

Long-term impact of the Boeing Welliver Faculty Fellowship Program

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Abstract

The Boeing - A.D. Welliver Faculty Summer Fellowship program brings university faculty to Boeing to expose faculty to the changing environment that today's engineers have to work in, in the era of global competition. Boeing hoped that this exposure will motivate engineering faculty to introduce innovative changes to the engineering curriculum and teaching methodologies so as to better prepare tomorrow's engineers. The co-authors participated in the program in 1997 (Kumar) and 1998 (Eberhardt). Upon leaving the program each participant had to present what was learned and what new goals will be set after leaving the program. There is no long-term follow-up of these goals. In this paper the co-authors will provide their long-term achievements resulting from the Welliver program.

Introduction

The Boeing Company initiated a program in 1995 called the Boeing - A.D. Welliver Faculty Summer Fellowship program (WFSF), in honor of the former chief engineer, Bert Welliver. This program is a product of a series of joint workshops organized by industry and academia to identify effective measures that promote improvements in engineering education. The goal of the WFSF Program is to keep mid-career engineering faculty abreast of the rapidly changing industrial environment for the purpose of improving engineering education. As such, it is the only program of its kind in the nation. Boeing expects participants to disseminate what they learned to the academic community (through papers such as this) and to increase the awareness of institutions of higher learning about modern trends in engineering practice in corporations striving to remain globally competitive.

The WFSF participants typically spent the first week together in Seattle, where they were introduced to a broad array of issues related to the key elements of global competitiveness and the practices of engineering at Boeing. The following six weeks consisted of individually-tailored "shadowing assignments," centering around each fellow's respective area of technical interest. During this time, the fellows were individually exposed to different management and technical programs and lived among Boeing engineers and staff engaged in the day-to-day dynamics of engineering practice. These activities included participation in Integrated Product Teams, customer and partner visits, planned tours of Boeing facilities, demonstrations of rapid prototyping, advanced

manufacturing, and CAD/CAE/CAM processes, and meetings with company employees ranging from top executives (including CEO Phil Condit), to mid-level managers and senior and junior engineers.

The WFSF participants also learned about the development and management of processes to promote cultural change among engineers. Among topics extensively discussed were: 1) the meaning of being customer-driven; 2) the environment, attitude and beliefs that lead to global competitiveness; 3) economics and economic interactions in the practice of engineering; 4) the importance of focusing on processes and process improvements; 5) the role of "people skills" in engineering in team environments 6) system integration processes encompassing design, engineering, and factory practices; and 7) the roles of information technology.

During the final week of the program, the fellows returned to a workshop environment to share, discuss and begin documenting their collective observations and their implications on engineering education and curricula. Each fellow presented his/her experiences and ideas and implementation plans for curriculum enhancement.

Industry Needs

The WFSF was one result of a Boeing-University workshop. The program was modeled after Boeing's highly successful student summer internship program. In this case, faculty will return to their universities with a clear understanding of what professional engineers actually do.

Another result of the Boeing-university workshop was to create a list of "Desired Attributes of an Engineering Graduate". These attributes have been incorporated into the ABET 2000 Criteria 3. More specifically, in reference 1, McMasters and Matsch specifically outline what industry needs. A brief summary of these needs includes the following:

- Recognition that "Design" and "Engineering" are synonymous.
- Recognition that what you design has to be built.
- Students must be prepared for life-long learning since it is impossible to teach everything in a four to five year program.
- Recognition that strong University-Industry relations are important for future prosperity.
- Provide students with a proper context, including legal, ethical, economic, etc. contexts.
- Provide an appropriate reward system for educators that stress industry experience.
- Focus on education rather than training.
- Proactive leadership from professional societies.

The Welliver program opens the Boeing Company to participants so that they can recognize these needs first hand. Although individual faculty can not address these needs alone, the more faculty to recognize these needs, the easier it will be for the educational

system to satisfy these needs. In this sense, Welliver fellows are like disciples of industry needs.

In the views of the authors the program was a great success. Much was learned during the fellowships. What is missing, however, is a feedback loop describing how the program has indeed changed certain aspects of the participants' professional lives. This paper will present what the authors have accomplished since their graduation from the program, Kumar (1997) and Eberhardt (1998)..

Eberhardt

Upon returning from my summer fellowship I enthusiastically took on the role of Undergraduate Committee chair. This committee decides all undergraduate issues, including curriculum issues. With our ABET review slated for 2001 (recently passed with no "concerns" or other negative remarks) the Undergraduate Committee Chair had a very important role to play. I felt that my Boeing experience helped me recognize the importance of having processes in place. It also showed me the importance of continuous feedback. The result in our department has been a major revamping of our undergraduate core curriculum.

The use of instituting processes and continuous quality improvement has led to an improved undergraduate program. Feedback from students, industry and the faculty pointed to problems that could be fixed. Examples include having bi-weekly meetings of faculty teaching undergraduate courses to coordinate material, homework and exams. Content in core classes has been shifted to make room for additional, practical, material, such as a hands-on electronics class.

Finally, through contacts made during the fellowship guest lecturers have been identified, case studies added to classes, and Boeing engineers have been invited to participate in various undergraduate functions, including our Undergraduate Committee meetings.

