A Three Year Analysis of the Benefits Accrued by Women Engineering and Science Students who Participated in a Large-Scale E-Mentoring Program

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Abstract

MentorNet (www.MentorNet.net), the E-Mentoring Network for Women in Engineering and Science, leverages technology and draws on the benefits of mentoring to address the underrepresentation of women in engineering, science, math, and technology fields. A multi-institutional, large-scale, structured electronic mentoring (e-mentoring) program, MentorNet pairs women students in engineering, science, math, and technology fields with industry professionals who volunteer as mentors, and supports them through year-long e-mentoring relationships.

This paper reports on the most salient benefits accrued for women students based on three years of evaluation results from the 1998-99, 1999-2000, and 2000-01 program years. During these three years, MentorNet matched, supported, and helped facilitate more than 3,700 e-mentoring pairs, which represented women students from 70 colleges and universities, and professionals from more than 700 corporations, professional societies, governmental agencies and laboratories. The collective program evaluations support the need for and efficacy of the program. For all three-time periods, at least 80% of the students reported they would recommend MentorNet to other students. Both students and mentors emphasized the importance of making the college-to-work connection and identified this as the primary reason for participating in MentorNet. The college-to-work connection provided students with invaluable knowledge about their career opportunities, the benefits of networking, and the development of networking skills. The students reported increased self-confidence, enhanced knowledge of the workplace and workplace skills, and valuing the support they received from knowledgeable and impartial mentors. These benefits are particularly important since they address the obstacles faced by women pursuing degrees in fields where they are underrepresented.

Introduction

Engineering has remained a field in which women are severely underrepresented. Over the past 30 years the number of women and men in most educational fields has converged, including some science and math fields. As a career aspiration, however, engineering still shows the

greatest divergence between the number of undergraduate men and women[1]. Consistently, research suggests that this discrepancy is not due to the female students' lack of motivation, ability, or academic preparation[2,3]. Instead, it seems that environmental and societal factors are responsible for deterring women from entering or persisting in engineering. These factors include the competitive and often unwelcoming classroom environments in college[4-7] and the presence of male-dominated culture in engineering, both in the college classroom and in society as a whole, which may cause women to question their ability or commitment to a greater extent than their male counterparts[8,9]. Mentoring and research experiences, identified as some of the most important predictors of academic persistence and success, appear to be less readily available to women students[10]. Consequently, formalized women in science and engineering programs have become an important part of supporting and encouraging women students[11].

MentorNet brings together the benefits of structured mentoring programs and electronic communications to address the underrepresentation of women students in science and technology on a large scale. In this paper, we introduce and explain MentorNet and its various program features. Then, we present the results of three successive year-end program evaluations, presenting qualitative results from the 1998-99 year and quantitative results from the 1998-99,1999-2000, and 2000-01 program years.

MentorNet: The E-Mentoring Network for Women in Engineering and Science

MentorNet (www.MentorNet.net) was founded in 1997 to address the underrepresentation of women in engineering and related sciences by creating a large-scale structured e-mentoring program[12]. MentorNet pairs women engineering, science, math, and technology students at the undergraduate and graduate levels with men and women industry professionals who volunteer to serve as mentors. Then, MentorNet supports them through year-long one-on-one e-mentoring relationships. By relying on email as the primary medium for establishing mentoring relationships, MentorNet can pair students with professionals regardless of geographical and time constraints. As a multi-institutional program MentorNet allows for significant economies of scale in administration as well as opportunities for program growth because it can reach broader and deeper pools of mentors and students and can provide mentoring at campuses where such opportunities might be limited. (See Table: MentorNet's Actual and Projected Growth Chart). The size and structure of the program permits MentorNet to develop and employ specialized systems and resources, such as a web-based interface to a customized, relational database related to a set of computer programs to optimize the matches between mentors and students and personalized, customized communications with participants. A *structured* e-mentoring program, MentorNet provides training and ongoing coaching to participants throughout the program. While structured mentoring programs require an additional investment in program staff, these elements increase the numbers of successful mentoring pairs and the benefits associated with mentoring[13,14].

