AC 2007-2438: IMPACT OF A GK-12 PROGRAM ON THE DEVELOPMENT OF UNIVERSITY STUDENTS ACADEMIC AND PROFESSIONAL SKILLS

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Impact of a GK-12 program on the development of University students academic and professional skills

Introduction

In recent years, improving STEM education has particularly been encouraged in the K-12 classroom. The benefit of having partnerships between Universities and their local schools is looked at as a possible positive contributor to enhance STEM education within the classroom. Several outreach programs have been established including a well known National Science Foundation (NSF) funded program that involves students in college establishing a relationship with a teacher through a school year by helping them in the classroom encourage students to excel in STEM education.

The NSF Graduate Teaching fellows in K-12 Education (GK-12) *"provides funding to graduate students in NSF- supported science, technology, engineering, and mathematics (STEM) disciplines to acquire additional skills that will broadly prepare them for professional and scientific careers in the 21st century."*[3]

In 2002-2006, The National Science Foundation supported a GK-12 fellows program at the University of Maryland Baltimore County called the Teaching Enhancement Partnership Program (TEPP). It was run out of UMBC's Shirver Center. Designed to improve classroom instruction of mathematics and science in the nation's primary and secondary schools, the program placed both graduate and undergraduate science, technology, engineering and math (STEM) majors in five high-needs middle schools within the Baltimore Metropolitan Area. A project evaluation was designed to assess the extent to which TEPP met the following National Science Foundation expectations regarding outcomes.[3]

1) Improved communication skills and teaching skills for *graduate and undergraduate **fellows***;

2) Enriched learning by K-12 ***students***;

3) Professional development opportunities for K-12 ***teachers***;

4) Strengthened partnerships between ***institutions of higher education*** and ***local school districts***.

The program at the University of Maryland Baltimore County could be compared to other NSF granted GK-12 programs such as the STOMP program at Tufts university[2]. Though, the program distinguished itself from other GK-12 programs through its use of undergraduates. TEPP consisted of 5 graduate and 20 undergraduates' students enrolled at the university each year. Each graduate student was place in one of the five local high needs middle schools along with four undergraduates. Both the undergraduates and the

graduates were assigned one to two teachers to assist throughout the school year in implementing activities and serving as resources to curriculum in the STEM fields.

The roles and responsibilities of the undergraduates and the graduate students varied slightly. Although both the graduate and undergraduate fellows spent 10 hours in the classroom, the undergraduates spent additional 5 hours for developing curriculum and activities, whereas the graduates spent 10 additional hours. The graduate fellows were also required to meet with their assigned undergraduate fellows on a biweekly basis in discussing activities and plans that they were implementing in the classroom. Every activity was required to be recorded in a specified form and handed in during the meeting to their graduate fellow. These activities were archived with the program coordinator and made available to all the schools participating in the program.

The TEPP program stood on it's own in how it attracted a large amount of engineers and computer scientist. The College of Engineering and Information Technology (COE&IT) at the University of Maryland Baltimore County consists of the following engineering programs to include mechanical, chemical, computer and computer science. The percentage of engineers recruited in each year is seen in Table one below:

Table 1: Percentage of Engineering and Computer Science fellows 2002-2006

TEPP Year	Total Fellows	Percentage of engineering including Mechanical, Chemical, Computer and Computer science.*
2002-2003	25	36%
2003-2004	24	58%
2004-2005	19	58%
2005-2006	4	100% (ALL ME)

The other fellows in the program were STEM focused including majors in biology, chemistry, information systems and mathematics.

Out of the four years of participation, there were a total of 25 engineers and computer scientist who participated in the program. 40% of them were Mechanical Engineers, 17% were computer science, 13% were chemical engineers, and 6% were computer engineers. Due to the considerable amount of undergraduates, several continued in all three to four years of TEPP; transitioning from undergraduate to graduate students.

