



Mentoring Undergraduate Students in Engineering

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Abstract

In this paper, case study was used as a qualitative research method, and the data were collected and compiled through interviews, field notes, fax messages and phone calls. Both faculty advisors and peer mentors at the undergraduate level in engineering were taken into account. Also, small and large engineering schools were considered. The results show that there is no universal law nor any rule of thumb for mentoring. Size of the school, human resources, such as the mentee/mentor ratio, total years of the undergraduate program and the local culture are some of the factors that govern the effectiveness of mentoring.

Key words: role model, peer mentoring, academic counseling, sponsor, international students.

Introduction

The dictionary definition of the word 'mentor' is "an experienced and prudent advisor", stemming from the Greek name *Mentor, the advisor of the king Telemachus* [1]. Mentoring differs from academic counselling in many ways. Both the mentor and the mentee need to know each other at a personal level, and thus a stronger bond develops between the two, maintaining a lasting relationship often throughout their lifetime. In the ancient epics of India, Krishna became the powerful mentor of Arjun in *Mahabharata*, and in *Ramayana* the king-god of the monkeys, Hanuman was the faithful mentee of Rama. In the modern history of atomic physics, Niels Bohr became the mentor of some of the greatest physicists of 1930s, namely Schrödinger, Heisenberg, Gamow and others in the famous Gottingen School of Physics in Germany [2]. Such a bond of commitment for working together needs a common goal. A true mentor is an advisor plus a teacher, a role model and a friend.

In most of the Engineering schools in USA, Canada, and also in Puerto Rico, each academic department or program has an undergraduate student counsellor who offers general guidance from semester to semester. Nevertheless, a student in a professional school, such as engineering, medicine or law, needs a more intimate image of a role model, a mentor who ignites academic inspiration on a very personal level throughout the undergraduate years and beyond. The multiple roles of a mentor are summarized by the sociologist Morris Zelditch of the American Council of Graduate Schools as follows: Mentors are advisors, people with career experience willing to share their knowledge; supporters, people who give emotional and moral encouragement; tutors, people who give specific feedback on one's performance; masters, in the sense of employers to whom one is apprenticed; sponsors, sources of information about and aid in

obtaining opportunities; models of identity, of the kind of person one should be to be an academic.” [3]. Thus, a mentor is a very unique advisor who takes a special interest in helping a student develop into a successful professional. Mentoring is a professional as well as a personal relationship. It is with this spirit in mind, mentoring is compared among some of the US and Puerto Rican engineering schools of similar sizes.

Department of Mechanical Engineering, University of Puerto Rico at Mayagüez (UPRM), Puerto Rico

The department has about twenty full-time faculty members and one is currently on a leave of absence. During the preparation for an ABET (Accreditation Board for Engineering and Technology) visit, the need for undergraduate student mentoring was felt. The department has a full-time student counselor; however, there happened to be cases where some specific technical expertise in mechanical engineering was required. Thus, during a departmental faculty meeting two senior professors were selected for helping the students with technical issues; one professor in the area of thermo-fluidics and the other in materials, machine tools and manufacturing. Each one was given one and half (1.5) credit hours of release time per semester for mentoring the undergraduate students with their specific technical problems, such as technical projects and their oral presentations, preparing them for job interviews, writing technical papers for publication in journals and conference proceedings, etc. Both the professors maintained a written document like a log-book or field notes for each mentoring session. These are powerful tools, for the qualitative research method of case studies, similar to recorded interviews [4]. The results were very satisfactory both for the students in need of technical advice and for the faculty advisors as mentors.

Department of Mechanical Engineering, University of Florida (UF) at Gainesville, USA

Apart from a full-time student counsellor, the department appoints a senior ME faculty to deal with any special technical problem of any undergraduate student. Such a problem can also be related to ethical and professional issues of an engineering practitioner, an engineer in training (EIT) or in a CO-OP internship. Generally, a senior faculty member who is no longer very active with funded research projects but possesses years of experience in engineering education and in engineering practice, is selected as a mentor and is given three (3) credit hours of release time per semester for helping the students in technical as well as ethical issues related to engineering profession. More senior professors are encouraged to lead this role. The ME department at the University of Florida (UF) in Gainesville is comparable in size with that of the University of Puerto Rico at Mayagüez (UPRM) in the sense of both the undergraduate student population as well as the faculty strength. Hence, some similarities can be observed and inferred. Qualitative results of educational research in both the institutions suggest satisfactory implementation of mentoring by the dedicated senior faculty members [5]. Also, in both the ME departments, at UF and at UPRM, the faculty mentors were compensated through release time.