MentorNet's Actual and Projected Growth Chart					
|---------------------------------------Actual--					Projected
[-------------Years Included in this Paper---------------]					
	Pilot Semester 1998	Year 1 1998-99	Year 2[*] 1999-2000	Year 3[*] 2000-01	Year 4[*] 2001-02	Year 5 2002-03
Students Matched	204	539	1,250	2,000	3,191	5,000
Mentors Matched	204	539	1,214	1,913	2,953	5,000
Participating Campuses	15	26	36	70	116	125
Companies Represented by Mentors	93	261	588	690	828	-
*In Years 2, 3, and 4, MentorNet paired more than one professional with a student, thus explainingthe difference between the number of mentors and students who participated.						

Corporate and governmental sponsors and various professional societies, and affiliates recruit prospective mentors. Students are currently eligible for participation as protégés if they are enrolled at participating colleges or universities, and are recruited by campus representative who serve as liaisons to MentorNet. As part of the recruitment process, students and prospective mentors are directed to the MentorNet web site (www.MentorNet.net), where they can complete an on-line application. The information entered in the on-line applications is automatically entered into a database and a sorting program identifies the most suitable mentors for the students.

Mentors and protégés are expected to communicate via email *at least* twice a month. Some choose to supplement their email interactions with phone conversations and face-to-face visits, although these options are not particularly promoted. Each student-mentor pair commits to the relationship for one academic year.

As a structured e-mentoring program, MentorNet utilizes various features to facilitate one-on-one e-mentoring opportunities and to develop and understand the role of electronic communities. These include an interactive web site, training, coaching curricula, electronic newsletters, and electronic discussion groups that provide opportunities for building community among participants[15]. MentorNet provides on-going support and communications to the e-mentoring pairs through its coaching curriculum – a set of regularly delivered, customized discussion suggestions. The discussion suggestions serve an educational purpose in supporting pairs as they progress through the stages of mentoring[16, 17], while also serving as reminders for participants to keep in contact with their e-mentoring partners.

A final feature of the MentorNet program is the group of electronic discussion groups (e-groups; see Single, Muller, Cunningham, and Single for an in-depth discussion of the e-groups[18]). MentorNet sponsors electronic discussion groups to provide an opportunity for the students and mentors to interact with others outside of their one-on-one e-mentoring relationships. All the participants are invited to participate in one or more of the lists.

Participants and Evaluation Methods

Each year and based on available resources, the MentorNet organization has identified a targeted number of mentors and protégés to participate in MentorNet, and has matched as many e-mentoring pairs as possible. At the end of each program year, MentorNet conducts a program evaluation, based on the responses to a web-based survey. The 1998-99 year was MentorNet's first full year of operation so we conducted additional qualitative analyses that helped increase our knowledge of the program and informed the development of subsequent web-based surveys. While we collect and analyze data on both mentor and students experiences, for the purposes of this paper we focus only on the student responses to the evaluation program.

After the application deadline, MentorNet matches interested professionals and students. In 1998-99, 973 professionals and 693 students applied to MentorNet; we matched 539 pairs. In 1999-2000, 1521 professionals and 1405 students applied and we matched 1250 students and 1214 professionals in one-on-one e-mentoring relationships or in experimental mentoring groups. (This paper reports on the results of those participating in the one-on-one e-mentoring pairs.) In 2000-01, 2022 students and 2630 professionals applied to participate in MentorNet; 2000 e-mentoring matches were made. A number of the professionals were paired in two one-on-one relationships, resulting in 2000 student pairings with 1913 professionals.

The majority of the students who participated in MentorNet was undergraduates, representing 78%, 76%, and 72% of the total population of participants for the 1999-98, 1999-2000, and 2000-01 programs. MentorNet particularly attracted a large percentage of students, and mentors, in engineering, information technology, and computer science fields – the percentage of these students ranged from 72% to 83% across the program years, while the remaining students were in mathematics or the natural science fields. The majority of the MentorNet students and mentors were Caucasian, reflecting the demographics of the students in the field.

