Can Service-Learning in K-12 Math and Science Classes Affect a Student's Perception of Engineering and their Career Interests

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Abstract - **The objective of a National Science Foundation (NSF) sponsored grant entitled, "Making Connections: Resources for K-12 Service-learning and Experiential Learning in STEM Disciplines" was to encourage K-12 educators to incorporate service-learning into the science and math curriculum by providing an easy-to-use resource. It was hoped that the use of service-learning in the science and math curriculum would help promote the entry of women and minorities into the Science, Technology, Engineering and Mathematics (STEM) fields, increase the potential pool of engineers and scientists in the United States, contribute to the development of STEM educators and enhance cultural sensitivity, ethics and social responsibility in future STEM workers. As part of this grant, 60 local K-12 teachers were asked to use the website, facilitate an activity identified on the website and assess the usefulness of the website as well as the perceived affect the activity had on the students. All participants were asked to fill out a survey to assess the usefulness of the website as well as the perceived impact of service-learning in enhanced student interest in STEM. A subset of this group facilitated well developed career interest inventory tools prior to and after facilitating the activity in an effort to determine if the activity had an affect on the students perception of engineering or the resultant career choices. This paper will focus on the survey, assessment tools and will present the results obtained from the survey.**

Index Terms – engineering education, service-learning, STEM

INTRODUCTION

A 2004 National Science Board (NSB) report entitled *An Emerging and Critical Problem of the Science and Engineering Labor Force* presents troubling statistics regarding the declining number of students pursuing engineering and science degrees and the anticipated increased need for scientists and engineers. The report goes on to say that, " The United States has always depended on the inventiveness of its people in order to compete in the world marketplace [1]." Additional factors such as a changing global economy, a national economy that is changing from a manufacturing base to a knowledge base and the increased need for science and engineering solutions to problems associated with limited natural resources, increased demand and global climate change make the need for scientists and engineers a problem that threatens not only national security, but also the health of our planet [1-3].

Unfortunately, reversing this trend is not something that can be achieved quickly. The NSB suggests that the process can take as much as 10 to 20 years [1]. Why such a slow process to reverse this trend? Studies have been conducted that suggest that many children start losing interest in science and math during middle school (grades 6 – 8) [4-6]. Scientists and Engineers who are entering the workforce today were at this critical point in their education, middle school, at least a decade ago [4-6]. Therefore, the NSB recommends that significant investments at the local state and national level be made to recruit, train and retain scientist and engineers [1].

Numerous resources are available for teachers to enhance their teaching and to provide them with innovative ideas for making science and math more appealing to students. Many of the resources are web based which makes them easily accessible. One excellent example of such a resource is the TeachEngineering website hosted by NSDL, NSF and FiPSE. This free, searchable website provides activities, lessons, hands-on modules and real life examples for K-12 teachers that is connected to the math and science curriculum standards for numerous states [7]. The Center for Innovation in Engineering in Science (CIESE) website provides science, engineering and math projects and curriculum including online collaborative, virtual projects with other schools [8]. Many professional societies such as ASME, ASEE and IEEE have resources for K-12 teachers and students including curriculum, career information and

activities. The ASEE site also includes an outreach program data base, blogs and games [9-11]

One pedagogical strategy that is finding increasing use in engineering education is service-learning [12-14]. In a report from the national commission on service-learning entitled *Learning In Deed – The Power of Service-Learning for American Schools*, service-learning is defined as, " A teaching and learning approach that integrates community service with academic study to enrich learning, teach civic responsibility and strengthen communities [15]." Several papers have presented data which suggests that service-learning may be an effective tool for increasing the interest of students, especially females, in science and math and may be useful in recruiting students into Science, Technology, Engineering and Math (STEM) related fields [14, 16-19].

Although there are many on-line resources for K-12 science and math teachers and there are many on-line resources that support service-learning, few if any of these resources connect the STEM subjects with service-learning activities [20-23]. Therefore, the objective of this project was to develop a website for K-12 science and math teachers to make it easier for them to incorporate service-learning into their classrooms.

GENERAL APPROACH

In May of 2006, The University of Dayton was awarded a National Science Foundation (NSF) grant entitled, "Making Connections: Resources for K-12 Service-learning and Experiential Learning in STEM Disciplines". The objective of this project was to develop a website that housed service-learning modules for K-12 science and math teachers to make it easier for these teachers to incorporate service-learning into their curriculum. It was hoped that by incorporating service-learning into the math and science curriculum, that students would become more interested in these subjects, have a greater awareness of the STEM fields and be more likely to pursue STEM careers later in life. Furthermore, it was hoped that science and math educators would become more informed on the content and application of STEM subjects and careers.

Development of this website included identifying appropriate resources and curriculum materials, developing advertising brochures for website promotion, website design, pilot testing, assessment and evaluation of the site, website revision, identification of additional content, student/teacher assessment and final presentation of the resources to Ohio K-12 educators and to a national audience.

