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# SURGICAL DEVICE DESIGN IN ENGINEERING EDUCATION

An Interactive Qualifying Project Report

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by

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## Abstract

The objectives of this project are to identify the ways biomedical engineers contribute to surgical device design and propose methods of integrating design training into WPI's undergraduate biomedical engineering program. WPI's program is compared with ABET-accredited and other non-accredited programs. Interviews of design engineers and physicians are used to define the biomedical engineer's role in the medical device industry. The project shows that WPI's undergraduate program could benefit from a more educational relationship with the University of Massachusetts Medical Center.

**Abstract**

Biomedical engineering is a growing multidisciplinary field. Along with the traditional mechanical, chemical, and electrical disciplines, biomedical engineering encompasses the study of fundamental physical principles and their relationship to biological phenomena. In addition, biomedical engineers fill a variety of roles in the clinical, industrial, and academic settings. The objectives of this project are to identify the ways biomedical engineers contribute to surgical device design and propose methods of integrating design training into WPI's undergraduate biomedical engineering program. The undergraduate biomedical engineering program was compared with ABET-accredited and other non-accredited programs. Samples of industry practices and interviews of academic engineers, industrial design engineers, and physicians were used to define the biomedical engineer's role in the medical device industry. The results indicate that industry uses biomedical engineers primarily to design and develop medical devices and WPI's undergraduate program could benefit from a more educational relationship with the University of Massachusetts Medical Center. The project demonstrates that engineering design education must be consistently linked with application.

Table of Contents

## 1.0 – Introduction

Biomedical engineering is one of today's fastest growing engineering disciplines. The Engineering Workforce Commission reports, "From 1991 to 1995 the number of B.S. degrees granted in biomedical engineering grew by twenty five percent" (Panitz 1996). In addition, biomedical engineering attracts higher caliber students than traditional engineering disciplines. Beth Panitz, of the American Society for Engineering Education, found that, "Those in bioengineering credit the field's growth to scientific developments in biology coupled with advances in technology." Indeed, it appears to be the next major engineering discipline.

Originally, biomedical engineering education existed exclusively at the graduate level, most suitable for students with the background of a traditional engineering degree. And even after the first undergraduate programs surfaced in the 1970's, most biomedical engineering students pursued medical or other graduate degrees. Currently, however, the trend is for more biomedical engineering graduates to enter industry directly after a bachelor's degree. David Gough, professor and chairman of undergraduate biomedical engineering at University of California, San Diego, said that, "as the job market has expanded, the number of students seeking advanced degrees has decreased over the last few years" (Williamson 1998). So the quality of undergraduate biomedical engineering education is becoming increasingly significant to industry and students alike.

Biomedical engineers can be found performing many different tasks. They work in hospitals, the medical device industry, or academic research; they create new techniques and tools for biomedical imaging, surgery, and drug delivery. They interact with other engineers and often with clinicians, so they must be conversant with technical and medical terminology. In addition, biomedical engineers address regulations from the U.S. Food and Drug Administration and international regulatory bodies. But what skills does the biomedical engineer possess, and how can he or she contribute to the design of a medical device?

The biomedical engineering discipline creates a slew of challenges for higher education institutions, particularly at the undergraduate level. Traditional engineering disciplines like mechanical, electrical, and chemical engineering, are based on distinct fundamental principles; undergraduate programs in these disciplines can produce engineers with extensive experience and knowledge of these fundamentals. Biomedical engineering, in contrast, is a multi-disciplinary program that demands knowledge of traditional engineering principles and the ability to apply those principles to biological problems. The challenge for academic institutions is to accommodate the breadth of biomedical engineering with a depth of knowledge and design experience sufficient to attack real bioengineering problems.

The purpose of this Interdisciplinary Qualifying Project is to define biomedical engineers' roles in medical device design, and to propose ways of integrating relevant design experience into WPI's undergraduate biomedical engineering program. WPI's biomedical engineering department recently adopted a revised curriculum in preparation for ABET evaluation. It incorporates more courses, labs, and a more flexible curriculum that can be tailored to the interests of each student. In addition, a new introductory design course is available for underclassmen. While the new curriculum presents several improvements, it is still deficient in adequate and relevant design experience. By incorporating more design experience throughout the curriculum, beyond the dedicated design courses and projects, WPI's biomedical engineering program can produce engineers that are prepared for their roles in industrial medical device design.

This project team's primary goal is to understand how biomedical engineers contribute to the design of medical devices and how engineering schools currently incorporate design experience into their undergraduate biomedical engineering curricula. In addition, the team aims to improve WPI's undergraduate program by offering recommendations based on the results of this project. The project begins with a literature review that establishes a definition of the biomedical engineering discipline, describes the gap between academia and industry, and

presents ways of incorporating design experience into undergraduate engineering curricula. Next, the project delineates the methodology used to gather information about industry expectations and design practices and current educational trends. Then, the results of the gathered data are presented, analyzed, and discussed. Finally, the project includes recommendations on how to expose the student to medical device design through WPI's current undergraduate biomedical engineering program.

Ultimately, the results of this project will act as a proposal for continued collaboration between WPI's Biomedical Engineering Department and University of Massachusetts Medical Center's (UMMC) Minimally Invasive Surgery Unit (MISU). In addition, this project fulfills Worcester Polytechnic Institute's degree requirement called an Interactive Qualifying Project by illustrating the social and economic features of medical device design and how these features can be brought to the undergraduate biomedical engineering student.

## 2.0 – Background

### 2.1 – Defining the Discipline

The definition of biomedical engineering (BME) is a basic and essential premise for this project. The discipline originated nearly forty years ago with the advent of modern health technology; yet, there is no definitive set of guidelines for what the biomedical engineer does or what he or she knows. The Johns Hopkins University, recently ranked as the top school for undergraduate biomedical engineering by *U.S. News & World Report*, offers this definition,

> Biomedical engineering is the application of techniques drawn from engineering to the analysis and solution of problems in biology and medicine. It differs from other branches of engineering in that there is no particular subject matter or set of techniques which belong exclusively to biomedical engineering. Rather, biomedical engineering applies the techniques of all the classical engineering disciplines to problems encountered in living systems. (JHU 1997)

This definition summarizes the broad scope of biomedical engineering, and it is representative of most institutions' perception of the discipline. One point of confusion lies in the terminology, because *biomedical engineering* and *bioengineering* are two common variations on the name. The Accreditation Board for Engineering and Technology (ABET) considers the two terms synonymous, as do most academic institutions. The term "engineering" carries significant denotations as well; V. Wilczynski, U.S. Coast Guard Academy, says, "to engineer is to design" (1995). Certainly engineering encompasses more than the design process, but another basic premise of this project is that biomedical engineering education must include elements of the design process, particularly with respect to medical devices.

But what do biomedical engineers do, how are they different from "traditional" engineers, and how can they contribute to medical device design? The answer to this question is often rather elusive for industrial employers, students, and academic faculty alike. In many ways, biomedical engineering is rapidly evolving and expanding. The medical device industry is naturally tied with the fast paced computer and biotechnology industries; advances in these fields continuously pave new paths of research and design for medical device manufacturers.

In addition, academia is still developing a vision for the discipline. As a result, biomedical engineers' job opportunities are numerous and transient. One of the first articles about the discipline appeared in the December 1971 issue of *Science*, and it describes three common roles of the biomedical engineer. One role, described as the most common and useful, is that of the "problem solver." The author explains, "This biomedical engineer maintains the traditional service relationship with the life scientist, who originates a problem that can be solved by the application of the specific expertise of the engineer" (Bronzino 1971). A second option for the biomedical engineer is to be the "technical entrepreneur." In this role, the engineer (rather than a scientist) recognizes a problem, and he or she proceeds to find a solution. First the engineer synthesizes a conceptual solution, and then proceeds to construct a prototype. To complete this role, "he must convince the medical community that a useful task has been performed..." (Bronzino 1971). The third type of biomedical engineer that Bronzino describes is the "engineer-scientist," who is "not concerned with the invention or construction of hardware at all. He is primarily interested in applying engineering concepts and engineering techniques to the investigation and exploration of biological processes." This type of engineer formulates mathematical models of biological systems, and uses those models to better predict and understand biological behaviors. Bronzino describes these three "types" or "roles" of the biomedical engineer as distinct and separate. Over the last 30 years, all three roles have combined and expanded to form the contemporary biomedical engineer.

According to current literature, modern biomedical engineers often fulfill each of Bronzino's roles. The Biomedical Engineering Society (BMES), in a 1996 article titled "Planning a career in Biomedical Engineering," explains,

> The biomedical engineer works with other health care professionals including physicians, nurses, therapists and technicians. Biomedical engineers may be called upon in a wide range of capacities: to design instruments, devices, and software, to bring together knowledge from many technical sources to develop new procedures, or to conduct research needed to solve clinical problems.

The Michigan Occupational Information System (MOIS) provides a list of general job tasks associated with a biomedical engineering position:

> Study engineering aspects of bio-behavioral systems of humans, using a knowledge of human anatomy and physiology. Plan and conduct research concerning behavioral, biological, psychological, or other life systems. Develop mathematical models and computer simulations of human bio-behavioral systems in order to obtain information to measure or control life processes, using knowledge of computer graphics and other related technologies (MOIS 1998).

The descriptions given by the BMES and the MOIS complement each other and in combination indicate how the modern biomedical engineer must interact with scientists, conduct research on biological systems, and produce solutions to biological or clinical problems.

The biomedical engineer's multiplicity of roles allows him to work in a variety of settings. The BMES's article, "Planning a Career in Biomedical Engineering," also explains that, "Biomedical engineers are employed in universities, in industry, in hospitals, in research facilities of educational and medical institutions, in teaching, and in government regulatory agencies." (BMES 1996) The article notes that biomedical engineers often act as coordinators or interpreters between the engineering and medical fields, and they perform specific tasks:

> In industry, they may create designs where an in-depth understanding of living systems and of technology is essential...In the hospital, the biomedical engineer may provide advice on the selection and use of medical equipment...They may also build customized devices for special health care or research needs (BMES).

The biomedical engineer can play one of many specific roles in the clinical, industrial, and academic forums. Ideally, an undergraduate program would provide adequate background for each of those roles, and therein lies the challenge of preparing students for work in biomedical engineering.

**2.2 – The Biomedical Engineer in Industry**

A recent article in *Machine Design* explores the medical industry's increased demand for engineers and how academic institutions are meeting that demand (Williamson 1998). "Rapid growth [in the medical industry] coupled with the need for ever more sophisticated devices has created an exceptional demand for engineers" (Williamson 1998). And to meet the demand,

more and more engineering schools are offering undergraduate students a degree in the biomedical discipline. One paradoxical problem with the biomedical discipline, however, is rooted in academia's inability to agree on biomedical engineers' skills and functions. In general, each school has a different curriculum, and this makes it difficult for employers to know what background a prospective biomedical engineer has. J. Thomas Mortimer, professor of biomedical engineering at Case Western Reserve University (CWRU), explains, "There's a question in many employers' minds about what a biomedical engineer is" (Williamson 1998). To date, there is no resolution to the problem, "but experts agree that no single curriculum addresses all of industry's diverse needs" (Williamson 1998). As the job market expands and more students pursue an undergraduate biomedical engineering degree, the coordination between industry and academia will become more and more important.

Another recent article in *Machine Design*, "Getting Biomedical Engineering in Synch with Industry Hiring," explores the problem further. It includes views from educators and industry, and identifies ways of bringing higher education in touch with industry. Prof. Gustav A. Engbretson, Dept. chair of Bioengineering and Neuroscience at Syracuse University,

> believes that a recent biomedical engineering grad should bring a range of expertise to his or her new firm. The new graduate should have excellent problem solving skills, experience in design, good communication skills, the ability to work in a team setting, and an appreciation of how biological systems interact with engineering measurement and control devices. Beyond those general requirements, new graduates should also have some depth of knowledge in a specific area of biomedical engineering (Manji).

The balance of "range of expertise" and "depth of knowledge", however, is subject to the inconsistent and changing needs of industry. In an effort to more accurately assess job market demands, many biomedical engineering departments are striving to make stronger ties with industry. The BME department at Johns Hopkins, for example, recently created a new committee of industrial advisors to help with curriculum improvements, student career development, and technology transfer. "The biomedical engineering department has recognized a need to increase its understanding of and involvement with industry," said Cathy

Jancuk, a department representative. Other ways of facilitating communication with industry include the development of internship and co-op programs, and industry-mentored research projects. Such collaboration allows industry and academia to share resources and would facilitate the convergence of their perceptions of the discipline.

**2.3 – Integrating Design Across the Curriculum**

ABET is increasingly pressuring engineering departments to integrate design experience across the curriculum; this pressure is in direct proportion to industry's demand for graduates with the ability to design. So, there is an obvious need for engineering departments to evaluate their curricula based on students' exposure to design problems. It is important, however, to first understand what is meant by "design." The ABET definition of design is found in the Criteria for Accreditation publication:

> Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences and mathematics and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. The engineering design component of a curriculum must include most of the following features: development of student creativity, use of open-ended problems, development and use of modern design theory and methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, production processes, concurrent engineering design, and detailed system descriptions. Further, it is essential to include a variety of realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics, and social impact (ABET 1998).

This definition is followed by ABET's criteria for design experience in an engineering curriculum. The criteria are vague and open-ended, but two points are particularly relevant to this project. First, the nature of the design experience must be related to the discipline: "The scope of the design experience within a program should match the requirements of practice within that discipline" (ABET 1998). The practice of design in biomedical engineering, for example, is different from that in chemical or mechanical engineering, so BME students should be exposed to the unique features of medical device design (these features are pursued later in the project). An alternative approach incorporates design aspects of the traditional engineering disciplines,

rather than an independent biomedical design experience. The second point is that design should be integrated across the curriculum: "Design cannot be taught in one course; it is an experience that must grow with the student's development" (ABET 1998). Including elements of design in courses throughout the curriculum allows students to develop and refine their ability to design. The culmination of the design experience, in the form of a project or thesis, can then be an opportunity for students to apply their design skills without having to first acquire them. Engineering departments need to incorporate design experience that is relevant to their respective disciplines throughout the curriculum; as such, WPI's BME program should include the unique features of medical device design in all aspects of the undergraduate curriculum.