For the three years reported here, MentorNet used both quantitative and qualitative methods to evaluate the results of participation in MentorNet by mentors and students. The quantitative portion of the evaluation used a web-based survey administered near the end of each academic year. All participants were invited via email to fill out the survey and a series of follow-up reminders were sent to non-respondents. The goals of this evaluation were to obtain participant assessments of their mentoring experiences, to discern the benefits and value of the program, and to investigate variables predictive of or related to successful e-mentoring experiences. The surveys from both years relied principally on close-ended questions that were rated with 5-point scales. The surveys provided opportunities for the participants to rate their satisfaction with the program. Examples of student questions included "Has your MentorNet experience affected your self-confidence about your ability to succeed in your field?" rated from Decreased (1) to Increased (5) and "How satisfied were you with your one-on-one e-mentoring relationship?" from Not at all (1) to Very (5). Each year we also included open-ended questions to collect data relating to positive outcomes associated with participation or suggestions for improving the program such as, "What were the most useful topics you discussed with your mentor?" In addition, both surveys included a checklist of possible discussion topics and the students were given the opportunity to check more than one item. Topics included discussing: "Your backgrounds", "Managing time, stress, or workplace demands," and "Balancing a career and other interests, family, etc."

The second part of the qualitative evaluation, which we termed email monitoring, was conducted with a small sub-sample of the MentorNet participants in 1998-99. We asked consenting e-mentoring pairs to copy the evaluator on their e-mentoring exchanges. E-mentoring is a relatively new phenomenon and the nature of e-mentoring allows for an actual text-based record of the relationship; we employed this form of data collection to learn about the topics and content of the e-mentoring relationships, which informed the program coaching curriculum and survey instrument in subsequent years.

Results

Of the 515 e-mentoring pairs that completed the program in 1998-99, the student response rate was 50.9% for the year-end survey. In the 1999-2000 year, analysis focused on a subsample of 200 e-mentoring pairs. The response rate for this subsample was 58% for students. In 2000-01, we again sampled the entire population – 52% of the students matched at the beginning of the year responded to the year-end survey and 43% completed the survey.

Quantitative Results: Experiences with MentorNet and E-mentoring

The year-end evaluation showed that most of the responding students were very positive about their experiences in the MentorNet program and that the e-mentoring format was a successful way to establish a mentoring relationship. The students felt very comfortable asking questions of and answering questions from their e-mentors. They also responded positively to the quality of the e-mentoring partnership into which they were matched. For all years, students reported high rates of retention and engagement in their majors ($M = 3.49$ in 98-99; 4.42 in 99-00, 4.41 in 00-01) and intentions to pursue careers in industry ($M = 4.17$; 4.20; 4.16). For all three years, he students rated their satisfaction with their one-on-one e-mentoring favorably (3.95, 3.44, 3.82).

In 1999-2000 and in 2000-01, the students were asked to rate how their MentorNet experience affected their self-confidence and commitment to pursuing jobs in the field they were studying. The students responded that participation in MentorNet influenced their self-confidence (3.57 in 99-2000; 3.70 in 2000-01), their desire to work in industry or a government laboratory or agency (3.60; 3.73), and their desire to pursue a job in their field (3.74; 3.83), all in a positive manner. Interestingly, the students rated their interest in staying in their major (4.42; 4.41) and interest in working in private industry, a government laboratory, or a government agency (4.20; 4.16) even higher.

Seventy-two percent of the students in 1999-2000 and 81% of the students in 2000-01 chose connecting or interacting with a professional in industry as the reason they signed-up with MentorNet, making it the most frequent reason for participation. In 1999-2000 and in 2000-01, the majority of the students (84% and 92%) said they would recommend MentorNet to a friend.

The evaluation asked the students to identify the topics that they discussed with their e-mentoring partners. As would be expected, they discussed their backgrounds and their mentors' backgrounds, the mentors' jobs, the students' college experiences, and the students' future plans. One finding of note is that the students' fifth most frequently chosen topic was social interaction, shared jokes, and discussions about non work- or school- related topics. These informal and

lighthearted social interactions may help to sustain a relationship so that important issues can be discussed when the need arises.

