (10.8)
13. Preparing a science demo will make/has made me more excited to study biology.	2.9 (1.8)	3.1 (2.1)	2.9 (4.2)	1.8 (5.6)
14. This project will help/did help me improve my grade in BIOL I/II this semester.	2.3 (3.6)	2.4 (1.9)	2.3 (2.9)	1.4 (9.7)

[1]Average (Avg) and standard deviation (SD) is given for each survey response (1= strongly agree; 5= strongly disagree).

Table 2. Welleby Elementary School *NSU Volunteer Participant* survey given at the end of the *Science Alive!* evening event on March 28, 2012 at Welleby Elementary School, Sunrise, Florida in Broward County.

Questions	Strongly agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly disagree (5)	Total	Average	Standard deviation
1. I enjoyed this experience for community service.	61	6	1	0	0	68	1.1	26.6
2. I enjoyed working with my team members	59	9	1	0	1	70	1.2	25.4
3. I made new contacts with classmates and/or upperclassmen that may be useful to me throughout my education.	49	9	4	0	4	66	1.5	20.2
4. I plan to put my participation in this event on my resume.	50	6	9	2	1	68	1.5	20.6
5. I believe these experiments were a great way to present simple science demonstrations using basic household items.	52	14	2	1	0	69	1.3	22.1
6. I plan to return again next year, if I am in the area and available.	61	2	2	0	1	66	1.2	26.7
7. I can imagine myself doing these experiments again at another school or with a family member.	61	9	0	0	0	70	1.1	26.6

NSU participant survey comments:
1. "Great experience!"
2. "Great time, I would love to volunteer again"
3. "Always a pleasure"
4. "Excellent!"
5. "Some of the groups were very large and overwhelming, 30+ students at once"
6. "Some of the groups were too big"
7. "More supplies were needed for the penny pipetting experiment"
8. "You are the best Dr. Schmitt!"
9. "Need more food coloring colors"
10. "I love Science Alive!"
11. "Science is awesome!"
12. "Yay for science!"
13. "I loved it, I will be back next year!"
14. "We should have the teachers help us calm the students down, that would help the process go smoother."
15. "Thank you for allowing me to participate, it was a splendid evening. I would love to do this at the high school level with alternate experiments more suitable for the higher school levels!"
16. "I enjoyed the experience, it is something I would love to participate in again and I look forward to do these experiments at home with my little sister!"
17. "Good time"
18. "I had so much fun! Possibly even more fun than the kids, I am glad they all enjoyed the demonstrations!"
19. "Thanks for having us Welleby Elementary!"

Everyone benefits from science education service learning

Interactive and fun science activities provided a benefit for everyone involved. The college faculty generally felt a greater sense of community involvement and purpose to their work, college students felt like they were making a difference in the community and in their own education, the grade-school children had fun and in some cases were surprised at how much fun they had doing science. The

parents were thankful for the opportunity and for ideas of ways to have fun exploring science at home. School administrators were delighted that there was an additional way of presenting science content while making it engaging and fun for the students and teachers without much of an additional burden placed on the school. Over the years that this program has been growing, the original elementary school has been featuring the program activities in regional newsletters (Broward County Public Schools, 2010) and the school yearbook (Welleby Elementary School, 2012-2013). Students and their families genuinely look forward to these events every year. The following comments represent typical sentiments from each of the different groups involved in the science education SL project (college students, college faculty, school children, families and community members, school teachers, and school administrators).

From college students

"Throughout this experience I learned more about myself; I learned that I can be a leader within a group. I even got a compliment that I was a good speaker."

"The *Science Alive!* project wasn't only pleasant to prepare during class and experimenting at home, but it was also rewarding to know that the children at the elementary school enjoyed and learned from our efforts. The littlest experiment can bring so much joy to these children. With this experience, I have been able to teach and show my own children what I was taught."

"It was a great learning experience and I feel honored that I was able to give back to the community and receive a grade for it. This event was a great addition to our biology course and teaches the elementary kids as well as the college students."