Industry's demand for engineers who can design is well documented. Leland Nicolai, of the Lockheed Advanced Development Company, said in a recent article, "American industries...place the highest value on engineering design in their product development" (1998). Nicolai explains that universities are developing engineering curricula with too much emphasis on theory and a deficiency in practical application. He said, "...for the past 30 years the engineering graduates have been weak in design...It is ...the view of industry that the American engineering schools are turning out great scientists, but mediocre engineers" (Nicolai 1998). In addition, he reports the results of an evaluation the College of Education at Arizona State University conducted by students, faculty, and industry representatives:

> The results of their two year study revealed that the unanimous number one attribute desired for a newly graduated engineer was the ability to identify and define a problem, develop and evaluate alternative solutions, and effect one or more designs to solve the problem (Nicolai 1998).

Denice Denton, Dean of the University of Washington College of Engineering, reports a similar, and more encompassing, finding from the academic perspective:

> The message from our industrial partners concerning desired attributes of engineering graduates is very clear: a good grasp of engineering science fundamentals, a good understanding of design and manufacturing, good communication skills, curiosity and a desire to learn for life, and a profound understanding of the importance of teamwork (Denton 1998).

Nicolai concludes that there is a strong exigency for engineering schools to meet the needs of industry, and he notes that curricula only need to be modified, rather than completely restructured, to accommodate the components of design. He recommends that faculty use open-ended problems that force students to create their own links between theory and practical applications and that students should be exposed to these problems in all four years. Current literature indicates that industry expects and demands that engineers be competent in common design practices.

One proposed method of enhancing design experience is through more hands-on experimentation. David Beebe, of Louisiana Tech University, described his experience with, and value of, hands-on projects in his article, "Teaching Hands-on Biomedical Instrumentation." He established the value of the laboratory experience, saying,

> ...an engineer's training should be structured to allow the prospective engineer time to do engineering in a practical, hands-on way...the art of designing and building things is best taught via experience. In addition, hands-on projects and laboratory experiences provide a fertile ground for students to acquire skills in logical thinking, problem solving and basic troubleshooting. These are skills that are more difficult to teach in the lecture setting (Beebe 1996).

Beebe gave some suggestions on how to structure biomedical instrumentation labs, too: "The labs should be designed not only to reinforce the lecture material but also to teach students laboratory skills such as trouble-shooting problems...and ultimately design" (Beebe 1996). In this way, the hands-on laboratory experience is another tool for integrating design across the curriculum. Beebe outlined the course material and described the group design projects that create the design experience. The benefits of hands-on experience are best understood in his comments about the group design projects:

> The projects force the students to take the final and critical step in engineering education – to think for themselves. No longer is the answer given or even suggested. The design projects are not a follow-the-instructions experiment, but rather an actual engineering problem in many ways analogous to an entry level engineering assignment in industry. The students must work within the framework of a team to accomplish a common goal (Beebe 1996).

Surely, undergraduate engineering education, of any discipline, should strive to push students to this point. By developing more undergraduate laboratory-based design courses and projects, WPI's biomedical engineering curriculum will expose students to the hands-on, practical nature of the design process.

The National Science Foundation has funded research on the topic of introducing design early in engineering curricula through many programs, one of which is titled SUCCEED. SUCCEED involves eight universities in the Southeastern United States, and its mission is to "develop 'Curriculum 21,' a comprehensive redesign of undergraduate engineering education for the 21st century" (Gordon, et.al. 1996). In an article presented at the 1996 ASEE Annual Conference Proceedings, representatives from SUCCEED present their research projects on incorporating design early into their engineering curricula. None of the projects addresses biomedical engineering specifically, but the strategies they include may be useful in improving WPI's program nonetheless. One project, targeted for civil engineering majors, describes how the faculty at North Carolina State University organized a course composed of sophomore, junior, and senior students for a design competition. The students were assembled into "vertically integrated design teams" that allowed underclassmen to learn from the upperclassmen. The other significant aspect of this course is that the design problem involved constructing a physical model; this allowed students to make the connection between the analytical models learned in lecture and the physical problems observed in the lab. With the proper labs and equipment, such a course adapted for the biomedical discipline may benefit students throughout WPI's program.

The article continues to discuss the concept of design and the advantages of incorporating design early in the curriculum. The authors stress that "design is a process, and learning this process requires that students engage in that process by working on a realistic problem" (Gordon, et.al. 1996). In addition, the authors note that students enjoy and appreciate practicing the design process, saying, "Many engineering students are motivated by the desire

to understand and immerse themselves in real-world problems and technology" (Gordon, et.al. 1996). WPI's undergraduate biomedical engineering program should include hands-on design experience throughout the curriculum to keep students motivated and excited about the discipline.

Biomedical engineering encompasses a wide variety of tasks, work environments, and areas of research. In addition, the medical device industry is struggling with the definition of a biomedical engineer and his or her skills. The incorporation of design experience into undergraduate biomedical engineering will become increasingly important as more students pursue a career in industry directly after graduation. Students should be exposed to the design process throughout the curriculum, and their experience should reflect the practices of the medical device industry. This design experience may be integrated into courses by way of more open-ended problems, group projects, and hands-on lab experience. In addition, enhancing the department's relationship with industry through organized co-op and internship programs will provide more opportunities for students to be part of the industrial design process early in their careers.

## 3.0 - Methodology

This project was completed via a four-pronged methodology including literature research, interviews, site visits, and surveys. Through this methodology, the project team:

- Became familiar with industrial medical device design process,
- Explored the roles of biomedical engineers in medical device design,
- Investigated current educational trends in undergraduate biomedical engineering training,
- Learned what industry expected of biomedical engineering graduates, and
- Synthesized and analyzed the resulting information in order to develop recommendations for improving WPI's biomedical program.

The project team became familiar with the design process of medical devices in industry through interviews and site visits. Once this design process was understood, the project went even further and identified the role of the biomedical engineer in this process as well as what experience was required to fulfill this role. Specific interview questions were drafted in order to detail and specify the role of the biomedical engineer in medical device design.

For investigating the current educational trends in undergraduate biomedical engineering training, the project team found literature regarding these trends via Internet research of all the accredited and non-accredited institutions that supported an undergraduate biomedical engineering program. The project team developed several factors to evaluate these programs in order to address the goal of this project. These factors were discussed in more detail later on in this section. Yet, if there was any information that could not be found on the institution's web site, the project team e-mailed a survey to the head of the biomedical engineering department on any information that was absent or unclear.

Finally, for gathering information on what industry expects of biomedical engineering graduates, the project team conducted Internet research of local company web sites and job descriptions. A set of factors was developed for evaluation of these web sites and job

descriptions and is discussed in more detail later in this methodology. The project mailed out surveys on any information that was unclear or absent. As a result, this combination of methods allowed the team to gather current information directly from the experts and practitioners in the field.

To compile all the results for each evaluation, the project team utilized Microsoft Excel to keep a spreadsheet of this information. Statistical techniques, including the t-test and averaging, were used to analyze the data. Finally, the results were compared numerically with percentages and graphically with charts.

### 3.1.0 - Literature and Internet Research

The first stage of the methodology was split into two categories: literature and Internet search and review. Literature research was beneficial to the project since it provided specific, published material. The project team located several relevant articles with catalog and journal search engines available at WPI's Gordon Library. In addition, the project team browsed through several collections of engineering education journals that were not searchable via electronic databases. The project team photocopied the articles that were relevant to this project and recorded a summary of each article's contribution to this project. In general, the articles found in this literature research provided essential information on background necessary to understand all aspects of this project.

On the other hand, Internet research provided material that was more relevant to the data collection part of the project. More specifically, Internet research aided in finding:

- Current information on undergraduate biomedical engineering programs, and
- Industry's expectations of entry-level biomedical engineers.

The majority of the Internet research was conducted through Internet search engines. Most engineering schools have web sites for each department, so much of the information about undergraduate curricula was gathered from those sites. The Whitaker Foundation provided a particularly useful web site with links to all of the Biomedical Engineering Departments across

the U.S. Job search engines provided job descriptions for openings across the country. The Yahoo Classifieds and HeadHunter.Net provided most of the descriptions used in determining industry's expectations of entry-level biomedical engineers. Once information was found, the project team downloaded and printed the information for future reference within this report.

### 3.1.1 – Review and Analysis of Academic Programs

The project team investigated every known undergraduate BME program in the U.S. (Whitaker 1998), and segregated them based on ABET accreditation. The biomedical programs of the selected institutions were examined on the basis of the following factors:

- The number of undergraduate biomedical students and faculty,
- Biomedical courses offered with focus on design and labs,
- Specialty areas/concentrations,
- Internships,
- Affiliations with hospitals and/or medical schools,
- Independent studies, and
- Accreditation.

A more detailed layout of this evaluation is contained in Appendix D. In order to gather the necessary information for this evaluation, the project team searched the web sites of all the institutions that had accredited programs as well as the institutions offering non-accredited programs. If any information was absent or unclear, then questions were mailed in the form of a survey to the biomedical chairmen or department heads of respective institutions via electronic mail (e-mail). A sample survey can be found in Appendix D as well.

Below is a list of the factors used for the academic evaluation and the analytical techniques performed on those factors.

- ❖ Number of Undergraduate BME Students, Number of Total BME Courses Offered, Number of Required BME Courses, Number Courses Dedicated to Design, Number of Courses with Lab, BME Faculty/Student Ratio, Lab/Course Ratio, Number of Hospital Affiliations, Percent of BME Undergraduates Involved in Internships, and Number of Other Accredited Programs

- For each group (accredited and unaccredited), the average number/percent/ratio was calculated. All undisclosed results were included in calculations.
- Bar charts were then generated to visualize the results of accredited vs. unaccredited vs. WPI.
- The student t-test was used to identify any significant differences between the accredited and unaccredited results (where $p>0.05$ is considered statistically significant).

- BME Concentrations
  - For each group (accredited and unaccredited), a list of the number of schools that support each concentration was generated.
  - A bar chart displaying the results from accredited programs, non-accredited programs, and WPI's program.

- BME Concentrations, Internships Available?, Internships Required?, Offer BME Independent Study, and Affiliated With Hospitals?
  - The percentage of schools that supported each factor was calculated for each group (accredited and unaccredited).
  - For each group (accredited and unaccredited), two separate lists were generated to record the number of schools that did and did not support each of the above factors.
  - Finally, a bar chart was plotted to display the possible differences between accredited and unaccredited schools.

- Placement of BME Undergraduates after Graduation
  - The average percentage of students within each post graduate placement (MD, MS/PhD, or industry) was calculated.
  - Bar charts were then generated to visualize the results of accredited schools vs. unaccredited schools vs. WPI.
  - The statistical t-test was used to identify any significant differences between the accredited and unaccredited results (where $p>0.05$ is considered statistically significant).

For each analysis, the number of disclosed values (responses) was incorporated into each chart and comparison in order to identify how strongly each evaluation was supported in the results. By comparing and analyzing the accredited programs with the non-accredited on the basis of these factors, the project team was able to identify which of the above factors play a major role

in constituting a strong, well-developed biomedical engineering program in design according to ABET. Then, the project team used these results as part of a process to develop recommendations so as to bring WPI's biomedical engineering program up to this level with regards to design.

### 3.1.2 – Review and Analysis of Industry Expectations

In addition to examining academic trends, the project team investigated several local companies to discover and categorize the most common employer expectations for biomedical engineers in industry. The project team evaluated companies on the basis of employee information, biomedical engineer's role in design process, design tools, physician partnership, internship/co-op programs, etc. A more detailed layout of the project team's evaluation could be found in Appendix C. Answers in terms of this evaluation were found by examining company web sites, press releases, as well as annual reports. However, if information was absent or unclear, then the project team again mailed out a survey of the remaining questions via electronic mail (e-mail) or stamped mail depending on the availability of e-mail addresses. A full version of this survey and cover letter could be found in Appendix C. Once all information was received and gathered, the project team analyzed the results to find the most common factors shared by most of the local companies. On the basis of the combined company and academic analysis results, the project had a more complete guideline in developing the best recommendations for WPI's undergraduate biomedical engineering program.

An accurate cross-section of current industrial expectations of biomedical engineers was perhaps the most valuable tool for evaluating an educational program. As there is no singular function or set of functions associated with the biomedical engineer, industry's needs span a variety of tasks. By understanding what employers needed from biomedical engineers, the curriculum could be modified or customized to better prepare students to meet those needs. Since the majority of B.S. graduates enter industry after graduation, it was necessary to understand what employers expect of entry-level biomedical engineers. With this knowledge,

the project team was able to develop recommendations for WPI's undergraduate program that would ensure that the expected background or experience was covered. Several job search engines on the Internet were used to obtain data on employer's expectations of new hires. Twenty-seven job descriptions from across the country were gathered via the Internet, each suitable for a recent biomedical engineering graduate. The criteria for selecting suitable job descriptions were the following:

- The degree requirements must include at least, and no more than, a bachelor's of science in biomedical engineering. Other disciplines for degrees (such as electrical engineering) may be mentioned, but the term "biomedical" must be mentioned somewhere in the job description.
- The minimum experience a biomedical engineering gradate must have either through industry, fellowships, research, or further education (Master's degree) must be less than five years.

These criteria were chosen to benefit students who would enter industry directly after receiving an undergraduate degree. It is for these students, in particular, that the curriculum should be improved because they are often competing with engineers of the traditional disciplines for the same jobs.