Initially, service-learning modules were identified on the web by math, science and engineering faculty from the University of Dayton. Criteria were established for evaluating the suitability of these modules for inclusion on the STEM website. Each module was then assessed to determine if it was age appropriate, curriculum specific (using the Ohio Department of Education Academic Content Standards for K-12 Mathematics and K-12 Science Standards as a guide), academically challenging, transferable, inexpensive, easy to implement and could be adapted for service-learning [24, 25].

For each module, a project abstract and summary sheet was created. The project abstract provided a short overview of the project which was created to allow teachers to review the modules quickly. The summary sheet provided more detailed information as well as a link to the source site. When the summary sheets were added to the website they enabled the use of a search engine to make it easier for teachers to identify appropriate modules. Each summary sheet contained useful information such as the curriculum topic, target grade level, time and cost required to implement, needed supplies, suggested community partners and links to related or support websites.

Using the content identified by the faculty, a prototypic website was designed and developed by a group of undergraduate engineering students as a service-learning project for an engineering management course. Once functional, the prototypic website was pilot tested by a group of 20 area K-12 STEM teachers. The teachers were asked to use the website, facilitate one module then assess the usefulness and aesthetics of the website. The overall design of the website was modified in accordance with the teachers' comments and a permanent website hosted on the University of Dayton server was procured, http://stem.udayton.edu/.

The following summer, additional service-learning modules were identified and/or developed and summarized by area teachers. The modules were then assessed for curricular content by a School of Education faculty using the Ohio Department of Education Academic Content Standards described above. Additional resources including general information on service-learning, career connections and downloadable engineering career flashcards were also developed. This content was added to the permanent stem website.

In the fall of 2007, area teachers were asked to use the website and facilitate and assess a service-learning activity during the 2007-2008 school year. Participating teachers were asked to fill out a survey regarding the functionality, content and aesthetics of the website as well as their perception about the impact that the project had on their students. A subset of these teachers was also asked to facilitate a pre- and post- test in an effort to determine if participating in the service-learning activity had an impact on how the students' career interests and perceptions of the field of engineering. The tools used to assess the students' career interest were the O*NET Career Interest Inventory from CFKR Career Materials and an addendum created by the project team [26].

RESULTS

Results of the survey are provided in Table 1. Data from the pre- and post- tests is currently being analyzed and should be available by May 1, 2007. Overall, the results from Table 1 suggest that the website was easy to use, provided good information on service-learning and provided modules that enhanced the course content. Furthermore, the service-

learning activities facilitated by the teachers correlated well with the curriculum, enhanced student learning on the subject matter, increased student motivation for learning and helped foster skills related to civic engagement and understanding other people. Most of the teachers strongly agreed that the students had fun participating in the service-learning activities. Unfortunately, results from the survey do not show strong support that the students were able to make a connection between the projects and the STEM careers, particularly engineering. Some of the teachers commented that the flashcards provided on the website were not appropriate for students in the younger grades. Many of the teachers also did not make use of the career connections provided at the end of the modules. Teachers also commented that there were not enough modules to support the physical sciences at the higher grades. In some cases the teachers developed their own modules which will be added to the website.

Although, not all of the data from the pre- and post- test is available for analysis, many of the teachers commented that the these tests took a long time to facilitate. Some teachers in the younger grades indicated that the students got bored doing the pre- and post- tests and that some of the tests, were difficult for the students to understand even though the tests were grade level specific. The addendum created by the project management team, was also difficult for the younger students to understand, but this was anticipated since only one addendum was created for all grade levels.

CONCLUSIONS

A web based resource was created for K-12 teachers to make it easier for them to incorporate service-learning activities into their science and math courses. It was hoped that the incorporation of service-learning activities into science and math courses would help increase student interest in these subject areas and hopefully encourage them to eventually consider pursuing STEM careers. Recently the service-learning website was assessed via a teacher survey and pre- and post career interest inventory tests. Results of the teacher survey indicate that the website was user friendly, aesthetically pleasing and contained useful information and modules. Most of the teachers felt that the service-learning activities helped to increase student interest and motivation to learn and helped to foster a sense of civic engagement, understanding others and teamwork. The teachers did not feel that the activities were highly effective at helping the students to understand STEM careers or to peak their interest in these careers. Suggestions were provided through teacher comments including more modules relating to the physical sciences. Results from the pre- and post tests are expected to be available in early May.

ACKNOWLEDGMENT

This project was sponsored by the National Science Foundation Grant 04-608, DIS: Making Connections: Resources for K-12 Service-learning and Experiential Learning in STEM Disciplines.