TEPP, as well as other GK-12 programs, developed the student's softer skills to include *"communication, teamwork, leadership….and an ability to apply these skills in engineering careers."*[2] Studies, in recent reports, show that engineers are lacking in

several common important skill areas, particularly communication and teaching skills. In a report entitled *Education and Careers 2000: Enhanced Skills for engineers,* these "soft skills" were reported as fundamental to industry as the engineering skills taught in college. *"The message from industry leaders is that young graduate engineers arriving at their companies do not possess skills in either the quality or quantity required. These extra skills include written and oral communication…"*[1]

In a study at the Michigan Technological University, professors were placed in industry settings for a short time to determine what successful engineers need in the industry. As a result, they found that "*engineers need a variety of soft and hard skills."* Included in these soft skills were teaming/people skills. "*For effective teaming the engineer must respect the contributions and points of view of teammates.*"[5] Along with this, the paper stated a reiterated the issue of communication skills. In this, it was discussed specifically that a *"valuable skill is to explain complex concepts clearly and concisely*. This paper shows that the TEPP experience helped develop such a valuable skill.

This paper will discuss how the TEPP alumni feel they have developed these skills through TEPP based on going through the program and there current status in their career choice as well as how they are actively engaged in K-12 activities today.

Methods and Sample

Throughout the three years of the program, surveys were conducted before the school year and after the school year. Since the fourth year of the program was funded on remaining NSF funds, surveys were not administered but considered in the post study.

For the purpose of this study, including certain parts of the TEPP experience while the fellows were in the program served to show the fellows and their partner teachers perspectives in how the fellow's skills were being developed. This study uses The University of Maryland Baltimore County GK-12 Teaching Enhancement Partnership Project Final Evaluation report to show the results of the TEPP fellows experience while serving.

Although the study was not specified to engineers, the majority of the years did compose of engineering fellows as seen in Table 1.

The procedures described the final report were broken up into the three consecutive years, showing minor differences per year. The surveys allowed the fellows in some areas to answer qualitatively and quantitatively. The questions in the quantitative group consisted using a rating scale of very able, somewhat able, not too able, and not at all able or very true, somewhat true, not too true, not at all true.

All the surveys focused on four major groups including the fellow's skills improvement, k-12 students' enriched learning, teacher's professional development, and strengthen university-community partnerships. For this study, the topic of fellow's skills improvement will be evaluated.

In year one (Fall 2002 – Spring 2003), four questionnaires were developed to gather information on participating teachers, fellows and middle school students. "*Two broad questions about the influences of TEPP on fellows' educational experiences and goals were asked."*

In year two (Fall 2003-Spring 2004), surveys were administered in both semesters. "*In the fall, fellows were invited to a lunch hour meeting during which time they were asked by The Shriver Center's evaluator to discuss TEPP as a group and to complete the questionnaire. The evaluator and program coordinator also hand-delivered folders containing a cover letter, questionnaire, and return envelope to teachers' schools (placed in individual mail boxes).* In the spring the fellows completed their surveys in an "*exit interview"* whereas the teachers surveys were administered the same as the fall semester.

In year three (Fall 2004-Spring 2005), the questionnaires were delivered both semesters. As in year two, the Shriver center's evaluator dispense the surveys' to the TEPP fellows at a meeting. This occurred both semesters. The same procedure as in year two for the teachers occurred in year three.

The long-term effects of the program were evaluated using interview and survey methods. Half of the fellows that were reachable through phone were interviewed the questions whereas the other half were contacted through e-mail. The fellows contacted through e-mail filled out the survey on their own.

In creating the post survey, it was discussed and researched the important questions that would be valid in evaluating an alumni engineering TEPP fellow. Since the program goals were to help develop soft skills, such as teaching and communication, identifying these skills in accordance to industry and academia became important.

Several reports and studies have been issued discussing the need for graduating engineers to have soft skills as they enter into their job. Several of these papers[1,4,7] were used, along with talking to professionals in industry, to create a valid list of skills needed for the work place. In academia, though, very little or no documentation was found discussing specific skills needed for an engineering professor or a person going into the academic field. To compensate, an interview of graduate students and professors' took place at the university to understand what skills are needed for their profession.