**3.2 - Interviews**

Interviews were another aspect of this methodology. The interviews conducted for this project were open-ended and informal. The project team interviewed industrial biomedical engineers, academic engineers, and physicians to gain a variety of perspectives of the discipline. Interviews provided insight on the specificity of the discipline, as well. For instance, interviews allowed the project team to collect opinions from professionals and gather recent, up to date information on the type of communication that exists between biomedical engineers and physicians and the roles biomedical engineers play in the design process of medical devices.

The questions for interviews were drafted according to two criteria: what was of immediate interest to this project and who the project team interviewed. For the first criteria, the project team focused on questions that requested insight to the industrial and academic design processes, and the type of communication that existed between biomedical engineers and physicians. In addition, the project team focused on questions that requested answers that clarified the roles of each profession in medical device design. By keeping the interviews open-ended, the interviewee was encouraged to make suggestions and recommendations for the project. For the second criteria, the project team developed a separate set of interview questions for each of the three different audiences that the project team interviewed. Industrial biomedical engineers, academic engineers, and physicians each have different backgrounds and experience associated with their careers so a standardized set of interview questions (Appendix B) was developed to capture this unique difference between each audience. These interview questions were developed by using the guidelines that were given in Appendix B. In addition, the profiles of all the individuals that were interviewed were gathered and summarized.

**3.3 - Site Visits**

The third aspect of the methodology for this project was site visits. Site visits were essential in gaining first hand experience with medical device design. In addition, site visits provided a means of establishing the design environment of industrial biomedical engineers. As a result, this method aided in the simulation of ideal environments for providing design experience to undergraduate biomedical engineering students. The project team visited and participated in:

- UMass Medical Center's Minimally Invasive Surgery Center (MIS)
- Smith & Nephew Endoscopy
- Surgical Rounds/Symposia
- Bard Electrophysiology (Billerica, MA)

Site visits were conducted simultaneously with interview visits. Site visits gave the team an opportunity to observe the tools, people, and various settings that were involved in the design process.

The project team met with Mr. Richard Beane, the lead design engineer at Smith and Nephew Endoscopy, three times to discuss a variety of issues surrounding the roles of the biomedical and the design process. He gave insight on brainstorming sessions, the origins of product ideas, FDA regulations, product testing techniques (lab/design tools), and everyday interactions with surgeons and physicians.

The surgical rounds organized by the UMass MIS and WPI's Department of Biomedical Engineering provided a unique opportunity to observe the interaction between engineers and physicians. These symposia gathered engineers, surgeons, company representatives, and students to discuss clinical problems associated with surgical devices, equipment, and procedures. Attendance at these symposia also gave the project team the opportunity to ask questions and set up interviews with other professionals for further information.

A site visit at Bard Electrophysiology (Billerica, MA) exposed the project team to the industrial environment, tools, and interactions a biomedical engineer may experience on the job. Workstations, lab space, and pilot production lines were all inspected and toured to understand the how and where of a biomedical engineer's job. In addition, the team gained first-hand knowledge of design practices typical to the medical device industry. This site visit was conducted in conjunction with an interview of an industrial biomedical engineer.

### 3.4 Surveys

Occasionally, Some information about biomedical engineering curricula and placement statistics was unavailable through the Internet searches. In addition, literature research on industry's expectations primarily yielded few results. To compensate for these gaps in data, the project team created and distributed surveys, to department heads and human resources personnel, respectively, via electronic mail and traditional mailing methods. The questions were

standardized for recipients of both surveys (see Appendices C and D). Specifically, these survey questions were derived from the evaluation factors that were created in each respective guideline (Appendices C and D). The project team generated a complete sample survey for each audience that accounted for all the factors listed in the evaluation guidelines. So, whenever certain information was absent or unclear, the project team either sent the complete survey (when all factors were absent) or subtracted questions that were already answered and mailed the resulting survey to the audience in question.

## 4.0 - Results

After performing the necessary analysis, the results are listed in three respective sections. The implications and conclusions that are drawn from these results are discussed in the Discussion Section of this report. For reference, the complete, compiled information that the project team gathered for each academic institution can be found in Appendix E, the individual calculations performed to generate bar charts and statistical data: Appendix F, and the returned surveys in Appendix G. The data and analysis of employer expectations are included in Appendices H, I, and J.

### 4.1 – Academic Program Analysis

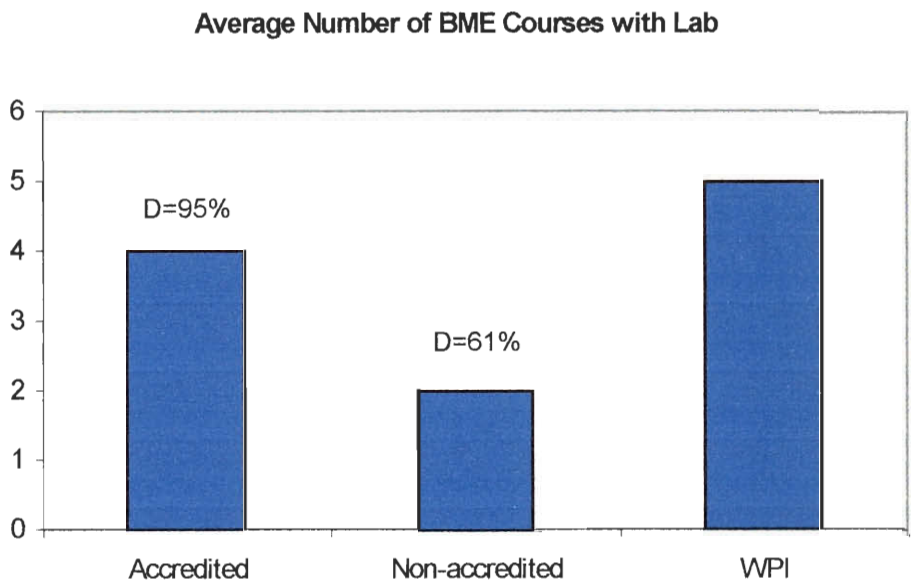


**Figure 4.1: Average Number of BME Courses with Lab.** WPI (5) exceeds the average value found for the accredited (4) and non-accredited (2) programs. *Statistical information*: p=0.15 for the comparison between the accredited and non-accredited programs; they are statistically similar. D indicates the percentage of reported values from the data set.

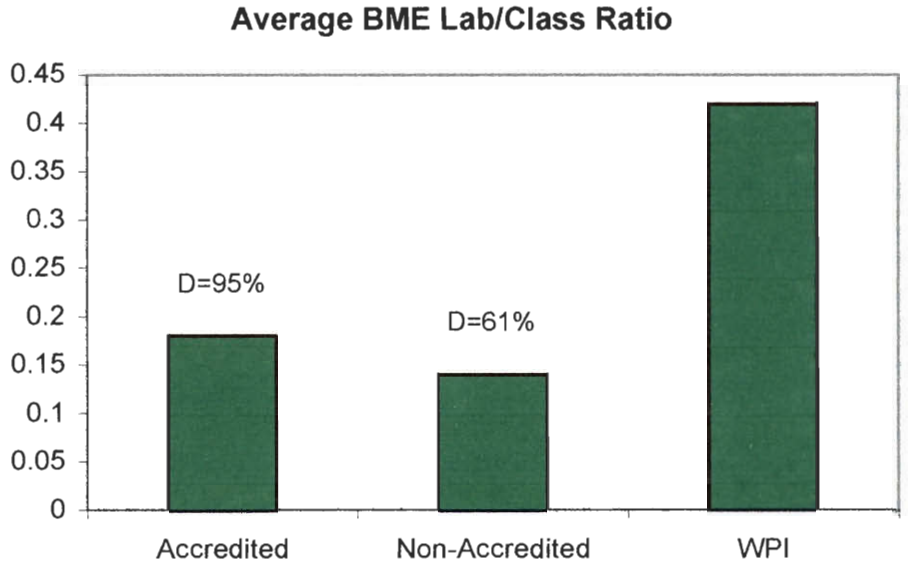


**Figure 4.2: Average BME Lab/Class Ratio.** The accredited program has a value of 0.18, unaccredited of 0.14, and WPI of 0.42. WPI exceeds the average of the other institutions. *Statistical information*: p=0.50 for the comparison between accredited and non-accredited programs; they are statistically similar. D indicates the percentage of reported values from the data set.

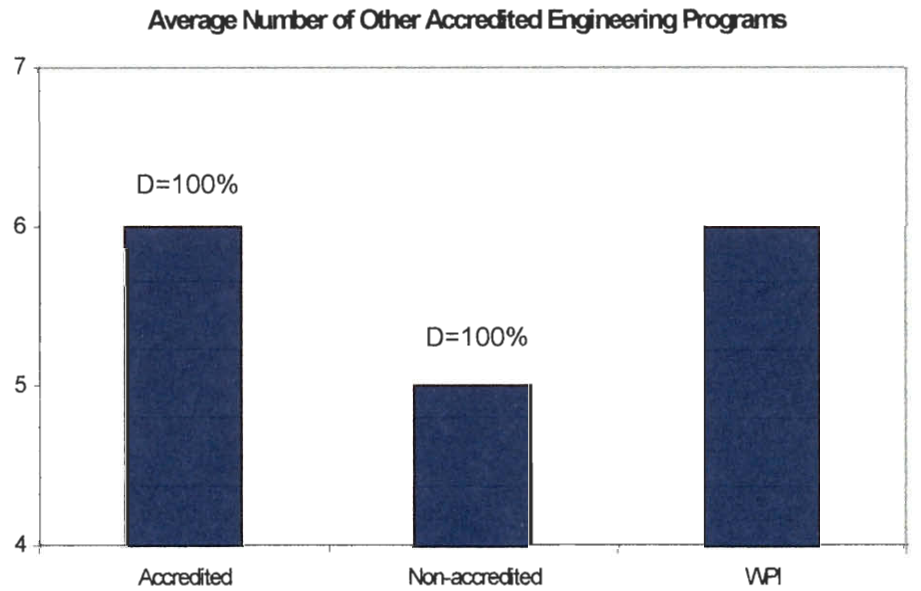


**Figure 4.3: Average Number of Other Accredited Engineering Departments.** The average values for both groups are statistically equivalent and similar to WPI's value. *Statistical information*: There is no significant difference between the accredited and non-accredited values (p= 0.34). D indicates the percentage of reported values from the data set.

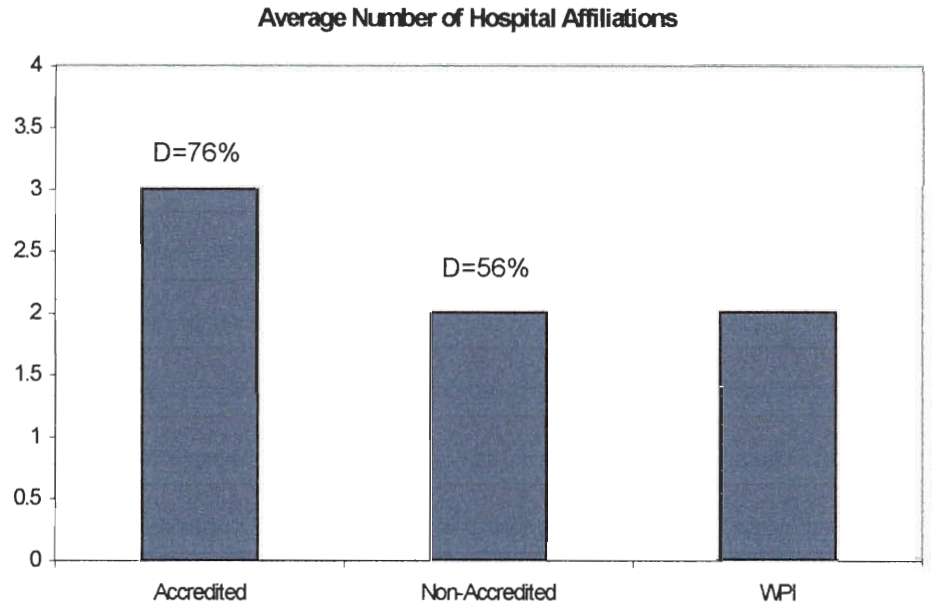


**Figure 4.4: Average Number of Hospital Affiliations.** WPI is equivalent to the non-accredited programs in terms of hospital affiliations. *Statistical information*: There is no significant difference between the accredited and non-accredited programs: p= 0.35. D indicates the percentage of reported values from the data set.

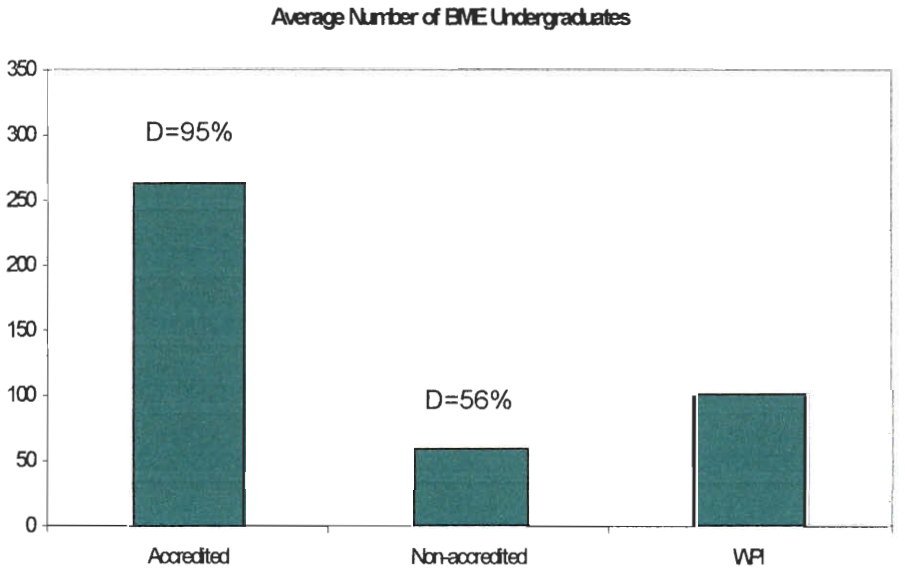


**Figure 4.5: Average Number of BME Undergraduates.** On average, the accredited program (263) well exceeds the non-accredited (50) and WPI (100) in this area. *Statistical information*: There is a statistically significant difference between accredited and non-accredited programs: p=0.003. D indicates the percentage of reported values from the data set.