Peer Mentoring at the Ana G Méndez University System: School of Engineering in Turabo Campus, Puerto Rico

Unlike the University of Puerto Rico at Mayagüez (UPRM), the Ana G Méndez is a private university system in Puerto Rico and its engineering school is in the Turabo campus. While the tuition fees here are much higher than those at the UPRM engineering school, many programs are offered in Turabo in the evening hours when the students who work fulltime during the day can take classes. This is a great advantage for the working class student population. Many of them are family fathers/parents and are more matured. Yet they need professional counseling. A “peer mentoring program” is established and mentoring ‘cells’

are designed and implemented where the students at their freshman and sophomore years are usually guided by their junior and senior year peer mentors [6]. Each cell has one mentor with roughly five (5) mentees. Each mentor works approximately eighty (80) hours per semester which is about five (5) hours per week. The mentors are remunerated on an hourly basis. The mentees receive awards and prizes (certificates, games, T-shirts, etc.) as a form of encouragement for participation.

Peer mentoring, when properly designed, implemented and tested, is a very effective teaching and advising tool, because the students feel themselves closer and more accessible to their peers than to their professors. The students have more confidence and trustworthiness among themselves than with their professors, mainly because they spend more time with their peers outside the classroom, and hardly any with their professors. Hence, the students open up more with frankness and sincerity with their peers when faced with a problem whether academic, moral or ethical. This sharing of quality time with the peers helps the transition from routine advising to individual mentoring as a 'partner and a pal'.

Department of Civil and Environmental Engineering, University of Vermont (UVM), USA

This is also a relatively small department, like the one at Turabo in Puerto Rico. Each faculty member has about ten (10) mentees. In the beginning of each semester the mentor meets with the mentees and explains to them the role of a faculty mentor. This initial invitation from a senior professor instils a feeling of trustworthiness in the students and ensures that there is someone closer to them with more professional and academic experience, and with whom they can speak freely about their academic as well as other professional and personal problems.

A checklist is maintained in a file called "Student Folder" for each student, and it is continually updated after each meeting with the mentor where the mentor makes sure that each student under her/his mentorship progresses smoothly in an ABET accredited curriculum. This activity is further reinforced by additional record keeping in the office of the Dean of Engineering. According to one of the mentors, who is a senior faculty member, this mentoring program has been evolved and expanded over many years up to a point where it has become a very effective and helpful system for both the incoming and the outgoing undergraduate students [7].

School of Engineering, Polytechnic University of Puerto Rico (PUPR), Puerto Rico

Seven (7) fulltime faculty members offer mentoring. Each mentor is assigned certain number of students and receives compensation for up to two (2) credit hours per semester. Students with eighty (80) or more approved credit hours are assigned a mentor for discussing their career plans, progress in the academic programs, optimal or alternative choices for course selection, and so on [8]. In addition, the office of Student Development and Retention Program offers tutorial sessions and career services.

The mentors perform a comprehensive analysis of each student's academic records in order to monitor the pace of progress throughout the program. Upon completing eighty (80) percent of the program, the students are advised to meet the Department Head in order to plan for a successful completion of the undergraduate capstone design project in conjunction with a local industry. The students are also mentored and encouraged to participate in the activities of the professional engineering societies, such as ASME, IEEE, ASHRAE, SAE, etc.

Department of Mechanical and Aerospace Engineering, North Carolina (NC) State University, USA

This is a department much larger than the previous ones discussed here. Unlike the other engineering schools, here a student has the same mentor throughout the entire undergraduate years till graduation, which creates a more trustworthy rapport between the mentor and the mentee. A student's progress is monitored, recorded and updated by the mentor in an Automated Degree Advisement (ADA) form. This is similar to the "Student Folder" at UVM except that it is much larger and handles more data. According to one of the mentors, "There is a real advising mode that can integrate humans with technology in a more efficient manner. It is my hope to somehow prepare a network that will advise, mentor and collect data for dissemination throughout the institution and the community as a marker of goals set and reached. I have an 'advising proposal shell' which describes the problem from my working point of view." [9].

Mentors of the undergraduate students in some research laboratories:

Undergraduates in engineering are not just confined in class lectures and teaching labs. They enjoy summer internship in several national research and development (R & D) laboratories, like Sandia, Lawrence Livermore, Lawrence Berkeley, etc. spread out throughout USA. Dr. Jeffrey Estes of Pacific Northwest National Laboratory, notes, "Connecting students to the world of science and technology that exists beyond the academic classroom holds great potential for helping the students decide on and pursue a career pathway. Whether that path leads to a career in research, teaching, business, or a related scientific or technical field, the advanced scientific laboratories of the U.S. Department of Energy (DOE) can enhance the knowledge and skills of *undergraduates*" [10]. Here are comments of some of the undergraduate engineering mentees about their mentors of this lab.