Kumar

The Welliver program has forever changed the way I look at teaching. Brought up in the classic "lecture" mode of delivering education, the program helped me realize that what we deliver through a lecture is for the most part "information". It does not become "knowledge" until the student has experienced it. I still remember when this realization first came to me. In the first week of the program, the Boeing President and CEO Phil Condit remarked that Boeing faced tough global competition, and it had to make structural changes and improve its productivity in order to survive. What competition, I thought, since there is just one other company that makes airplanes, namely the Airbus. How can this translate into a competitive pressure for Boeing?

We spent the following six weeks meeting and interviewing engineers and technical managers at all levels in various Boeing facilities in the Puget Sound area. We had permission to attend working meetings. We saw the magnitude of change that was happening at all levels in the organization: design process, manufacture and assembly, even at the individual level. The "process consciousness" and the "continuous improvement philosophy" could be seen in action everywhere. As I was writing the

summary of my experience in the last week of the program, the meaning of Phil Condit's remarks suddenly dawned on me. The huge conscious effort to change and to improve the productivity was indeed driven by the necessity to survive in the marketplace. For example, shift from a "product philosophy", i.e., the next model should have a better performance, to a "market philosophy", i.e., who can introduce the next model faster, was indeed a matter of survival, forced by the pressures of global competition.

In the first week, Phil Condit's remarks were just "information". It took six weeks of "experiencing" the change that Boeing was undergoing at various levels to convert that information into "knowledge" for me. That is, I understood what I was told at a deeper level, based on which I could use the information and act in a meaningful way.

This experience has led me to ask, "how can I convert information into knowledge for my students"? As a result, I seldom give a straight, old-fashioned lecture. I always now look for ways for students to experience the essence of the truths that I am trying to communicate. I draw on various active learning techniques: small group activities, laboratories and demonstrations, some form of "hands-on" experience.

Upon returning from the Welliver Fellowship I enthusiastically became Chair of the Undergraduate Education Committee of our department. I championed the "credit-for-coop" idea, which has been implemented now for over a year. A coop program has been in existence for mechanical engineering students for a long time, but the students never got any credit for it, and this led to a delay in their graduation. Under this program, mechanical engineering students can earn up to 4 credits for a six-month industrial internship (or 2 credits for a three-month internship). The program was designed to encourage students to opt for industrial experience before they graduate, and appears to be working. Some forty students out of a class of approximately 120 students took part in this program in the last academic year.

Perhaps the most important idea that I have brought to the department of Mechanical Engineering from my Welliver experience at Boeing is that of looking at the dispensation of the undergraduate engineering education as a "process". As part of the new ABET procedures, we have implemented the idea of a conference of all faculty that teach a particular course in a given year. Thus a required course offered every quarter may have three different faculty teach the course. The "course coordinator" calls a meeting once a year at which all faculty interested in teaching the course compare notes on what worked and what did not, etc., and what improvements to the course are needed, etc. This meeting ends with an agreement on what changes will be implemented and how it will be done. This simple process assures a continuous improvement of the course.

Teaching Innovations

Eberhardt

A course I teach is a "general education" course in aerospace engineering^{2,3}. The course is designed to satisfy a University graduation requirement and is not intended for students specializing in science or engineering. What was learned in the Welliver program has helped immensely. Teamwork is stressed, airplane design is taught from a marketing/business perspective, and the importance of cost is emphasized. The most

important aspect is the experience it has brought so that I can share those experiences with the students.

I started a another new course for our students, inspired by the Welliver program. The course replaces our weekly undergraduate seminar, during the winter quarter. Instead, students are taken on tours of Boeing facilities. One tour, the 777 plant, fills the students with the same awe that we felt during our tour as Welliver fellows. We also visit the simulator labs, manufacturing and flight test.

In my flight test course I have included guest lecturers from Boeing and received several case studies to use for classroom exercises. The course, which is offered spring quarter to seniors, focuses on many practical engineering problems. Students work in teams with rotating responsibilities. Reports are written following documentation requirements typical for certification. The students now have to become familiar with the FARs (Federal Air Regulations), as motivation for their data collection.

Kumar

I developed a Sterling Engine fabrication project for "hands-on", quarter long lab experience in ME 304⁴ (introduction to manufacturing). This was the first true " team project" in that a section of 12 to 15 students were asked to fabricate one sterling engine. Smaller teams of three to four students made their assigned parts, but had to coordinate with the other teams to make sure the parts will fit together. This project has been institutionalized, and now every year, about 150 ME undergraduates experience the joy of fabricating something that is expected to work. And when it does not work, they learn even more, dealing firsthand with the issues of manufacturing tolerances.

I introduced several new "hands-on" laboratories in ME 356 (Machine Design) with the help of graduate student Greg Branch⁵. One of the labs introduces the students to a number of "off the shelf" materials commonly used in fabrication. Another lab attempts to give them a feel for the torsional stiffness of materials, and the difference between the torsional stiffness of an open versus a closed section. We have now done two iterations on these labs, and student feedback is very positive. However more work is needed to better integrate the labs within the course.

Summary

There are roughly 70 alumni of the Welliver program. There is no formal mechanism for us to share how the program has affected us after we leave the program. We wish to use this public forum for providing such feedback. Also, we wish to share with others ideas that have resulted from the program.

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Biographies

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Assoc. Prof. Vipin Kumar has been a member of the faculty of Mechanical Engineering at the University of Washington since 1988. Prior to joining the university he worked for ITT Grinnel Corp. for 10 years in the area of piping systems. He holds a B.Tech from the Indian Institute of Technology at Kanpur, India, an MS and MBA from the University of Rhode Island, and a PhD in Mechanical Engineering from MIT.