"The enthusiasm and happiness in the children's eyes when they got a turn to do the science activity almost brought me to tears... One of the children came up to me and asked me to explain more details... He then told me... You are just so smart!, with the cutest scrunched up face I have ever seen. This experience gives you an unforgettable feeling of satisfaction and happiness that you can get addicted to."

"I think our school should have more events like this because it is not only a great activity and environment for the college students to exchange knowledge, but also creates a good image of the University in the mind of the elementary school student's parents."

"*Science Alive!* has truly opened the doors for these students and has provided reinforcement for pursuing college in the future. After volunteering here, I feel that I have impacted their lives and offered these kids a role model they can count on."

From college faculty

"Being able to facilitate this learning experience for my own students while connecting with the teachers and administration at my own children's school is a very meaningful and rewarding experience."

"The program has been greatly beneficial to me and my students. It has been a fulfilling experience engaging elementary school students and enriching to watch their eyes spark as they get curious and explore the sciences. It has benefited young college students who have expressed great thrill in being a mentor/teacher/role-model and a kid again! As a parent of elementary school students the program has been doubly useful to me (professionally and personally). Using *Science Alive!* experiments and topics at home has kept my children busy for hours and helped us build on fun family events. I look forward to taking the event to more schools and engaging more students in this wonderful program."

"Elementary and middle school students jump out of their seats begging to answer questions even if they don't know the answer. I always ask my college students a lot of questions during each lecture. I've become used to only having a handful of students participating in course discussion. Participating in *Science Alive!* has made me work harder for my students to reawaken their lost passion in scientific inquiry and discovery."

"Lab courses seem to be the most intimidating courses for science majors and the reason some don't pursue science. *Science Alive!* promotes scientific inquiry and discovery as it was meant to be... fun!"

"I love participating in *Science Alive!* because while these kids may not realize it in the moment, many will take their first step toward becoming scientists as a result of these events."

From school children

"It was really fun and I hope they have this in middle school because it was fun. I believe that the people from the college were fun, happy, and were enjoying themselves."

"Thank you for the fun and cool science experiments. My favorite part was turning a liquid into a solid. I loved it!!! I want to try it at home and I can't wait to do it again. You are such an inspiration. I love science now."

"You and your students are the most spectacular people in the universe since you did those experiments with my class. I remember you and your students making raisins dance and that balloon activity with vinegar and baking soda. Your work was amazing, wonderful and special. But the most surprising thing is that you made things that I didn't think were possible. Thank you so much."

"Science Rocks! Thank you for coming to our school and doing *Science Alive!* I learned a lot and had fun. Thank you."

"Thank you for the wonderful experiments. It was very exciting. Dancing Raisins was the best experiment I have ever seen. I even did it at home!"

From families and community members

"Awesome! We need this here monthly! Great activities, nice college students! The presentations were good and introducing names and their study major was also very good. I loved it all!"

"Pretty cool, good stuff, Thanks for this event, I am glad to see my daughter participated and I hope to see you next year."

"My family and I had such a great time doing the science experiments. I loved all the projects especially the one where the light glowed from strawberry power."

From school teachers

"Wow! What a spectacular, interactive science presentation you conducted with my students. The experiments were so exciting and fun! The students really learned a lot about solids, liquids, and gases. Thank you for your time and dedication in wanting to teach children about science. We are looking forward to the "Energy" lessons that will be done next month. When I told my class that you are all coming back...they let out shouts of "Yes!" and Yeah!"

"Awesome program! I love how great the volunteers were with the kids!"

"Great presentations! The students loved it."

"My students learned so much about matter. They all went home using words they learned."

"A fantastic experience! Thank you for taking the time to be here. Our students

really enjoyed everything. Hands-on is great for young children to grasp the concepts. This program is very beneficial."

"The students loved the hands-on activities. They were engaged in the learning experience. Everything was very well organized and kid-friendly!"

"*Science Alive!* was a great experience for the kids. They enjoyed the hands-on activities and enjoyed learning at the same time. Thank you for coming. We look forward to seeing you next month."

"The kids had a wonderful time. They wanted to spend the whole day learning with your team. Thank you."