-My summer here was an awesome and very educational experience. I am thankful that he gave me the resources and trust to work on a part of his research. He chose me to be one of his fellows. ----He made me feel every bit as important as the project itself. (Luis Aceves, Latin American intern).

-I greatly appreciate my mentor Dr. Anna Gutowska's ability to balance, lending me her support and expertise with challenge and entrusting me to accurately conduct lab work on my own.----English is not her first language, yet she explained to me numerous technical matters with effective idiomatic language, humor and clarity. (Young-Me Chung, mentee of Asian origin and European mentor).

It is very clear from the above comments that *trustworthiness* and *freedom of thinking* are the keys for an efficient and rewarding mentor-mentee relationship.

Impact of the study

This study, using qualitative research method of case studies, reflects the need of mentoring engineering students at the undergraduate level in both local as well as global perspectives. In the local level, such as in Puerto Rico, mentoring helps not only in course works but also in preparation for job interviews, résumé writing and other broader decisions as practitioners for the outgoing students. It also helps equally the incoming students, who just got out of high schools and have to cope with the transition of entering into a more flexible and liberal environment of a university.

At a global level, mentoring prepares a senior undergraduate student for working after graduation in a different country that has different language, work habits, social norms, in sum a different culture, very different from the one at home. With increasing trends in globalization of industries through technology

transfer from the giving to the receiving ends, such mentoring on international exchange programs in engineering, such as Engineers without Borders (EWB), is of utmost importance for the outgoing students.

Future Work

As a Work in Progress (WIP) paper, we intend to introduce some quantitative research tools, such as stochastic (statistical) data analysis in a few undergraduate courses in mechanical engineering. One such course at the junior undergraduate level is Manufacturing Processes. Students from both Mechanical Engineering and Industrial Engineering departments take this course as a compulsory requisite in their respective curricula. Because of their different background preparations, coming from two different departments, some faculty mentoring and peer mentoring are essential. We are attempting group sessions, mixing mechanical engineering and industrial engineering students in a group of 3 or 4 students, and assigning a faculty mentor for a few groups [11].

Closing Remarks

Small engineering schools, such as Turabo campus of the Ana G. Méndez University System in Puerto Rico and The University of Vermont (UVM) in USA, distribute evenly the task of mentoring among the faculty members. Each faculty member is responsible for mentoring a limited number of students, between 5 to 10 at Turabo, and between 10 to 15 at UVM. Larger schools like PUPR and UPRM in Puerto Rico as well as UF and NC State in USA have only very few faculty members for mentoring a large number of undergraduate students, which boils down to a much higher number of mentees per mentor, and hence less personal attention to each mentee. It should be noted, however, that in larger schools there are one or two fulltime administrative personnel who work as student counsellors.

In Puerto Rico, at Turabo campus, the peer mentors who are senior undergraduates, are remunerated whereas at UPRM it is *ad honorem*. It seems from the study that in Puerto Rico peer mentoring is very effective for improving the retention rate as well as for enhancing the academic (exam) grades of the mentees. Furthermore, the undergraduate engineering programs in Puerto Rico cover five years vis-à-vis four years in the US. This difference is due to the bilingual (Spanish/English) factor, and more importantly the bicultural influence in the island. The students do take not only two to four courses in English and Spanish languages and literature but also enroll themselves in courses on history and culture of the two countries as a part the socio-humanistic electives in their respective undergraduate curricula. Besides, in most of the European engineering schools, such as in France and Germany, (and with particular exception in the UK) the Bachelor of Engineering degree (like the *Diplom Ing.* in Germany) usually covers ten (10) semesters which is five (5) years. Puerto Rico is not any exception.

Hence, the bilingual and the bicultural nature of the island becomes an additional important parameter in mentoring. Culture is a very dominating factor in any country and cannot be ignored. Most of the undergraduate students in Puerto Rico are Puerto Ricans but many of them are born and raised in USA during their early years of education, and then moved to Puerto Rico with their parents. Hence, there are some cross-cultural identities. Besides, today many students from the other English, French and Creole speaking Caribbean islands come to Puerto Rico as engineering students. Similarly, in the engineering schools in USA, especially in the undergraduate programs, the lecture halls and the teaching cum research labs are filled with international faces. This makes both in Puerto Rico and in USA global mentoring more subtle, more complex and more challenging.

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