TABLE I
RESULTS OF SURVEY

Question	Average	St. Dev
Site Aesthetics		
1. The homepage is inviting.	6.44	0.856
2. Colors are pleasing.	6.22	1.166
3. Pictures are appropriate	6.56	1.149
4. Appearance is professional	6.56	0.922
Content		
1. Homepage has info on service-learning	6.22	1.517
2. Homepage has info on experiential learning	5.89	1.745
3. Operation of site understandable	6.56	1.338
4. Info provided at appropriate level of understanding	6.67	1.414
5. Module content appropriate for classroom implementation.	5.44	1.542
6. Module format is suitable.	6.17	1.383
7. Curriculum topics correctly categorized.	6.22	1.003
8. Student groups appropriately divided.	6.28	1.274
Navigation		
1. Site easily navigated	7.17	0.985
2. Info easily accessible.	6.89	1.231
3. Serach engine is helpful.	6.44	1.294
4. Added website links provide useful info.	6.78	1.396
5. Website navigation tools took you where you wanted to go.	6.44	1.464
Utilization		
1. Site enhanced traditional course content	6.17	1.465
2. Site was beneficial to planning lessons.	5.83	1.543
3. Module content was appropriate.	6.06	1.392
Service-Learning Evaluation		
1. Project correlated well with curriculum	6.65	1.693
2. Project description was clear and easy to follow.	6.53	1.767
3. Links on project description provided useful info.	6.86	1.027
4. Participation enhanced student learning on subject matter.	7.18	1.237
5. Project appeared to increase student motivation for learning	7.00	1.715
6. Participation enhanced student learning on:		
a. Civic engagement	6.00	1.581
b. Understanding other people	6.39	1.720
c. Team work	7.28	1.364
d. Careers realated to curriculum being covered (STEM)	5.35	2.029
7. The students had fun doing the project.	7.56	1.294
8. The school administration was supportive of project.	7.44	1.504
9. Career flashcards were helpful in understanding engineering.	5.25	1.915
10. Career connections at the end of modules were useful.	5.31	1.740

0 = strongly disagree; 2 = disagree; 4 = neutral; 6 = agree; 8 = strongly agree

REFERENCES

[1] http://www.nsf.gov/statistics/nsb0407, accessed 20 March 08.

[2] US Bureau of Labor Statistics, http://www.bls.gov, accessed Jan 1, 2008.

[3] National Science Board, Science and Engineering Indicators 2000, Washington, D.C., US Govt Printing Office, 2000.

[4] Miller, P., Blessing, J., Schwartz, S., *Gender Differences in High-School Students' Views About Science*, **International Journal of Science Education, 28:4**, pp. 363-381, 2006.

[5] Robinson, M., Kenny, B., *Engineering Literacy in High School Students, Bulletin of Science*, **Technology and Society, 23:2**, pp 95-101, 2003.

[6] Kimmel, H., et. al., *Bringing Engineering into K-12 Schools: A Problem Looking for a Solution*, **Proceedings of the 2006 American Society of Engineering Education Conference and Exposition,** 2006.

[7] http://www.teachengineering.com, accessed 20 March 2008.

[8] http://www.ciese.org, accessed 20 March 2008.

[9] http://www.engineeringk12.org, accessed 20 March 2008

[10] http://www.ieee.org, accessed 20 March 2008

[11] http://www.asme.org/education/precollege, accessed 20 March 2008

[12] Duffy, J. **Service Learning in a Variety of Engineering Courses, Projects that Matter: Concepts and Models for Service Learning in Engineering**, AAHE, E. Tsang, ed., Washington D.C., 2000.

[13] Riley, D., Bloomgarden, A.H., *Learning and Service in Engineering and Global Development*, **International Journal for Service-Learning in Engineering, 2:1**, pp. 48-59, 2006.

[14] Coyle, E., Jamieson, L., Oakes, W., *EPICS: Engineering Projects in Community Service*, **International Journal of Engineering Education**, 21:1, pp. 139-150, 2005.

[15] Learning in Deed: A report from the National Commission on Service-Learning, available at http://www.learningindeed.org, National Commission on Service-Learning, 2005.

[16] Watson, S., Sherick, H., Plumb, C., *Using a Service-Learning Project to Make Progress on Both Recruitment and Retention Objectives for American Indian Engineering Students*, **Proceedings of the 2007 American Society of Engineering Education International Exposition and Conference**, 2007.

[17] Barrington, L., Duffy, J., *Attracting Underrepresented Groups to Engineering with Service-Learning,* **Proceedings of the 2007 American Society of Engineering Education International Exposition and Conference**, 2007.

[18] Skokan, C. , Gosink, J., *Gender Participation in Humanitarian vs. Traditional Multidisciplinary Senior Design Projects,* **American Society of Engineering Education 2005 International Conference and Exposition,** 2005.

[19] Oakes, W., Jamieson, L., Coyle., *EPICS Meeting EC 2000 Through Service-Learning*, **Proceedings of the 2001 ASEE Annual Conference and Exposition**, 2001.

[20] http://www.servicelearning.org, accessed 20 March 2008.

[21] http://www.nylc.org, accessed 20 March 2008

[22] http://www.nationalservice.org, accessed 20 March 2008

[23] http://www.learningindeed.org, accessed 20 March 2008

[24] Ohio Department of Education Academic Content Standards K-12 Mathematics, Center for Curriculum and Assessment, Ohio Department of Education, www.ode.state.oh.us/ca/ci/

[25] Ohio Department of Education Academic Content Standards K-12 Science, Center for Curriculum and Assessment, Ohio Department of Education, www.ode.state.oh.us/ca/ci/

[26] O*NET Career Interest Inventory, Ferry, F., eds., CFKR Career Materials, CA., 2000.

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