Quantitative Results: Value of Students' Participation

In this section, we focus on data analysis from the 1999-2000 year, particularly on the value of participation to the students. To do so, along with reports on individual questions that indicate value of participation, we also conducted a factor analysis. This factor analysis statistically identified several variables that were highly correlated among them and created a constructed variable (construct) that focused on value of participation for the students. For the sake of easier interpretation, this construct was scaled so that the range of possible values remained the same as each of the components that comprise it. We first report on the quantitative analysis and the construct that related to the value of students' participation. Next, we examined the responses of the students to the open-ended question, "What was the most valuable aspect of your MentorNet experience?"

This construct describes how students' participation in MentorNet has affected their self-confidence, their belief that they would want to work in industry when they graduated, and their desire to pursue a job in their field. These items were rated on a 5-point scale from Decreased (1) to Increased (5) and were highly correlated with one another and so were grouped into a single construct. For all three items, half of the student reported that their MentorNet experiences had a positive influence on their self-confidence, their belief that they would enjoy working in the private or public sector, and their desire to get a job in a science, technology, engineering, or mathematics field when they graduated. Just over one-third reported they were neutral about how MentorNet influenced their self-confidence and goals. This could just be, as we did find from prior evaluations, that these students already are committed to their fields and exhibit a high level of self-confidence.

Value of Participation	------------Percentages of Ratings------------			Mean and standard deviation	
	1-2	3	4-5	M	SD
Has your MentorNet experience affected your:					
Self-confidence about your ability to succeed in your field?	2%	40%	50%	3.64	3.76
Belief that you would enjoy working in industry or a government lab or agency?	5%	34%	52%	3.66	3.79
Desire to pursue a job in your field?	3%	33%	52%	3.77	3.89
Value of Participation Construct	N/A	N/A	N/A	3.70	3.81

The students who completed the survey, they provided 429 comments[1] to the question "What was the most valuable aspect of your MentorNet experience?" Of these comments, the most frequently cited aspect was having the opportunity to learn about the industry or the field. 23%, or 99 comments, stated this was the most valuable aspect. 12% of the students reported

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[1] We identified comments as the unit of analysis. Therefore, the response from one person could include different comments if they addressed a few different issues in their response. Not all of the participants who answered the survey provided open-ended responses.

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that learning about the experiences of their mentors as the next ranked valuable aspect of the program. The third most frequently cited valuable aspect of the program was gaining the mentors' perspective. Below are some representative comments from the students about the most valuable aspect of their MentorNet experience:

Having someone outside of academic to get answers to subjective questions, they provide[d] a different perspective from say, an academic advisor/professor.

I've learning about different aspects in the field. I've also learned about the different opportunities available for people in industry.

Analysis of the Most Useful Topics Discussed by the E-mentoring Pairs

Still relying on the 1999-2000 data, we examined the most useful topics as identified by the students. For certain topics, however, there were some interesting differences between education levels that may be informative for discussion suggestions/prompts in the future.

Community college students were more likely than others to select "women's experiences at your mentor's company," and less likely to select "mentor's job, prior work experiences." Lower division undergraduates were more likely than others to indicate the importance of "managing time, stress, or workplace demands," "college coursework, majors, or advanced degrees," and "social stuff: jokes, stories, personal news." Upper division undergraduates selected "job hunting and interviewing" more often than others. This makes sense as they are nearing graduation and most likely beginning to think about job searching. Ph.D. students selected "industry workplace, culture, values" and "differences between academia and industry" more often than others. This pairing is not surprising either; both of these topics would help graduate students gather information about upcoming decisions. Masters, and Ph.D. students were more likely to indicate "balancing a career and other interests, family, etc." Masters students, and to a lesser extent upper division undergraduates and Ph.D. students, selected "your future career plans" most often. Again, this choice of a most important topic coincides with a major decision point in the academic careers of students at these levels. The three least frequently selected topics were the same for mentors and students.