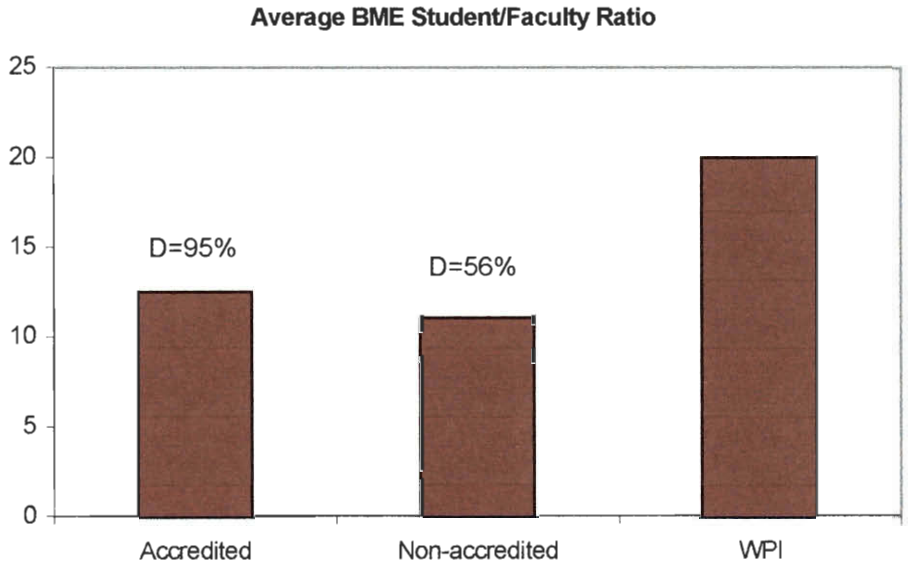


**Figure 4.6: Average BME Student/Faculty Ratio.** WPI's program has a higher student-to-faculty ratio than both accredited and non-accredited programs. *Statistical information*: There is no significant difference between the accredited and non-accredited program values: p=0.50. D indicates the percentage of reported values from the data set.

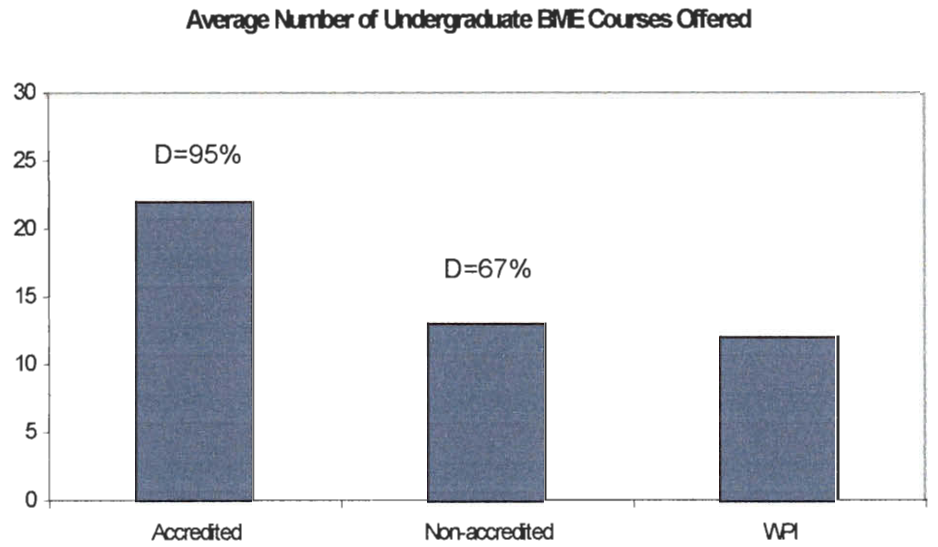


**Figure 4.7: Average Number of Undergraduate BME Courses Offered.** On average, the accredited programs offer the most courses. *Statistical information*: There is a statistically significant difference between the accredited and non-accredited programs: p=0.009. D indicates the percentage of reported values from the data set.

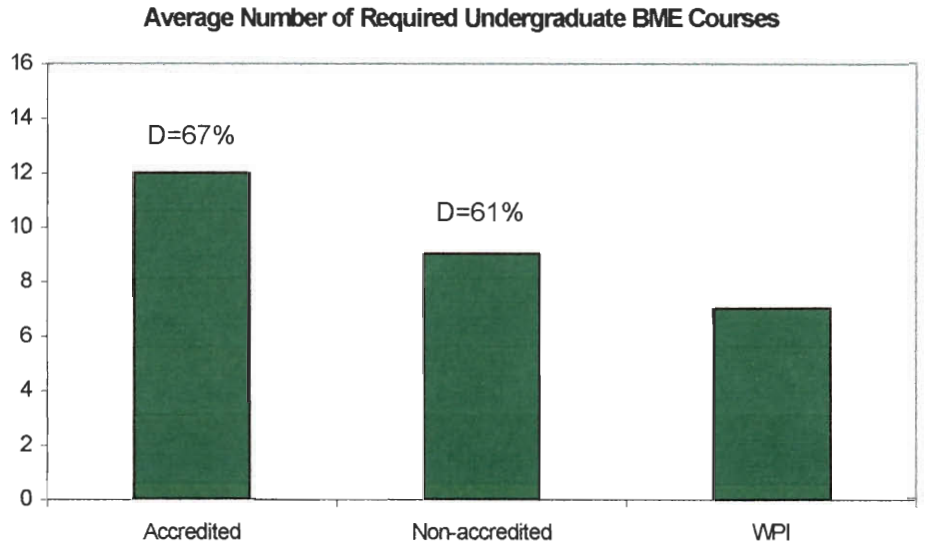


**Figure 4.8: Average Number of Required Undergraduate BME Courses.** On average, the accredited programs require the most BME courses (12). *Statistical information*: There is a significant difference between the accredited and non-accredited programs: p=0.018. D indicates the percentage of reported values from the data set.

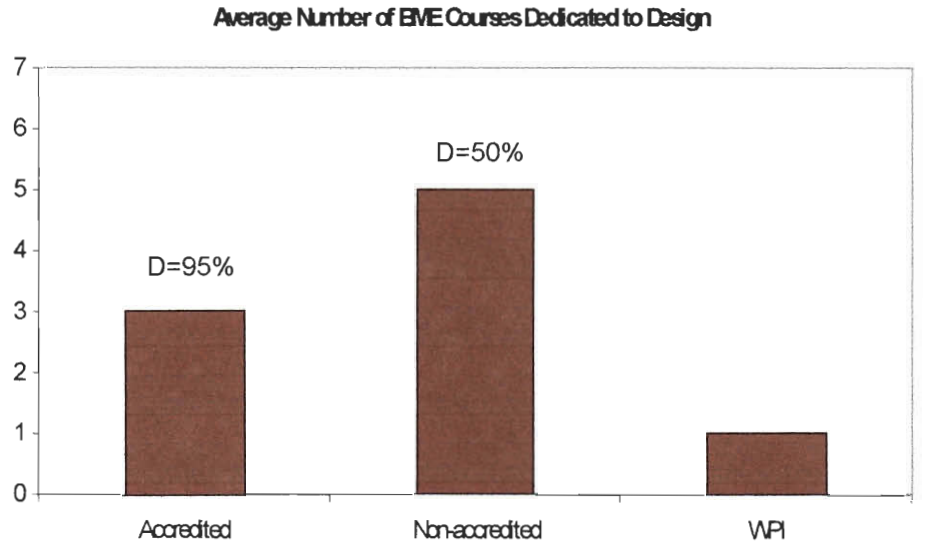


**Figure 4.9: Average Number of BME Courses Dedicated to Design.** On average, non-accredited programs offer the most courses (not including projects or theses) dedicated to BME design. Note: WPI counts the MQP Capstone Design Experience as a class; however, the BME department only offers one class that is dedicated to design. *Statistical information*: There is no significant difference between the accredited and non-accredited programs: p= 0.217. D indicates the percentage of reported values from the data set.

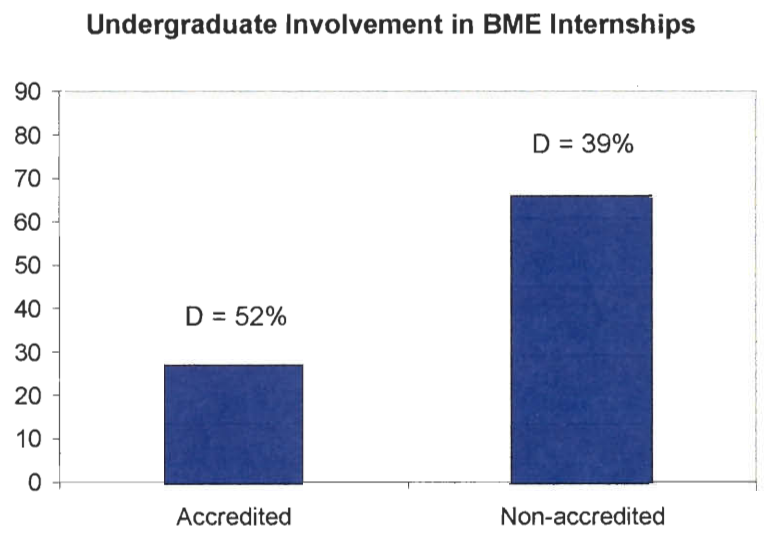


**Figure 4.10: BME Undergraduate Involvement in Internships.** On average, the non-accredited programs generate more involvement in internships. Involvement at WPI is currently undisclosed. *Statistical information*: There is a significant difference between the accredited and non-accredited programs: $p=0.033$. D indicates the percentage of disclosed values from the data set. ($p<0.05$)

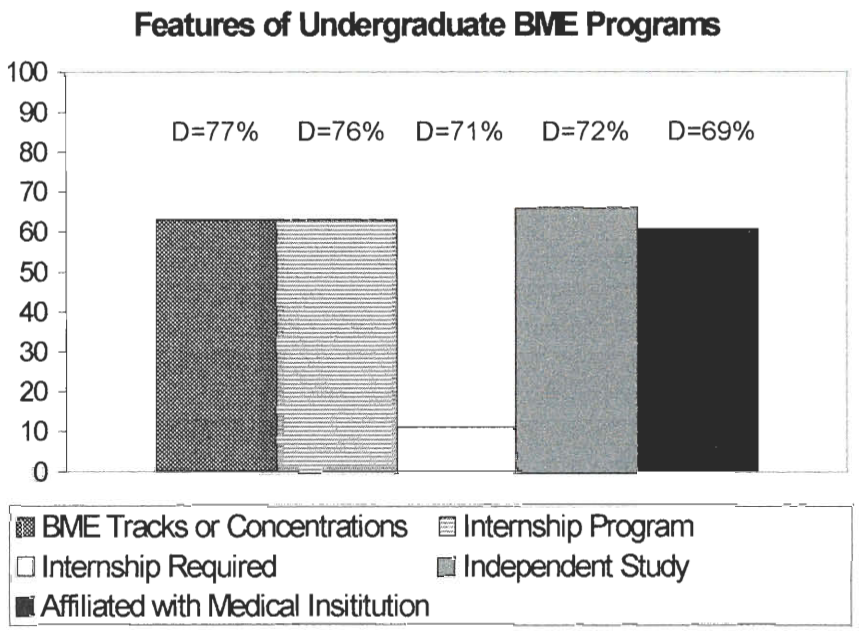


**Figure 4.11: Common Features of Undergraduate BME programs.** Many schools provide a mechanism for specializing within the biomedical discipline, offer internships and independent studies, and are in some way affiliated with a medical school or hospital. D indicates the percentage of reported values from the data set.

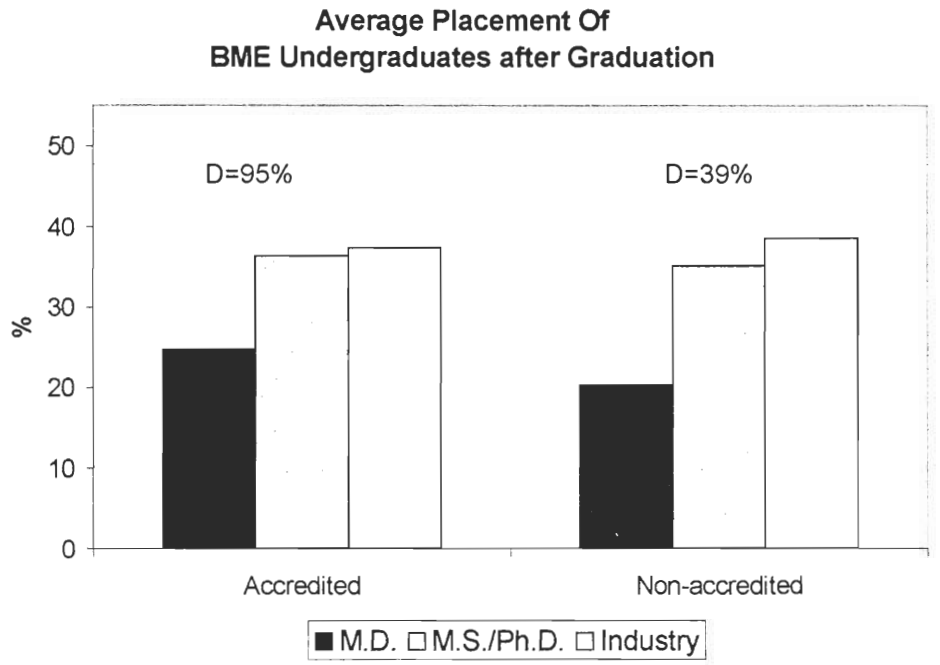


**Figure 4.12: Total Percent Average Placement of BME Undergraduates.** Many biomedical engineering graduates, regardless of program accreditation, pursue a career in industry directly after graduation. D indicates the percentage of disclosed values from the data set.