The survey consisted of 9 questions focusing on how their experience affected them in their course work during their time with TEPP, future decisions that were made during their employment with TEPP, what the TEPP alumni are doing today and how TEPP is integrated into their career choices. In the survey, both qualitative and quantitative questions were asked. Below in Table 2 are the questions asked of the TEPP alumni:

Table 2 Post TEPP survey questions

Questions
What was your major while you were in TEPP?
Did TEPP help Formulate your career Path? How?
What is your current stage in you career? (Industry or Academic, neither)
Are you actively involved in any engineering k-12 activities? (If yes, please explain)
Are you interested in getting involved with any future k-12 engineering activities?
Are you interested in becoming a Professor or k-12 teacher in the future? (You may answer both and elaborate)
Please Indicate Yes (y) or No (n) to whether TEPP helped you in these areas during your experience. You may explain any of these areas.

Areas	Yes	No
Grades		
Study habits		
Improvement to basic science and math skills		
Understanding the course work		
Time Management		

If you are in Academia (if not continue to question 9) please fill out the chart below on a scale between 1-5, rating each of these skills in how TEPP helped you develop and implement these skills today:
1=not true at all 5=very true

	1	2	3	4	5
Communication Skills					
Classroom Management					
Teaching Skills					
Writing					
Lesson Planning					
Ethics					
Patients					
K-12 University and local districts					
Simple Concepts (Math, Science concepts)					

If you are in Industry please fill out the chart below on a scale between 1-5, rating each of these skills in how TEPP helped you develop and implement these skills today:
1=not true at all 5=very true
Below are what are called "Soft skills" that many companies feel are imperative for an engineer to have. Again you may elaborate in the space
provided below.

	1	2	3	4	5
Communication Skills					
Teaching Skills					
Writing					
Basic Math & Science					
Conflict Resolution					
Safety					
Preparedness & Planning					
Research Skills					
Management & Direction					
Ethics					
Organization					
Flexibility					

All the above questions allowed the TEPP fellows to answer qualitatively.

Contacting the TEPP fellows began during the fall 2006 year and continued in the spring 2007. Since fellows started graduating up to 4 years ago, contacting them posed to be a difficult task. Among the 25 engineering graduates, 60% of them were reached through either e-mail or phone.

For further analysis and validity, coursework grades were obtained by a faculty member of UMBC. The purpose of this analysis was to validate how their undeveloped skills were becoming developed and directly affecting their grades. Many engineering classes at UMBC require the use of soft skills within the classroom. Along with this, the idea that the TEPP fellows were refreshing their basic math and science skills and soft skills could directly affect their grades as well as help them in their future careers. Only the cumulative average for the year, status of the participation (undergraduate or graduate), and major were provided. Student's names were not included in any form for confidentiality purposes.

Results

TEPP fellows study: During their experience

The following results in this section were obtain from the The University of Maryland Baltimore County GK-12 Teaching Enhancement Partnership Project Final Evaluation Report (2002-2005).

In all three years of the program, the survey focused on four key areas:

A) Fellows' skills improvement.
B) K-12 students' enriched learning
C) Teachers' professional development
D) Strengthened university-community partnerships

For the purpose of this study, the fellow's skill improvement section was focused on because of how it identified with the fellows thoughts on skill development in career related areas. Particularly, how the TEPP program provided Professional Development opportunity for the future.

Year one resulted in the following, that *"Ninety percent of fellows felt that participating in TEPP contributed positively to their educational experience. Half of the fellows reported that participating in TEPP encouraged them to consider teaching math or science to middle school students as a career."* The report indicated that the main focus was obtaining students grades and striking their interest in the STEM fields.