From school administrators

"Since the *Science Alive!* program has been growing at our school, I have noticed that our students' science comprehension has increased as is evidenced by the entries in their science notebooks and workbook activities. Additionally, the students' excitement for science and their desire to learn more on their own has also greatly increased. It is essential to be able to study this effect of increased early literacy in science education in a more formal manner."

"We look forward to developing this program over the years and tracking our students' successes in science."

Summary of survey results

The following is a summary of results from the program evaluation and learning surveys given to the various groups involved in this hands-on science education SL project.

Biology course service learning survey results

The college students involved in SL as part of their Biology I and II courses discovered that children really do love science and enjoy learning, many of them would like to be scientists when they grow up and preparing a science demonstration really made the college students more excited to study biology and helped them to improve their overall course grade. The biology majors also discovered that science really is fun, young children are not that difficult for them to teach when engaged in hands-on science learning experiences and in fact students are often more interested in the science activities than their parents.

General college student volunteer post-event survey results

College students found this SL project in science education to be a very enjoyable experience. They strongly agreed that they enjoyed working with their team members, made new contacts with classmates that will be useful throughout their education and they plan to put their participation in this event on their resume/cv. They also strongly agreed that they believe the experiments they learned and presented are great ways to present simple science concepts using basic household items. They strongly agreed that they plan to return again for future events, and they can imagine doing these experiments again at another school or with a family member.

Elementary school student post-event survey results

The elementary school students strongly agreed that they had a great time at *Science Alive!* and they want to come back again. They really liked each of the activities and they especially liked having the college students come and talk with them. They strongly agreed that the college student presenters were well prepared and they (80% of the children surveyed) plan to do the experiments (that they learned at the event) at home with their parents.

Elementary school student parent post-event survey results

The parents strongly agreed that they want to return to similar events in the future and that

they had a wonderful experience. They also believed that the experiments were a great way to present simple science concepts using basic household items, and they appreciated that hands-on activities make learning more fun. While some expressed that they had done some of the activities from previous sessions at home with their children (51% of the parents surveyed), 85% of the parents surveyed agreed that they plan to do some of the activities from the current event at home with their children. The parents also agreed that they planned to go to the school website to get the directions for the activities they had learned at the science family night (85% of the parents surveyed).

Teacher post-event survey results

Teachers strongly agreed that the SL activities were great ways to demonstrate the important science concepts they were teaching in the classroom and that hands-on learning is a wonderful way for children to learn science, in addition to learning the materials in the classroom. They also agreed that the volunteers were well prepared and that activities were of the appropriate level for students to be able to remember them and do them at home with their families. They agreed that the activities would greatly enhance the students' abilities in science literacy and knowledge. They looked forward to additional events and acknowledged that the students greatly enjoy interacting with the college students as role models and enjoy enhanced learning as a result of the program.

Conclusions

Students on all levels had an exciting, interactive, and genuinely fun time exploring science through this course-linked SL program and in general as a educational volunteer opportunity. College students gained an added sense of mastery over course content, while strengthening the community and fulfilling a need. Public speaking ability in college students was greatly enhanced as was their confidence levels as presenters. College students served as scientist-role models for the elementary school students, and directed groups of young children through activities of science exploration and discovery. Additionally, members of the University community were brought together (faculty, graduate students, undergraduate students, alumni, administrators and friends) while sharing the excitement of doing science. It was readily apparent that everyone involved grew in some way during the SL process. *Science Alive!* family nights and grade-level science days at Welleby Elementary School have grown in attendance and scope each year, attracting the attention of parents, as well as upper level grade school and college administration.

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Web Resources

1. Broward County Public Schools. www.browardschools.com

2. Carnegie Foundation for the Advancement of Teaching. List of 2010 Classified Institutions. http://www.carnegiefoundation.org/

3. TEDx Talks. TEDxNSU: Lighting the bulb: sharing your profession and passion with the community. E. Schmitt. January 2013. Viewable online at: http://www.youtube.com/watch?v=xgtj3Ue3uDY

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