## 4.2 – Industry Analysis

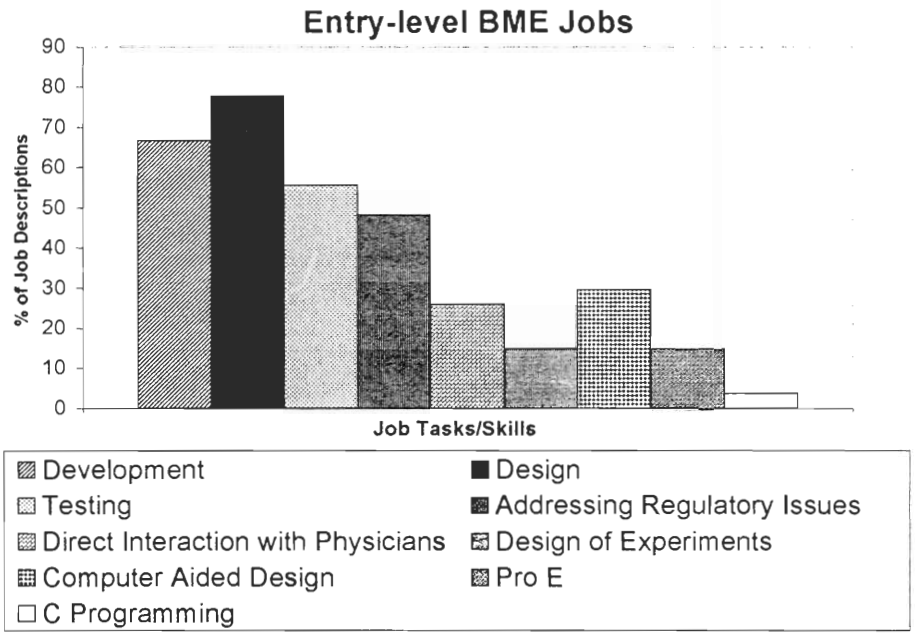


**Figure 4.13: Employers' Expectations.** Industry expects entry-level biomedical engineers to perform primarily design and development functions. n=27.

### 4.3 – Interview Profiles

#### Clinical Biomedical Engineer

Albert Shahnarian, Ph.D., earned bachelor's and master's degrees in electrical engineering before getting his Ph.D. in biomedical engineering at WPI. He most recently worked as the Chief Biomedical Engineer for the Department of Anesthesiology at the University of Massachusetts Medical Center. His experience with medical device design is limited and primarily academic; over the years, he participated in several senior projects with WPI undergraduates. His duties as Chief Biomedical Engineer included purchasing and writing the specifications for devices needed in the operating room, rather than the design of medical devices. He maintained and evaluated the equipment, and he was responsible for teaching medical residents (anesthesiologists) the technical aspects of the equipment they were using, including the physical principles that describe how the devices work. Dr. Shahnarian also interacted with medical device companies to organize evaluations of new products in the OR. When asked about his educational preparation for his position at UMMC, Dr. Shahnarian replied, "it's difficult to pinpoint specific classes. . .you never know what background you will need." Dr. Shahnarian also commented on the difference between academic and industrial design; the expectations and driving forces of each are different, and industrial design is typically more vigorous.

#### Industrial Biomedical Engineers

Ian McRury, Ph.D., did his undergraduate work in biomedical engineering at Boston University and went on to the University of Virginia for his master's degree and Ph.D. in electrophysiology. In 1997, he entered the industrial arena at Bard Electrophysiology located in Billerica, MA. He was hired as a Project Engineer, and has since been promoted to Senior Project Engineer; he leads a team of engineers and technicians in designing and testing cardiac ablation catheters. These medical devices incorporate challenges in the areas of materials science,

mechanical engineering, and electrical engineering. In addition, Dr. McRury responds to input on ergonomics, regulatory issues, and budget constraints from marketing and management personnel. His practical knowledge of human anatomy and physiology, combined with an understanding of mechanical and electrical principles, is necessary to identify the critical aspects of catheter design. Dr. McRury stressed the significance of the biomedical engineer's knowledge of physiology and how he uses that to inform mechanical and electrical engineers on what is important and what is not.

Dr. McRury also gave a brief overview of the design process at Bard. His description of this process is representative of industrial design, an iterative process. He notes a significant difference between the first steps of academic and industrial design. While academic design first investigates the theory behind their designs, companies first have marketing personnel assess the market's needs. This evaluation is accomplished primarily through direct contact with physicians and analysis of products on the market. Engineers then synthesize solutions to these needs and begin prototyping. Once prototyping is complete, physicians again interact with marketing to provide product feedback, which is passed on to engineers for design revisions. Patent races and profit motive often rush the design process in the industrial setting. Ultimately, Dr. McRury noted, industry generally has a "shove it out the door and fix it later" philosophy whereas academic design is more deliberate and investigative.

Mr. Neil Williamson is a veteran of the aerospace industry and now works for Microwave Medical Systems (MMS) located in Acton, MA. MMS is a small medical hardware company that specializes in the use of microwave technology. Mr. Williamson described the way a product is designed and developed at MMS and how physicians are involved in the process. Because MMS is so small (~20 employees total), the roles of the engineer and marketing personnel are not as distinct as in larger companies.

The first phase of a product's life includes preliminary research on the feasibility and need for that device. Engineers and marketing personnel both participate in the research and

evaluation of the device to prove that it is usable and worthwhile; usually, the bottom line in this phase is profitability. If research indicates that the device is physically and economically feasible, the next step in this phase is to compose grant proposals and a proposal to the FDA. MMS funds its research primarily through NIH grants, but the process is similar in larger companies with bigger bank accounts – the proposal for funding just remains internal to the company. In addition, engineers and marketing work to create allegiances with hospitals and physicians to help develop the device.

The second phase of the device's development involves establishing specifications for size, performance, tolerances, safety, and compliance with U.S. and European standards. Mr. Williamson noted that their on-staff biomedical engineer is responsible for maintaining the regulatory specifications associated with their devices. Phase three of product development addresses the functionality of the medical device and involves contacting physicians to ask about what they want. An interdisciplinary team of mechanical and electrical engineers begin the iterative process of developing prototypes for evaluation in the medical environment. Manufacturing issues are also addressed in this cyclic phase. The device undergoes safety and clinical testing after the FDA approves an Investigational Device Exemption application. The IDE is necessary for the company to perform *in-vivo* tests (animal tests) and clinical trials. Before the IDE application is approved, the company typically constructs *in-vitro* fixtures to test the device. These fixtures are designed to simulate the device's proposed application.

At Microwave Medical, Mr. Williamson explained, the engineers interact with doctors, nurses, and vendors, and they must be conversant with safety – the CE mark (European standards) and FDA – regulations, software, hazard analysis, system design, selecting components, grant proposal writing and physiology. All of the members of the engineering staff have bachelor's degrees (most in mechanical or electrical), a couple have dual degrees with biomedical engineering, and a few have master's degrees. In any case, the engineers work in interdisciplinary teams consisting of mechanical, electrical, and biomedical engineers. Oftentimes, Mr. Williamson noted, the company

hires a physician as a consultant; the physician will help to evaluate the device and also provide background on the medicine behind the device's application. The ideas for devices start with engineers and physicians who have a concept of how to solve a recognized problem.

**Physicians**

Dr. Robert Giasi is the Director of Cardiac Anesthesiology at the University of Massachusetts Medical Center. He studied biology as an undergraduate at Holy Cross, and completed fellowships in the areas of intensive care and anesthesiology before arriving at UMMC. In addition, Dr. Giasi received a master's degree in public health in 1993. Dr. Giasi's experience with medical device design began when he collaborated with Al Shahnerian on a continuous cardiac monitor. He has also provided input on numerous WPI undergraduate projects.

Dr. Giasi explained that the physician's role in design is to communicate what is important and what is not; in his words, "what we need to know." In this way, physicians' input can keep devices from being overengineered or providing extraneous information. Physicians often explain to engineers why a particular parameter is being monitored and what issues need to be addressed "from the operating room standpoint." Above all, Dr. Giasi said, the physician must contribute to medical device design by "bringing the engineer into the world of the physician."

When asked about biomedical engineers, Dr. Giasi had a few comments about their role in a hospital. In the clinical setting, biomedical engineers are largely responsible for the evaluation of new instrumentation. They test the reliability and safety of such devices, and they also help troubleshooting equipment failure. Dr. Giasi noted that in his experience at UMMC, all of the biomedical engineers that he worked with had at least a master's degree.

Dr. John Kelly is a laparscopic surgeon at Memorial Hospital in Worcester, MA. He graduated from Holy Cross with a bachelor's degree in Chemistry and attended University of

Massachusetts Medical School before completing a five year residency in surgery and a one year fellowship in laparscopic surgery under the guidance of Dr. Demetrius Litwin. Laparascopic surgery is distinguished from traditional surgery by minimally invasive techniques. These techniques make surgery a lower risk for the patient and speed healing. Two consequences of employing minimally invasive techniques are the increased dependence on technology and procedures more demanding of the surgeons. Laparascopic surgeons rely on small video cameras to "see" their work, and their surgical tools are designed to overcome confining work spaces, often at the sacrifice of tactile feedback and good ergonomic. Trocars (the tubes that act as passages into the patient's abdominal or thoracic cavity), cameras, light sources, stapling devices, and grasping and cutting devices are all found in the laparscopic surgeon's toolbox. Minimally invasive surgery creates vast opportunity for improving current medical device designs, and Dr. Kelly's work in laparascopic surgery places him at this new intersection of medicine and engineering.

When asked about the interaction between engineers and physicians, Dr. Kelly said, "In general, the average physician interacts with marketing people...only if you have an idea of your own do you get introduced to engineers." Sometimes, Kelly noted, companies will hire a physician as a clinical reference; but, only rarely do engineers directly interface with physicians or enter the clinical setting for the purpose of medical device design. "Even during clinical trials, the only available people are marketing," he explained. This is consistent with Ian McRury's description of Bard's design process – an indirect interaction between engineers and physicians is mediated by marketing personnel. Despite the industrial trends, Dr. Kelly expressed a desire for more engineers "on site," like the way Smith & Nephew has integrated a branch of their endoscopy division into the UMMC facility.

**Academic Engineers**

Fred Anderson, Ph.D., studied mechanical engineering at Tufts as an undergraduate and pursued biomedical engineering at the master's and Ph.D. levels at WPI. He is currently a

Research Professor at the University of Massachusetts Medical Center Department of Surgery. His graduate work was focused on biofluid mechanics and designing a device for noninvasive blood flow monitoring; as such, his experience with design is strictly academic. Dr. Anderson later expanded his studies and developed a method for diagnosing Venous Thrombosis with his device. Dr. Anderson "reinvented himself every five years," next running a training school for his method of diagnosing venous thrombosis and then shifting to epidemiology in an effort to understand why physicians were not adopting his new diagnostic technology. As an epidemiologist, Dr. Anderson found and is currently operating his Center for Outcomes Research, which tracks how the practices of thousands of physicians and hospitals treat various disease and conditions. The center's work is largely statistical and Dr. Anderson noted that his career has progressed away from scientific theory towards communication. He explained that his engineering education fostered creativity and problem solving skills that trained biostaticians and epidemiologists don't necessarily have.

Dr. Anderson is strongly opposed to an undergraduate biomedical engineering program. He argues that the BME undergraduate degree dilutes the student's background in a traditional engineering specialty like mechanical or electrical engineering. He suggests that undergraduate students develop a strong foundation in fundamental engineering principles and pursue biomedical engineering at the graduate level only. In addition, Dr. Anderson recommends a curriculum that incorporates elements of communication, like projects and presentations, and that "biomedical engineers should be trained to think on their own. . .like doctors."

Dr. Larry Bonasser received undergraduate degrees in both biomedical engineering and material science from The Johns Hopkins University and went on to the Massachusetts Institute of Technology for master's and doctoral work in material science. His post-doctoral work on cartilage cell metabolism was done at Massachusetts General Hospital and Harvard Medical School, and he currently works on structural tissue engineering at the University of Massachusetts Medical School.

Dr. Bonasser is working in one of the newest branches of biomedical research, known as tissue engineering. It involves elements of biomedical engineering and biotechnology, as it requires knowledge of material science (from both mechanical and chemical engineering standpoints) and physiology at the cellular and systemic levels. Dr. Bonasser defined tissue engineering as the design of "cellular and acellular implants that restore function of tissue lost to trauma, cancer, or congenital defects." The tools he uses for the design of tissue-based "devices" include finite element models, *in-vitro* and *in-vivo* models, and investigative methods like chromatography, calorimetry, and microscopy.

Dr. Bonasser notes that biomedical engineers have a background suitable for addressing the synthesis and processing of materials while considering the underlying cellular reactions. In addition, he described how there is an emerging difference between biomedical and other engineers; biomedical engineers are uniquely prepared to interpret physicians' needs into design problems. This function intersects that of the physician– "the physician's role in design is to provide critical input in terms of defining design specifications."

When asked about the differences between academic and industrial design, Dr. Bonasser described how, "in an academic environment, you're addressing a specific problem in great detail, while in industry you're finding a solution to the biggest number of problems. Industry needs solutions *now*." Legal and regulatory issues complicate the industrial process as well, especially with the disease transmission and rejection issues associated with tissue engineering.