In year two, the response rate was 67% of the 24 who were participating in the fall semester. In the spring semester, with 23 fellows, the response rate was 100%. Of the 23 teachers surveyed, 62% responded to the survey. "*A majority of fellows felt that with respect to communication and teaching skills specifically, self- and teacher assessments reflect "Very" or "Somewhat" able skills. In terms of developing job-related skills such as communication and leadership, 70% of fellows agreed that this was "Very True" of the TEPP experience. Fellows' abilities in the areas of teaching, communication, and leadership were rated by themselves and teachers as either "Very Able" or "Somewhat Able" (with communication skills rated most highly) both in the fall of 2003 and spring of 2004."*

In year three the fellows, *fellows had an 89% response rate in the fall and a 95% response rate in the spring. Of the 19 teachers participating in TEPP, 17 mailed their completed questionnaires to the Program Coordinator during the fall for a response rate of 89%. Thirteen of the 19 teachers mailed their completed surveys in the spring for a response rate of 68%."*

In the surveys, the responses of the TEPP fellows included the following:

- *The majority of fellows (94%) felt that their participation in TEPP helped them develop job-related skills.*
- *Many fellows (61%) felt that participating in TEPP helped them formulate a career path.*
- *Most fellows (94%) were confident in the ability to teach science and math to middle school students as well as teaching inquiry-based science and math (78%) after participating in TEPP.*
- *All fellows were confident in the ability to communicate with middle school students and most (94%) were confident in the ability to communicate with middle*

school teachers after participating in TEPP. Many (89%) were also confident in their ability to talk about their own research with people who know little about it.

Fellows also expressed an increased awareness of K-12 issues as a result of TEPP.

- *All fellows reported an increased interest in K-12 education issues after participating in TEPP.*
- *Fellows' understanding of various K-12 education issues also increased as a result of participating in TEPP. Most fellows reported a significant to deep understanding of the following issues after participating in TEPP whereas prior to TEPP few reported such understanding.*

The teachers, whom the fellows were paired with, also responded to the fellows ability to teach and communicate with the students as seen below.

- *Many teachers rated fellows' ability to teach science (61.5%) and math (75%) highly (e.g., somewhat or very able). Relatively fewer teachers viewed fellows' ability to teach inquiry-based science (46%) and math (67%) highly.*
- *All teachers felt that fellows were either "very" or "somewhat" able to communicate with middles school students and teachers. Sixty one percent of teachers rated fellows' ability to talk about their research with people who know little about it favorably.*

From this report, it was clear that the fellows and their partner teachers, truly felt they were able to develop the necessary skills for any future career, especially in teaching and communicating. It is also to note that the fellows indicated developing an understanding of the need for improvement in the STEM areas in K-12.

To validate and build from these results, further evaluation was done recently on the affects of the TEPP program today.

Post TEPP Evaluation

All the TEPP engineering fellows have graduated and are either working in the industry field or have continued on in pursuing a Masters or PH.D.
The fellows who reported (n=15), during their fellowship time, 6% held positions for four years, 13% held positions for three years, 6% held a position for two and a half years, 20% held a position for two years and 73% held positions for one year.
From these fellows, 26% transitioned from undergraduate to a graduate fellowship position.

How TEPP fellows Coursework and Career choices were affected

Fellows were asked if their experience in TEPP helped formulate their career path. In response, 40% of fellows said yes and 60 % answered no. Those who transitioned from an undergraduate fellow to a graduate fellow indicated that TEPP did encourage them to continue into graduate school.

Several qualitative responses from the fellows are included below.

No, but it helped me formulate future possibilities. TEPP helped me figure out what role I want to play in industry. It helped me see a bigger picture. I had one idea about what I wanted to do, more of research and education. As a result, I am interested in a position that related to research in the industry, which is outside my degree.

"I taught for some time after graduation and TEPP was a key factor in helping me prepare for that."

"Not directly. At that point (last semester senior year), I was still unsure of what path to take, but was leaning towards continuing for my MS. While participating in TEPP didn't necessarily redirect me towards teaching, I found it rewarding and felt that it was potentially worth pursuing later in my life."

In regards to their course work, fellows were giving a list of items, seen in Table 3, which during their experience would have had an affect.