	Five Most Useful Topics Discussed					
	Community College	Lower Div Undergrad	Upper Div Undergrad	Masters	Ph.D. Post doc	All Combined*
Your backgrounds (education, interests, etc.)	30%	29%	35%	36%	21%	31%
Balancing a career and other interests, family, etc.	26%	29%	29%	36%	41%	31%
Managing time, stress, or workplace demands	26%	37%	30%	28%	32%	32%
College coursework, majors, or advanced degrees	38%	45%	40%	31%	17%	37%
Industry workplace, culture, values	28%	27%	31%	30%	39%	31%
Women's experiences at your mentor's company	31%	22%	19%	18%	22%	22%
Mentor's job, prior work experiences	20%	32%	31%	30%	28%	30%
Job hunting and interviewing	22%	26%	39%	31%	29%	31%
Your future career plans	28%	31%	35%	45%	37%	35%
Your mentor's future career plans	4%	8%	5%	9%	9%	7%

Differences between academia and industry	9%	19%	19%	23%	37%	21%
Your reasons for participating in MentorNet	5%	3%	2%	1%	7%	4%
E-mentoring logistics (such as how often to write)	7%	6%	4%	3%	6%	5%
Social stuff: jokes, stories, personal news	19%	24%	20%	16%	11%	19%

* Column sums are larger than 100% since individuals select 5 topics

Qualitative Results: In Their Own Words

We present here the responses to the open-ended questions on the year-end survey for 1998-99 and the email-monitoring messages from that year's evaluation using the qualitative methodology of constant comparative analysis[19]. This qualitative data from the MentorNet participants allowed us to review, analyze, and learn from the mentors and protégés in their own words. Based on this analysis, we discovered that MentorNet mentors seemed to provide protégés with various types of support, which we grouped into three categories: offering an objective opinion; providing the college-to-work connection; and increasing self-confidence.

Impartiality. The students valued the opportunity to discuss academic and pre-professional issues with someone who had relevant knowledge, but did not have a vested interest in their academic or career decisions. Many of the e-mentoring pairs established relationships in which the students could freely express doubts about their academic choices, discuss various concerns or insecurities, and feel safe soliciting feedback about their future decisions. One student wrote:

> *The most valuable aspect was being paired up with a complete stranger and getting to know their life, as well as them getting to know you. It was valuable to me to be able to go to a neutral person on work place, scholastic, and personal matters.*

Another student added:
> *I had someone to write to when I was stressed who was not going to judge me by what I said or how I felt.*

Providing the college to work connection. In addition, the students reported that they profited from learning about their mentors' jobs and workplaces. The students appreciated learning about the skills that are used and valued in the workplace, while they still have time to acquire or develop these skills. These types of insights provided students with a realistic picture of their work opportunities that seemed to help them envision their future career options. Many students reported that an important part of these discussions addressed how the mentors balanced having a career and a family. These sentiments were voiced not only by advanced undergraduates or graduate students who were engaged in a job search, but also by the lower division undergraduate women. Since concerns over pursuing a career in engineering and science and being able to also have a family have been identified as an obstacle to women pursuing academic degrees in these fields[3], this finding could have long term and positive consequences in helping women stay the course in pursuing engineering, science, mathematics, and technology. Regarding insights into the workplace, one student said:

> *I had someone to encourage me through the rough weeks, give me an idea about what I am working so hard for, and to give me new ideas about what I can do now to get ready for the future.*

Another student commented:

> *I found to be most helpful [a description of] the duties my mentor had at her job. Industrial Engineering is so broad, it was good to hear some specifics. It also helped me to learn which classes my mentor actually USED on the job.*

Regarding balancing work and family, a first year student wrote:

> *I learned about balancing an engineering career, while being a female (a mother and a wife), which is very important to me!*

Increasing self-confidence. While there is evidence that the students who sign up with MentorNet begin the program with a high rate of self-confidence, a final and strong theme from the evaluation was the, perhaps additional, impact MentorNet had on the students' self-confidence and resilience due to the personal encouragement they received from their mentors. This is an important outcome of the MentorNet program since low self-confidence has been identified as one of the key factors that contribute to women's exodus from technical and scientific fields. In addition, the students consistently reported that participation in MentorNet helped them feel more confident about their abilities and helped them to put the struggles they were having in school into perspective. In addition, the students also appreciated the personal encouragement tailored to their particular needs that they received from their mentors:

> *I gained a great deal from this e-mentoring experience. For one, I learned to think more positively about myself and be more confident in my abilities. I learned that failure will happen, but you have to get up one more time than you get knocked down to succeed...My mentor is the first female engineer I've met. She's everything I've aspired to be and more.*

Another student wrote:

> *I feel a lot more confident about my abilities, but at the same time, I know that as a freshman, I don't really need to rush into things too much. It was really nice to have someone to ask the most detailed questions immediately, the type that you don't put up your hands to ask during some formal slide-show presentation. I think it was all around very nice, and I would like to continue the program even till I start working. I might even opt for being a mentor, then!*

Discussion

MentorNet capitalizes on the growth of email and the popularity and benefits of mentoring to develop and expand a large-scale program that provides support and information to women engineering, science, technology and mathematics students by pairing them with industry professionals in their fields. By developing a centralized program, MentorNet has utilized economies of scale to build an extensive infrastructure and concentration of expertise that allows for unprecedented growth for a structured e-mentoring program. Consequently, MentorNet is providing increasing opportunities for women students to be mentored by industry professionals, opportunities which otherwise might not exist on their campuses. MentorNet's expansion of almost 1000%, from pairing just over 200 students with mentors in 1998 to pairing 2000 students with mentors in 2000-01, based on demand from students (and at that, constrained by programmatic resources) supports the need for this program.

This paper focused on the outcomes associates with participation in MentorNet, as reported by the students. Nonetheless, all of the participants who were matched at the beginning of the program responded to the survey. As the MentorNet evaluation develops, we will conduct a response bias survey for the next evaluation year, with the plan to be able to say more about the students who did not complete the survey.

The email mediated mentoring appears to work quite well for this group of technologically comfortable mentors and students. Protégés expressed strong interest in recommending MentorNet to a friend – one measure of the value of the program – and they rated their experience with MentorNet's one-on-one mentoring, and with the whole program, very favorably. In addition, protégés reported relatively high comfort with asking questions and developing a mentoring relationship over email, thus supporting the notion that relationships can be established and developed using electronic communications.

The content of the mentoring relationships, or the most frequent topics that the mentors and students discussed, offer insights into how e-mentoring relationships are developed and maintained. The most frequently mentioned topic discussed was their backgrounds, which serves as a way for the newly paired students and professionals to establish a mentoring relationship. Next, both identified discussing the mentor's job as the most frequently discussed topic. That the mentor's workplace is the second most frequently discussed topic is notable in that it is in line with the most frequent reason that the students and mentors signed up with MentorNet: to make the connection between the workplace and college. These findings continue to underscore the value of bridging the college to work divide. Another notable topic was the exchange of social and personal information and jokes, which was marginally significantly related to higher satisfaction ratings by the students. Just like in face-to-face mentoring relationships[21], these types of exchanges serve to build trust and keep the lines of communication open in between the exchange of questions or discussions about specific issues.

A notable outcome of MentorNet: the protégés reported that participation in MentorNet helped to increase their self-confidence. Exposure to mentors' individual stories and experiences allowed students to identify with their mentors' previous academic struggles, to ascertain that they were not alone, and to believe that they could become successful engineers and scientists even if they experienced academic setbacks. In addition, students viewed their MentorNet mentors as impartial confidants, and thus were able to express their doubts and questions with impunity to their mentors – doubts and questions they might be reluctant to express to family members or academic advisors. Thus, an important result of MentorNet is that it supports women's self-confidence in their abilities to succeed in the science, technology, engineering, and mathematics fields.

MentorNet's emphasis on mentoring by industry professionals helps women students make the college-to-work connection. While students often have access to academic engineers and scientists on campus, many do not have access to professionals in industry unless they have relatives in these fields or have had internship experience. Through their participation in MentorNet, students had the opportunity to discuss the mentors' job and related experiences, gathered insights and information about the industry workplace, and visualized the options and opportunities for themselves when they graduate. Thus the mentors served as invaluable role models to the students. The majority of the students and mentors signed up with MentorNet

because they believed it was important for students to hear from professionals in industry, and vice versa.

MentorNet relies on email to connect women students in engineering, science, mathematics, and technology with industry professionals, and provides training and a coaching curriculum that supports the establishment of e-mentoring relationships. Through its continued operation and ability to serve increasing numbers of women students, MentorNet is able to provide women students with opportunities to learn about the workplace, to increase their self-confidence, and to have access to a supportive, yet impartial, senior advisor, opportunities which may prove invaluable to students as they persist in fields where women remain underrepresented.

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