Richard Beane was educated as an industrial designer and electrical engineer, and his experience was primarily with medical devices. He currently works for S&N Endoscopy at the UMMC facility; in addition, he is pursuing a Ph.D. in biomedical engineering at WPI. Mr. Beane explained how the design process worked through the Smith & Nephew/UMMC team, noting that it was "very different from industry...and somewhat similar to a consulting firm." In general, there were two ways that a design idea originates; the first occurs when an engineer observes a

need. "If the current tools seemed rudimentary or there were questions about the therapy itself," Mr. Beane explained, "we could go to a doctor and discuss the premise with him." Since the engineers are exposed to the clinical setting, they can readily observe problems and physicians' needs. In addition, the availability of physicians (and other clinicians) allows the Smith & Nephew engineers to evaluate concepts quickly and more effectively than in a typical industry setting. The other way ideas originate, Mr. Beane said, is by the "direct expression of a need by a doctor." In this case, the physician formulates a solution to a problem and goes to the engineers for its design and development. So, the collaboration between Smith and Nephew and UMMC creates a uniquely efficient dual-feed design mechanism that is oiled by the direct interaction of biomedical engineers and physicians. The efficiency of the design process is evidenced by Mr. Beane's comment about development time: "we [Smith & Nephew] could complete a medical device in one year when other companies need five or more years."

**4.4 – Site Visit Results**

In the fall of 1996, Smith & Nephew Endoscopy joined forces with the University of Massachusetts Medical Center for the "joint research and development of high-tech tools used in 'minimally invasive' surgery, a booming filed of medicine." (Saltus 1996) Through this collaboration, "...UMass surgeons work with biomedical engineers from Smith & Nephew on a variety of endoscopic devices." (Saltus 1996) The engineers work in-house at UMMC, and regularly interact with surgeons to design, develop, and test medical devices. Richard Beane, is the principal engineer for the UMMC/Smith & Nephew venture, and he gave the project team a tour of the facilities available to Smith & Nephew. The medical center's animal labs, catheterization lab, and other miscellaneous lab space are available for prototype construction and *in vivo* and *in vitro* testing. The engineers conduct brainstorming sessions in conference rooms or offices, and Mr. Beane indicated that he uses Pro-Engineer modeling software to illustrate his detailed designs. The most significant aspect of the Smith and Nephew site is its location within a research-oriented medical center. Engineers have the luxury of discussing a

wide range of problems with a variety of medical professionals, all within walking distance of their office. Whether inquiring the immunology staff about the inflammatory response for a drug-delivery device, or consulting the surgeons on the strengths and weaknesses of a spinal fixation device, engineers can attack such problems with an veritable army of scientists and clinicians. An intimate relationship between engineers and physicians is rare in industry, but offers an efficient mechanism for medical device design.

Bard Electrophysiology (EP), located in Billerica, MA, is a division of medical device giant C.R. Bard, Inc. The EP group employs twenty-five engineers for the design and development of radiofrequency ablation catheters and patient electrophysiology monitoring systems. Approximately three quarters of the engineering staff holds at least an undergraduate degree, while the rest rely on other technical experience. The facility consists of two labs, one for catheter development, and the other for systems development; each lab is used primarily for testing and troubleshooting. In addition, there is a pilot production line in the manufacturing facility of an adjacent division of Bard. The other workspace is organized into cubicle-type workstations where engineers use Pro-Engineer modeling software to generate detailed design drawings. In sharp contrast to Smith and Nephew, however, Bard EP engineers do not typically interact with physicians for design feedback. Rather, marketing personnel are responsible for gathering and delivering that feedback. This configuration, more typical of the medical device industry, limits the rate at which the iterative design process cycles.

The surgical rounds held at UMMC provided an opportunity to witness the way engineers and physicians meet and discuss device design. The physician's, or end-user's, perspective is a necessary consideration when designing a medical device, and this forum facilitated the exposure of engineers to the physician's perspective. Industrial representatives (engineers and marketing personnel), physicians, and academic engineers each presented a unique aspect of the problem, and the presentations were followed by a discussion. In addition, biomedical engineering undergraduate and graduate students were present at the rounds. This

"team" of problem-solvers dissected the challenges of designing spinal fixation devices, the ideal operating room, and ergonomic surgical tools. Overall, these visits revealed the multi-dimensional, multi-disciplinary, and far-reaching nature of medical device design.

## 5.0 – Discussion

The purpose of this project is evaluate and propose improvements to WPI's undergraduate BME program. This discussion identifies deficiencies through the comparison of WPI with other academic programs, an analysis of what the medical device industry expects from entry-level biomedical engineers, and an interpretation of the biomedical engineer's role in medical device design. First, the project team compares WPI's program with other engineering schools' programs. Next, the results of Internet job searches illustrate the need for biomedical engineers to partake in the design and development of medical devices and delineate some of the skills and tasks associated with those jobs. The third section explores the most common views and opinions about biomedical engineers, the design process, and engineer-physician interaction. Finally, site visits are discussed in terms of project quality control and educational simulation of the industrial design process. Altogether, these four parts combine to aid in developing the recommendations for WPI's undergraduate BME program.

### 5.1 – Trends in Education

Analysis of the academic programs reveals that WPI's undergraduate biomedical engineering program has its comparative strengths and its weaknesses with respect to design training in the curriculum. One advantage WPI's program has over both accredited and other non-accredited programs is a relatively high number of lab courses and labs associated with courses (WPI 1999). Both the number of labs and the lab-to-course ratio are higher than other programs (**Figs. 4.1** & **4.2**). This suggests that the BME department recognizes the need for hands-on experience and observation of biological phenomena. One detail this analysis does not reveal, however, is the type of lab activities each school offers. In order to enhance the undergraduate design experience, these labs should include real-world design problems and the opportunity to assemble and test models.

Another strength in WPI's program lies in its dependence on other engineering departments. The BME curriculum offers three pathways – bioelectrical, biomechanical, and

biochemical – based on portions of ABET-accredited programs in other disciplines (WPI 1999). The curriculum remains flexible while being supported by well-established coursework. WPI is not unique in this strategy, and most other programs have access to a similar number of supporting ABET-accredited departments (**Fig 4.3**). This strategy allows BME students to interact and work with engineers and students of other disciplines and thus experience a multi-disciplinary learning environment. It is important to note, however, that a common, contemporary vision for BME departments is to become independent by developing courses that specifically address engineering fundamentals in the biological context (Panitz 1996).

The concept of pathways or concentrations within biomedical engineering is widely accepted, as indicated by the results. Virtually all programs offer a mechanism for specializing. WPI's selection of bioelectrical, biomechanical, and biochemical paths is consistent with many other programs (**Fig. 4.11**), though the degree of specialization is quite variable. Focusing on one aspect of biomedical engineering is important because it furnishes depth of knowledge in engineering fundamentals.

WPI is also competitive in terms of the number of affiliations with local medical schools and hospitals (**Fig. 4.4**). More than half of the BME departments are in some way associated with a medical school or hospital (**Fig. 4.11**). This statistic does not, however, indicate the nature of the affiliation. In many cases, the collaboration with an external medical institution is kept at the research or graduate level; students and faculty participate in research alongside clinical or scientific investigators. In some cases, like at the University of Akron, the link between the institutions results in shared faculty, coursework, and facilities (U. of Akron 1998). WPI's associations with UMMC, St. Vincent's Hospital, Memorial Hospital, and Tufts Veterinary School are primarily reserved for graduate work and some undergraduate projects. While some of the framework is in place, the BME department should strive to develop these affiliations. Undergraduates would benefit from a vehicle for regularly witnessing and experiencing the engineer-physician interaction. Medical institutions provide an excellent opportunity for

observing the clinical environment and assessing device performance and physicians' needs. UMMC, in particular, is an obvious target for this development, given its established interest in biomedical engineering and device design, evidenced by its collaboration with Smith and Nephew Endoscopy, and the regular surgical rounds organized by WPI engineers and UMMC physicians. The BME department at WPI should develop stronger ties with local medical institutions, like UMMC, so that students may experience and directly observe the relationship between engineers, physicians, and medical device design.

WPI's undergraduate BME program is still growing and maturing. One deficiency that cannot persist, however, is the lack of faculty. WPI's program has fewer students than the average accredited and non-accredited programs (**Fig. 4.5**). But more importantly, the student-to-faculty ratio is also high compared to the other programs (**Fig. 4.6)**. In order to grow and establish a competitive program, the BME department must acquire more faculty. One major repercussion of having limited faculty is a low course offering. WPI offers fewer BME courses than accredited programs (**Fig 4.7**), and the WPI undergraduate program requires fewer BME courses than accredited and non-accredited programs (**Fig. 4.8**) (WPI 1999). In addition, despite the recent addition of an introductory BME design class, WPI's program offers the fewest number of courses dedicated to biomedical engineering design (**Fig. 4.9**). The program's relative deficiency in course offerings is one consequence of having too few faculty members. Faculty members also generate new research areas and links with industry; by hiring more professors, WPI's BME department can cultivate more educational opportunities. Integrating design across the curriculum may require more courses and certainly more faculty.

Another weakness in WPI's biomedical engineering program is the lack of a formal internship program for undergraduate students. Many other programs have adopted internship programs and co-op opportunities specific to biomedical engineering, and a few have made such experience a required component (**Fig. 4.11**). WPI's BME department and Career Development Center foster arrangements with local medical device manufacturers, but there is

no formal program or process for acquiring such an internship. Organizing internships is a reliable way of exposing students to industrial practices and the design process. WPI's BME department should strive to establish closer relations with the numerous local medical device manufacturers so that students may have the opportunity to be immersed in the medical device industry as undergraduates.

Nearly 40% of undergraduate biomedical engineering students go to industry directly after they graduate (**Fig. 4.12**), and most schools report that the number is increasing. In conjunction with the analysis of employers' expectations (see below), this trend creates the premise for this project – biomedical engineers need preparation in the design and development of medical devices.

**5.2 – Employer Expectations**

The sparse literature and a relatively weak response (<28%) to the project team's surveys limited the evaluation of industry's expectations. The Internet job searches and interviews of engineers provided the most useful information about what employers expect of biomedical engineers. The results of the job searches indicate that medical device manufacturers need entry-level biomedical engineers to participate in design and development (**Fig. 4.13**) (See Appendix K). In addition, 25% or more of the job descriptions listed product testing, addressing regulatory issues, computer-aided design (non-software specific), and interacting with physicians as primary functions of the biomedical engineer. The surveys that were returned by medical device manufacturers reflect similar expectations (See Appendix J).

**5.3 – Interviews**

The interviews of engineers and physicians provide a sampling of perspectives on the roles of the biomedical engineer, the engineer-physician relationship, and the design process. Two industrial engineers, Ian McRury and Neil Williamson, both indicated that the biomedical engineer contributes to the design process by applying his or her knowledge of physiology to the problem. Biomedical engineers are especially capable of defining the biological limits and

tolerances that define medical device design problems. In addition, they agreed that biomedical engineers work as part of a team, most often with engineers of traditional disciplines. WPI's undergraduate biomedical engineering course and project work needs to be infused with this multi-disciplinary approach to medical device design.

The physicians the project interviewed commented on their roles in the device design process. They stressed the importance of understanding the clinical significance of a device, i.e., it's intended purpose, environment, and most important features. Engineers should be aware of how physicians use the devices and the physiological value of each device's purpose. Without considering the physician's expectations of a medical device, engineers cannot accurately define a design problem. Richard Beane and Dr. John Kelly also described how physicians can be designers as well, conceiving their own ideas about how a device should work or be constructed. Engineers need to be prepared to meet with physicians for the purpose of discussing device design; this implies that engineers must be capable of communicating on a variety of levels. While common industry practice does not typically accommodate this interaction, new engineering strategies, led by biomedical engineers, may make the interaction between physicians and engineers mainstream. It is, therefore, important that WPI's undergraduate biomedical engineering program expose students to the engineer-physician interaction. Such exposure to the clinical environment and physician's perspective could be facilitated by a formal affiliation with UMMC.

The interviews of academic engineers, including Larry Bonasser, Ph.D., and Fred Anderson, Ph.D., further revealed the unique skills and paths open to biomedical engineers. Fred Anderson also offered his opinion of undergraduate biomedical engineering education. When asked how such a curriculum may be optimized for a career in biomedical engineering, he suggested the incorporation of more projects, presentations, and activities that demand communication skills. Aside from those suggestions, however, Anderson suggested keeping biomedical engineering exclusively at the graduate level. Instead of struggling with a

constrained undergraduate curriculum, he argues, students should develop a strong background in a traditional engineering discipline and pursue the biomedical interest in a graduate setting. Many veteran biomedical engineers hold this opinion, and it may pose the biggest obstacle to improving or changing the undergraduate curriculum at WPI. The BME program, however, could produce design engineers competitive with those from the traditional disciplines by integrating design experience across the curriculum. In addition, this strategy may help to establish WPI's undergraduate BME as a worthwhile and attractive partner for surgical device research at UMMC.

**5.4 – Industrial Site Visits**

The visits to Bard Electrophysiology and Smith and Nephew Endoscopy helped to establish the biomedical engineer's design environment. Each site, however, represents a different aspect of medical device design. The Bard EP site, in general, typifies the medical device manufacturer. Engineering, marketing, and management personnel work in a common environment to design and develop devices; the devices are prototyped and tested in in-house labs, and the design process is very remote from the clinical atmosphere. Engineers, oftentimes, must interpret physicians' needs second-hand from marketing reports because engineer-physician interaction is non-existent. In contrast, the Smith and Nephew site represents an ideal industrial design environment where engineers have the unique opportunity to develop surgical tools in labs and in the clinical setting. Its close proximity to a hospital facilitates communication between engineers and physicians, which has proven to accelerate and enhance the design process.