Table 3: Impact on Fellows Coursework

	Yes	No	N=
Grades*	43%	57%	14
Study habits	46%	53%	15
Understanding the course work	26%	73%	15
Improvement to basic science and math skills	50%	50%	10
Time Management	80%	20%	15

one fellow was only taking research credits, therefore grades were not applicable

The TEPP fellows showed a great deal of support towards their experience helping them with their time management skills. Although some failed to answer whether their basic and math skills benefited from the program, many did indicate it helped refresh their skills for their coursework.

Some of the TEPP fellows, in addition, choose to respond qualitatively:
"At the end of the senior year, TEPP helped you work on your speaking and communication abilities."

"TEPP consumed a lot time that could have benefited towards school work."

"I really don't feel like TEPP had any influence on my own schooling besides forcing me to be organized due to the time commitment. However, I do feel that TEPP was a good introduction to the working world and the importance of good communication."

"Simply by merit of the time commitment to TEPP, I had less time for goofing off, and so my time management and study habits became more efficient. I don't, however, feel this had a significant impact on my grades or understanding of course material."

In further examination of the impact that TEPP had on the fellow's grades, a blind study was conducted were student's grades before and during their experience were examined (See Table 4). Several grades were unable to be obtained.

Table 4: TEPP fellows Cumulative Grade point average Pre and During fellowship

Student	Cumulative GPA Pre-TEPP	Years Participated	1st year	2nd year	3rd year	4th year
1	3.49	2	3.14	3.86		
2	2.32	2	2.74	2.22		
3	3.28	1	3.79			
5	3.39	2	3.63	3.8		
6	2.73	4	3.43	3.59	3	3.25
7	3.53	1	3.07			
8	3.28	3	3.61	3.33	3.33	
9	2.44	1	1.92			
10	3.40	1	3.3			
11	2.35	.5	1.13			
13	3.76	1	3.89			
14	3.52	1	4.0			
15	3.28	1	4			
19	3.94	1	3.59			
20	2.96	1	3.4			
22	2.79	1	3.57			
23	1.74	3	2.67	2.88	2.75	
24	3.11	1	2.91			
25	4.0	.5	4.0			

Key

Decrease in grade

Increase in Grade

In an examination of Table 4, a majority of the engineering fellow's grades increased as they went through their TEPP experience. Looking at the pre-tepp averages, the students showed to be fairly motivated ranging around a 2.30 - 3.50 with outliers of 1.74 and 3.94/4.0.

Current Status of TEPP fellows

Among the fellows who reported, 60%, n=9, are currently working in industry field and 40%, n=6, is in academia (pursuing a PhD or master degrees).

Fellows who continued in academia were asked questions pertaining to research and vital skills in that career.

Three fellows, in the academia field indicated that due to TEPP, they have integrated engineering education research into their thesis. Two are particularly focusing on K-12 education while the other chose a K-16 focus. One is interested, after completing a master's degree in Mechanical Engineering, in pursuing a PhD in engineering education.

Table 5: Valuable Skills in Academia that TEPP helped develop (1=not true; 5=true)

	1 Not True	2	3	4	5 Very True	N=	Mean
Communication Skills			1	3	2	6	4.17
Classroom Management				3	3	6	4.5
Teaching Skills				3	3	6	4.5
Writing	2		3	1	1	6	3.33
Lesson Planning			2	2	2	6	4
Ethics	1		2	1	2	6	3.5
Patients			1		4	5	4.6
Simple Concepts (Math, Science concepts)			2	2	2	6	4

In examining Table 5, clearly classroom management and teaching skills were valued as important verses writing. Since they spent a majority of their experience in the classroom, this becomes important in their future careers as possible professors.

The fellows in the academic profession felt that "*TEPP helped them develop skills to teach abstract ideas and engage students in learning."*

For the fellows in industry, questions pertaining to important "Soft Skills" that is needed in industry were asked and shown in Table 6.