It is important to consider the limitations of the design process inherent to common industrial practices, and BME students should learn how multi-disciplinary teams function in industry. By simulating the ideal scenario, however, undergraduate biomedical engineers learn to appreciate the physician's perspective and envision the clinical atmosphere. WPI's BME program should include elements of clinical observation and discussion with physicians so that

students are exposed to these increasingly relevant factors of medical device design. Such opportunities could be accommodated by closer ties with UMMC. The medical center already supports the engineer-physician interaction via its relationship with Smith and Nephew Endoscopy, and WPI's graduate BME program has established the framework for extrapolation to the undergraduate studies. Ultimately, biomedical engineering education may be linked with surgical resident training through mutual journal club meetings and research projects, and surgeries witnessed by engineers. In addition, seminars, telecommunication links, and shared laboratory resources between UMMC and WPI would be beneficial to the maturing undergraduate BME program and the medical center's interest in surgical device research.

## 6.0 – Recommendations

These recommendations focus on strengthening the undergraduate biomedical engineering student's educational background in medical device design. They are based on the premise of continually engaging students in engineer-physician interaction and realistic biomedical design problems, and fostering the development of students' communication skills and experience with multi-disciplinary design teams. Some specific strategies, listed in order of value and importance, include:

1. Continue and expand collaboration with UMMC.
    - Offer more undergraduate courses that include contributions from UMMC physicians and faculty.
    - Fund more research in medical device design, and synchronize this research with UMMC's well-known interest in minimally invasive surgical tools.
    - Hire a full-time liaison to organize joint research projects, engineer/physician symposia, and undergraduate BME courses taught by UMMC faculty.
    - Establish a satellite BME office at the UMMC facility.
2. Faculty.
    - Hire more full-time faculty to meet the growing interest in undergraduate BME.
    - Offer more undergraduate BME courses that present traditional engineering concepts in a biological context.
3. Design experience through coursework.
    - Do not rely on the MQP and "design" courses for the design experience.
    - Incorporate more open-ended problems into BME (and traditional engineering) courses to demonstrate and apply biomedical engineering concepts.
    - Encourage a multidisciplinary team approach to these open-ended problems.
4. Include more hands-on experience.
    - Construct more lab space for BME undergraduates.
    - Focus lab activities less on observation and more on problem solving and design practices; labs should include equipment appropriate for this purpose.
    - Provide exclusive access to Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and prototyping equipment for medical device design.

The most important step in improving WPI's program is the continued and increased collaboration with UMMC. The affiliation can be developed along existing ties at the graduate school level and between the BME Department and the Minimally Invasive Surgical Unit. By involving clinicians and scientists from the medical center in undergraduate courses and projects, students can benefit from more research opportunities and exposure to the physician's perspective. In addition, UMMC's faculty and laboratory resources can be applied to the

growing undergraduate curriculum at WPI. In return, UMMC gains added research in the design of surgical devices and other areas of biomedical interest.

This enhanced collaboration should be developed at both the WPI and the UMMC campuses, and organized by a non-faculty liaison. In addition, administrative personnel will need to negotiate the details of this development. The BME department should establish a permanent presence on the UMMC campus to maintain convenient communication and curriculum development between the institutions. Seminars, surgical symposia, and telecommunications links between the campuses would allow BME undergraduates to regularly interact with physicians and other clinicians. Above all, the BME department should cultivate a more dynamic relationship with UMMC so undergraduate students may engage in the engineer-physician interaction.

Hiring more full-time faculty is another issue that WPI's BME department must address. Faculty are the primary source of research, industry links, and curriculum development. If the number of faculty can be increased, the department can attack the program's deficiencies in course offerings and design experience; the department will also be able to advise more projects. In addition, biomedical engineering is an increasingly popular interest for incoming undergraduates. Collaborating with UMMC can, in part, resolve the lack of faculty by involving the medical center's clinicians and faculty in more shared research ventures and coursework. In order to meet growing demand and become competitive, WPI BME must strive for a lower student-to-faculty ratio.

The third recommendation is not easy to quantify; rather, it is more a comment on teaching style and strategy. Students should be introduced to the design process at all stages of their undergraduate education. WPI currently expects students to acquire *and* apply design skills through the Major Qualifying Project (MQP). However, the BME department should endeavor to include more open-ended problems and group projects throughout the curriculum so students can acquire the design skills necessary before applying them in the MQP. In

addition, project teams should be multi-disciplinary, combining students from biomedical and traditional disciplines. Such experience emulates industry practice, and so is especially valuable for those students entering industry. The proposed strategy for a more educational relationship with UMMC would also naturally complement the strategy of integrating design into multiple aspects of the curriculum. Seminars and symposia, offered at UMMC and WPI, can lend depth to the undergraduate design experience.

Finally, WPI's BME department should open more lab space to undergraduates, and BME lab activities should focus more on problem solving and testing practices. The lab space and equipment should be appropriate for the purpose of medical device design. Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and other prototyping tools should be available for device design projects and coursework; in addition, telecommunication links to active or experimental operating rooms may be housed in such labs. UMMC has extensive lab facilities, so, developing that relationship may partially fulfill the need for more lab space.

These recommendations are made with the knowledge that economic constraints may prove them prohibitive. Certainly the cost of hiring more faculty members, building more labs (and filling them with equipment), and installing telecommunications hardware are all daunting budget items. However, expanding the educational relationship with UMMC is a relatively convenient way of acting on each of the other three recommendations. Again, the details of sharing lab space and faculty need to be resolved by administration at the provost or chancellor level. Yet, by following the first recommendation, the BME department can have access to more faculty, labs, and tools for integrating design experience across the curriculum.

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## 8.0 - Appendix A

This project will addresses UMass Medical Center's Minimally Invasive Surgery Unit (MIS). Since the beginning of the 1990's, this department has been working with biomedical engineers in developing surgical devices that are less invasive (meaning less and smaller openings on the body) yet perform the same tasks as those used in conventional open surgery.

The overall purpose of this project is to propose the involvement of the University of Massachusetts Medical Center (UMMC) MIS with the development of Worcester Polytechnic Institute's (WPI) undergraduate biomedical engineering education. The project proposes the use educational methods that involve UMMC's MIS as a partner. These methods may include new design labs, on-campus surgical rounds, telecommunications with surgical teams, and internships. By incorporating these elements into the undergraduate program, the student can understand the value of surgical device design to both the engineer as well as the physician. In addition, UMMC's MIS will have the opportunity to extend their resources to undergraduate biomedical engineering students and benefit from added research in surgical device design.

## 9.0 - Appendix B

### Guidelines for Interview Questions

**Education:**

- Degrees earned
- Design training (if any)
- Adequate for job?

**Job History:**

- Titles – number of years

**Experience with Medical Devices:**

- Projects, etc.
- Academic
- Industrial

**Observations of Design Process:**

- Roles of biomedical engineer and physician/surgeon
    - Communication/Interaction?
- Academic vs. Industrial
- Value of design training

**Recommendations:**

- WPI's undergraduate biomedical program
- Necessary experience and education training

## Standardized Interview Questions

**What is your name?**

**What is your title or position?**

- The interviewee is introduced and these types of questions help get things rolling into more specific questions.

**What is your role in surgical/medical device design?**

- The perspective of the interviewee is understood so that this project can compare and contrast with other types of professionals.

**What do you think is the role of the biomedical engineer (physician) in surgical device design?**

- This provides an opinion of where each profession fits into the design process.

**In your experience, what kind of communication exists between the biomedical engineer and physician in industry?**

- Dialogue is established and ways to better improve this communication can begin.

**Do you feel there is a difference between academic and industrial design? If so, why?**

- Differences between academic and industrial design will be established.

**How do you value design training?**

- Establish the degree in which design training is essential in the field.

**Is there anything you would change in the type of interaction that exists between engineers and physicians?**

- This aids in identifying the problem. In addition, the interviewee might suggest possible ideas for improvement.

**How well did your undergraduate education prepare you for your career?**

- May help support claim that undergraduate programs need improvement in practical means. In addition, the interviewee will state the problems he encountered. This project can take these problems and try to improve them.

**Do you think the interaction with physicians should be exposed to a biomedical student in his undergraduate years?**

- This could aid in supporting the purpose of our project. Confirm that the practical aspect of biomedical engineering should be included in undergraduate programs.

**In your opinion, would new design labs, telecommunication tools, on-campus surgical rounds, and internships improve this interaction or better prepare an undergraduate for his professional career?**

- This question would give a clear answer as to whether this project is taking the right approach in preparing an undergraduate for his professional career.

**Do you have any recommendations for WPI's undergraduate biomedical engineering program? For the students in regards to what education and experience they should have?**

- Give insight to what improvements or recommendations should be made.

## 10.0 - Appendix C

### Guidelines for Evaluation of Companies

**Descriptors:**

- Name
- Location
- Product Line

**Personnel:**

- Total Number of Employees
- Number of Engineers
- Percent Engineers
- Percent with Undergraduate Engineering Degree
- Number of Biomedical Engineers By Training or Practice

**BME's Job:**

- Synthesis of Solutions
- Analysis (qualitative or quantitative)
- Construction
- Testing
- Evaluation/Interpretation
- Interaction with Clinicians
- Project Leadership
- Marketing
- Intellectual Property Law
- Addressing Regulatory (FDA, etc.) Issues

**Tools:**

- Design Tools
- Physician Partnership
- Industry on Education
- Favored Programs/Schools
- Internships/Co-ops for Undergraduates

**Worcester Polytechnic Institute**

100 Institute Road
Box 886
Worcester, MA
01609

(508)-791-9987
corourke@wpi.edu
or
chrisgw@wpi.edu

April 30, 1999

Company Address

Attn: Human Resources

Dear Sir or Madam:

I am a junior at WPI, and I am researching current industrial and educational trends in biomedical engineering for a project. This project aims to explore the strengths and weaknesses of undergraduate programs across the country and how companies use biomedical engineers, particularly in the area of medical device design. Ultimately, the project will tie the two together by highlighting ways of improving WPI's BME program to meet the needs of local companies. Biomedical engineering (BME) is a somewhat elusive discipline because it is exceptionally broad and continually evolving at both the industrial and academic levels. My project partner (Christopher Wilson, another junior studying biomedical engineering) and I designed the attached survey to capture the role of the biomedical engineer in an industrial setting. We hope that Human Resources can complete the survey, or will direct it to another appropriate audience. Your response would be greatly appreciated and your questions are welcomed (our email addresses are included above).

Sincerely,

Colleen O'Rourke and
Christopher Wilson

## Company Survey

1. How many engineers does your company employ?

2. How many of those engineers have at least an undergraduate degree in engineering?

3. How many engineers are "biomedical" engineers (if any) by training or practice?

4. What is the biomedical engineer's role in medical device/equipment design at the company? Please check all that apply.

   - Synthesis of solutions ☐
   - Analysis (quantitative and/or qualitative) ☐
   - Construction of Devices ☐
   - Testing of Devices ☐
   - Evaluation/Interpretation of Test Results ☐
   - Interaction with Physicians/clinicians ☐
   - Project Leadership ☐
   - Marketing ☐
   - Intellectual Property Law ☐
   - Addressing Regulatory (FDA, etc.) Issues ☐

5. What tools are used to design medical devices at your company?

   - Pro-Engineer ☐
   - Other CAD program(s) (please list) ☐

     _____

     _____

   - Animal Studies ☐
   - *In-Vitro* Testing ☐

   Other _____

6. What is an example job description of a biomedical engineer at your company?

7. Does your company have any partnerships with physicians for the purpose of design evaluation? If so, are engineers involved in this interaction?

8. Are there any biomedical engineering programs (i.e. from different schools) that look better than others on a resume? If so, which ones and why?

9. What type of training is most valuable for medical device design?

   - Academic ☐
   - Industrial ☐

   Comments:

10. Does your company offer internships to undergraduate biomedical engineering students?

11. Does your company sponsor academic research, tours, or participate on college advisory boards?

We thank you for completing this survey. To return, please mail to:

Colleen O'Rourke
21 Mildred Ave
Worcester, MA 01603

Chris Wilson
100 Institute Road
Box 2894
Worcester, MA 01609

## 11.0 - Appendix D

### Guidelines for Evaluation of Academic Programs

**Student/Faculty:**

- Number of Undergraduate Biomedical Students
- Student/Faculty Ratio

**Courses/Lab:**

- Number of Undergraduate Biomedical Courses
- Number of Classes Dedicated to Biomedical Design
- Number of Biomedical Courses with Lab
- BME Lab/Class Ratio
- BME Lab Space Available to Undergraduate
- BME Concentrations/Tracks (if any)

**Internships/Independent Study:**

- Internships Available?
- Internships Required?
- Percent of Students Involved
- Offer BME Independent Study?

**Affiliations:**

- Affiliated with a Hospital?
- How many?
- How?

**Accreditation Information:**

- Accredited BME Undergraduate Program?
- Date of Accreditation

**Placement of Undergraduates in BME:**

- Percent who go MD
- Percent who go MS/Ph.D.
- Percent who go to industry

## Academic Program Survey

To the BME Chairperson-

I am a junior at WPI studying biomedical engineering. As part of a project, I am researching current trends in undergraduate biomedical engineering education; my project partner and I would appreciate any help
you could give on answering the following questions about BME at {name of the engineering school}.

What is the current undergraduate enrollment in the BME program?

How many full-time faculty are part of the BME department?

How many undergraduate BME courses does the dept offer?

How many BME courses are required for a BME degree?

How many undergraduate courses are dedicated to BME design?

How many BME courses include or are laboratories?

How much and what kind of lab space is available to BME undergrads?

Does the BME dept offer independent studies to undergrads?

Does the BME dept offer internships to undergrads?

What % of BME undergraduates participate in the internship program?

Is the BME dept affiliated with (a) hospital(s)?

If so, how?

What % of BME graduates go on to medical school?

What % go on to other graduate studies (M.S. or Ph.D.)?

What % go straight into industry?

If you have any questions about this project, please feel free to email myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu). Thanks for your time!