Table 6: Valuable Skills in Industry that TEPP help Develop (1=not true; 5=very true)

	1 Not True	2	3	4	5 Very True	N=	Mean
Communication Skills		1	2	1	5	9	4.1
Teaching Skills			2	3	4	9	4.2
Writing	3	1	2	2	1	9	2.6
Basic Math & Science	1	3	2	1	2	9	3
Conflict Resolution	1	1	4	2	1	9	3.1
Safety	1		2	5	1	9	3.5
Preparedness & Planning	1		2	4	2	9	3.6
Research Skills	1	4	1	2	1	9	2.7
Management & Direction			3	4	2	9	3.8
Ethics		1	2	6		9	3.5
Organization		3	1	5	1	9	3.7
Flexibility		1	2	3	3	9	3.8

Communication skills and Teaching skills were the most valuable to the industry fellows as shown in Table 6. Whereas writing showed to be the least skill that was useful in their career.

The fellows in industry clearly indicated that TEPP helped develop many skills that extremely vital to their position in their company.
"The biggest help was in basic science. Most of the stuff I hadn't done since middle school, so it was pretty much a refresher. It also helped with management and direction, since it was dealing with pre teens and teens. I don't really feel like it enhanced or detracted from any of the others though."

"Writing- learned that the things that are not necessarily clear depending on an audience. Writing to people in different fields, helped understand different perspectives."

"The biggest things I got out of TEPP were bolstering my teaching abilities, which I enjoy doing, effectively planning a lesson or a presentation, and properly communicating that. I am very happy that I participated in TEPP, it was a great opportunity."

Both the academic focused and industry fellows asked if they were currently involved in K-12 activities, 46% responded "yes" and 53% answered "no" but, would like to in the

near future. Some of these activities involve volunteering at UMBC in a First Lego League (FLL) tournament. Several coach their own FLL teams at the schools they partnered with in the TEPP fellowship. One is extremely involved in Society of Women Engineers (SWE) as a cor-representative. She participants in numerous activities sponsored through SWE that are K-12 engineering education related. Another fellow responded that she is involved in the Professional Development for the engineering program Project Lead the Way at UMBC. Others are in the process of initiating new programs at the university.

They were also asked if they were interested in becoming a either a K-12 teacher, Professor or both in the future. Out of the 7, 40% said Professor, 33% responded to K-12 teacher and 26% responded to both. One qualitatively responded that they *"would like to continue working with K-12 educators while in industry."*

"I'm more interested in becoming a professor, and still would like to at some point return to school for my master's and teach at the college level part time. I don't really think I'd do k-12 though"

In continuing the support for University/Industry outreach activities to local schools, the fellows indicated that they encouraged their fellow colleagues and companies in supporting and participating in K-12 activities.

"*My company sends me to different events, especially during national engineer's week for K-12 activities."*

"I've encouraged my company to sponsor a Society of Automotive engineers group at UMBC."

Discussion

As seen in the results above, as well as other GK-12 program and engineering outreach programs[5,6], the fellowship experience showed to have a lasting impact on the engineering fellows.

In both industry and in academia, communication and teaching skills were the highly rated skill that helped the fellows in their career. Along with this, many agreed that their time management skills, 80%, and their understanding of basic math and science skills were greatly affected to help them in their coursework and careers. Their coursework reflected this showing a general increase among most of the fellows in their grades.

This outcome is commonly shown through many of the Gk-12 programs and is believed that such findings can be nationally evaluated.

Conclusion

Engineering and Computer Science fellows who joined the TEPP program showed to have received an inspiring experience. Most importantly, from this experience they were able to develop skills that are vital to any engineering company. TEPP also raises awareness among the fellows by encouraging them in the direction of continuing in academia. Teaching, creating curriculum and hands on activities, and evolving partnerships with the students and teachers has caused engineering TEPP fellows to improve in their engineering field and consider new paths of research.

Improving engineering graduates in industry and academia is a needed area of evaluation. The quality of graduates will ultimately affect the industry and the University of the Alum. It is important that these fundamental skills are encouraged in the University. Along with this, having programs such as TEPP will help create such quality graduates for the future. In turn, this encourages the partnership between the University, industry and K-12 education.

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