Christopher Wilson

| Academic Program Template | U. of Akron | Arizona State | Boston University | UCSD | Case Western Reserve | Catholic University | Columbia | Drexel |
|---|---|---|---|---|---|---|---|---|
| # of Ug BME Students | 23 | 205 | 425 | 913 | 230 | 55 | 50 | |
| BME Faculty/Student Ratio | 9/23 | 7/205 | 1/17 | 10/913 | 16/230 | 1/11 | 11/50 | |
| # of Ug BME Courses | 15 courses | 18 | 30 | 25 | 19 | 20 | 25 | |
| Required BME Courses/Credits | 11 courses | | 8 courses | 13 courses | | 10 | 9-12 (track dep) | |
| # of classes dedicated to BME Design | 5 | 2 | 3 | 6 | 2 | 5 | 1 (also have a regulations type course) | |
| # of BME courses with Lab | 3 | 4 | 8 | 2 | 5 | 2 | 5 | |
| BME Lab/class ratio (calculated) | 1/3 | 2/9 | 4/15 | 2/25 | 5/19 | 1/10 | 1/5 | |
| BME Lab Space available to Ug | 9 labs | 21,000 sqf | 330,000 sq feet | | 32,000 sqf | | 4 labs, | |
| Research Expenditures | | $2,376,000 | | $4,942,000 | $4,799,000 | | | |
| | | includes chemical + materials engineering | | | | | | |
| BME Concentrations/Tracks (if any) | Biomechanics & Instrumentation, Signals, Imaging | | none | yes (pre-med) | Biomechanics, computers, materials, instrumentation | biomechanics, bioinstrumentation, cell/tissue engineering, rehab eng., telemedicine/bioimaging | biomechanics, cellular engineering, biomedical imaging, | |
| Internships available? | y | y | no | yes | yes | yes | y | |
| Internships required? | co-op required | n | | no | no | no | n | |
| % Students involved with Internships | 100 | 41 students/3 years | | | 5-10% | | ~20% (industrial,paid) | |
| Offer BME Independent Study? | | y | yes (Senior Project) | yes (Research Project) | | yes (Senior Design) | y (Senior Design) | |
| Biomed Society? | y | y | y | y | yes | y | n | |
| Affiliated with a Hospital? | yes | y | yes | no, but with industry & medical school | yes | | y | |
| How Many? | multiple | multiple | 10 | industry: 8 | 5 | | medical school | |
| (How?) | faculty | research | graduate student training through project work | research collabration, internships | research source: clinical environ. | | labs, courses, research | |
| Accredited Program? | n | y | y | y | y w/ Co-Op | y | n | n |
| Date of Accreditation | | 1986 | 1983 | 1987 | 1977 | 1990 | planned for March 99 | |
| # of Other Accred. Eng. Programs | 4 | 7 | 5 | 4 | 10 | 3 | 7 | 6 |
| Job Placement rate for Ug in BME | | | | | | | | |
| % graduates who go MD | N/A | 17% | 10% | 50% | 25% | 25% | 45% | |
| % who go MS/PhD | N/A | 27% | 40% | 1.9%\6.9% | 45% | 50% | 25-30% | |
| % who go to Industry | N/A | 40% | 50% | | 30% | 25% | 25-30% | |
| | contact noted that she figured 1/3, 1/3, 1/3 | | | | | | | program started this year |
| | program just started last year | | | | | | | |
| | cool program -- 45 clinical and research scientists from surrounding area employed as adjunct faculty | | | | | | | |
| | seems like WPI could have something like this | | | | | | | |

| | *Duke* | *U. of Hartford* | *Hofstra* | *Illinois at Chicago* | *Iowa* | *Johns Hopkins* | *Louisiana Tech* | *Marquette* |
|---|---|---|---|---|---|---|---|---|
| **# of Ug BME Students** | 400 | 23 | 30 | 82 | 170 | 300 | 160 | 240 |
| **BME Faculty/Student Ratio** | 17/400 | 3/23 | 1/30 | 55/82 | 20/170 | 17/300 | 1/32 | 12/240 |
| | | | | | | | | |
| **# of Ug BME Courses** | 10 | 4 | 6 | 16 | 11 | 30 | | 25 |
| **Required BME Courses/Credits** | | 4 | 5 | 11 courses | | 9 | | |
| **# of classes dedicated to BME Design** | 0 | 0 | | 2 | 2 | 2 | | 7 |
| **# of BME courses with Lab** | 1 | 0 | 3 | 3 | 2 | 5 | | 5 |
| **BME Lab/class ratio (calculated)** | 1/10 | 0 | 1/2 | 3/16 | 2/11 | 1/6 | #DIV/0! | 1/5 |
| **BME Lab Space available to Ug** | 3000 sqf | | 3 labs | 4 labs, 1500 sqf | 13 labs | 15 labs 1700sqf | ~63,000 sqf | 10 labs |
| **Research Expenditures** | $3,256,471 | | | $51 | $684,902 | $6,389,106 | $966,944 | $931,435 |
| | | internships + research course provide lab experience | | | | | | |
| **BME Concentrations/Tracks (if any)** | n | standard, pre-med | n | yes (5) | Biomaterials, Biomechanics, Biomedical computing & systems, Pre-med | Chem E, Computer E., Mechanical E., Electrical E., Computer Sci., Materials Sci., Life Science/Physiology | Chemical, Electrical, Mechanical, Pre-Med | Electrical, Mechanical |
| | | | | | | | | |
| **Internships available?** | y | y | y | no | yes | yes | yes | yes |
| **Internships required?** | no | y | n | no | | no | no | no |
| **% Students involved with Internships** | most all (?) | 100 | 20% | none | | 10-20% | | 70% |
| **Offer BME Independent Study?** | yes (research project) | n | y | yes (research project) | yes | | | |
| **Biomed Society?** | y | | | y | yes | yes | yes | yes |
| | | | | | | | | |
| **Affiliated with a Hospital?** | n | y | n | y | yes | yes | yes | yes |
| **How Many?** | | 3 | | 1 (UIC Med School) | 3 | 3 | multiple | 2 |
| **(How?)** | | senior ug research projects | | faculty | | | Internships – design projects + clinical rotations | co-ops, internships |
| | | | | | | | | |
| **Accredited Program?** | y | n | n | y | y | y | y | y w/Co-Op |
| **Date of Accreditation** | Sep-72 | | | 1976 | 1986 | 1983 | 1978 | 1983 |
| **# of Other Accred. Eng. Programs** | 4 | 3 | 3 | 6 | 5 | 6 | 5 | 4 |
| | | | | | | | | |
| **Job Placement rate for Ug in BME** | | | | | | | | |
| **% graduates who go MD** | 33% | 0% | 10% | 5-10% | 33% | 35-40% | 15% | 50% |
| **% who go MS/PhD** | 33% | 90% | 20% | 50% | 33% | 40% | 35% | |
| **% who go to industry** | 34% | 10% | 40% | 50% | 33% | 20% | 50% | 50% |
| | | | | | | | | |
| | | | engineering Science ABET | | | | | |
| | | | program an "option" | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| | *Mercer University* | *Miami* | *Milwaukee School of Eng* | *Northwestern* | *U Penn* | *U. of Pittsburg* | *Rensseleer Poytech* | *Rice University* |
|---|---|---|---|---|---|---|---|---|
| **# of Ug BME Students** | 115 | 120 | 101 | 316 | 250 | 120 | 185 | |
| **BME Faculty/Student Ratio** | 1/23 | 8/120 | 7/101 | 25/316 | 15/250 | 1/40 | 8/185 | |
| | | | | | | | | |
| **# of Ug BME Courses** | 14 | 46 | 22 | 48 | 23 | 15 | 24 | |
| **Required BME Courses/Credits** | 15 credits/ ~7 classes | 13 | 20 | 2~8 Courses | 15 | 12 | | |
| | | | | | | | | |
| **# of classes dedicated to BME Design** | 2 | 4 | 5 | 1 | 1 | 2 | 1 | |
| **# of BME courses with Lab** | 1 | 4 | 15 | 7 | 4 | 2 | 2 | |
| **BME Lab/class ratio (calculated)** | 1/14 | 2/23 | 15/22 | 7/48 | 4/23 | 2/13 | 1/12 | |
| **BME Lab Space available to Ug** | 2 labs | 1 ug =700sqf, 6 | all labs | 1700 sqf | 5 Labs | 60,000 sqf | | |
| **Research Expenditures** | | | | | | | $1,187,000 | |
| | | | | | | | | |
| **BME Concentrations/Tracks (if any)** | n | Electrical, Mechanical, Pre-med | | Electronic Instrumentation, Mechanics, Transport Processes, Biotech, Biomed Signals & Images | Biomaterials, Biomechanics,Medical Device Industry, MD/PhD | biotechnology, biosystems, biomechanics | Electrical, Mechanical, Materials | |
| | | | | | | | | |
| **Internships available?** | n | y | y | n (only co-op) | | y | y | |
| **Internships required?** | n | n | n | n | | y | n | |
| **% Students involved with Internships** | ~25% co-ops, etc. | 2-3% | | 20% co-op | | 100 | small %, 20-25% co-op | |
| | | | | | | | | |
| **Offer BME Independent Study?** | y | yes (is&sen proj) | y | y | y | y | y | |
| **Biomed Society?** | y | n | n | y | | | y | |
| | | | | | | (required) | | |
| | | | | | | | | |
| **Affiliated with a Hospital?** | y | y | y | y | y | y | y | |
| **How Many?** | 2 | 2 | | NWU Med School | 4 | 1 | 1 | |
| **(How?)** | co-op and senior design projects | project work | clinical eng. Internships, MS Perfusion Program | faculty, ind studies | | faculty | life science course taken at Albany Medical College | |
| | | | | | | | | |
| **Accredited Program?** | n | y | y | y w/Co-op | y | n | y w/Co-op | n |
| **Date of Accreditation** | | 1997 | 1990 | 1982 | 1982 | | 1972 | |
| **# of Other Accred. Eng. Programs** | 1 (engineering) | 7 | 5 | 8 | 6 | 8 | 12 | 5 |
| | | | | | | | | |
| **Job Placement rate for Ug in BME** | | | | | | | | |
| **% graduates who go MD** | 20% | 20% | <5% | 40% | 22% | 33% | 20% | |
| **% who go MS/PhD** | 30% | 50% | 50% | 20% | 22% | 33% | 60% | |
| **% who go to Industry** | 40% | 30% | 50% | 40% | 56% | 33% | 20% | |
| | | | | | | (expected) | | new this year |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| | U. of Rochester | University of Southern California | Syracuse | Texas A&M | U. of Toledo | Trinity College | Tulane | Vanderbilt |
|---|---|---|---|---|---|---|---|---|
| # of Ug BME Students | | | 112 ('96) | 550 | 88 | | 180 | 270 ('94) |
| BME Faculty/Student Ratio | | 8 | 7/105 | 4/275 | 5/44 | | 12/180 | 11/270 |
| # of Ug BME Courses | | 12 | 20 | 13 | 20 | | 48 | 13 |
| Required BME Courses/Credits | | 7 | 30 Credits ~10 courses | 11 | 14 | | 15 courses | ~10 courses |
| # of classes dedicated to BME Design | | | 3 w/ thesis | 2 | 20 | | 4 + Team Design + Senior Projects | 1 |
| # of BME courses with Lab | | | 6 | 2 | 4 | | 7 | 2 |
| BME Lab/class ratio (calculated) | | | 3/10 | 2/13 | 1/5 | | 7/48 | 2/13 |
| BME Lab Space available to Ug | | | 2 Labs | 10 Labs | 5 labs | | 22000sf, 9 Labs | |
| Research Expenditures | | | $23,439 | 0 | | | $1,212,000 | $1,502,798 |
| BME Concentrations/Tracks (If any) | Electrical, Mechanical, Chemical, Optics | Chemical, Mechanical, Electrical | Bioinstrumentation, Biomechanics | | | | Bioelectronics, Biomechanics, Biomaterials, Tissue Engineering | Pre-med, mechanics, instrumentation, computer science, Double Major EE,ChE |
| Internships available? | | | summer fellowships | y | y | | y summer | y new summer program |
| Internships required? | n | | n | n | y | | n | n |
| % Students involved with internships | | | | 50% (w/co-op) | | | | 25 postitions |
| Offer BME Independent Study? | | y | y | y | y | | senior project | y |
| Biomed Society? | y | | y | y | | | y | y |
| Affiliated with a Hospital? | | | | y | y | | y, Children's Hospital | |
| How Many? | | | | 1 | 1 | | Team Design Projects | |
| (How?) | | | | a class is taught at the hospital by a clinical engineer | pre-med program | | | |
| Accredited Program? | n | n | y w/Co-op | y w/Co-op | n | n | y | y |
| Date of Accreditation | | | 1989 | 1977 | | | 1981 | 1992 |
| # of Other Accred. Eng. Programs | 3 | 6 | 7 | 12 | 6 | 1 | 4 | 5 |
| Job Placement rate for Ug in BME | | | | | | | | |
| % graduates who go MD | | | 6% | 33% | N/A | | >33% | ~33% |
| % who go MS/PhD | | | 41% | 33% | N/A | | 33% | ~33% |
| % who go to industry | | | 48% | 33% | N/A | | ~17% | ~33% |
| | | | (rest go to Law, Opt) | | | | (Rest go to ROTC) | |
| | | | | | | eng sci "option" | | |

| | U. Virginia | Washington UniversitySt. Louis | University of Washington | Western NE College | University of Wisconsin-Mad | Wright State | WPI |
|---|---|---|---|---|---|---|---|
| # of Ug BME Students | | | | 20 | 24 | | ~100 |
| BME Faculty/Student Ratio | | 6 | | 3/20 | 13/24 | 5 | 1/20 |
| | | | | | | | |
| # of Ug BME Courses | | 6 | | 8 | 20 | 17 | 12 |
| Required BME Courses/Credits | | | | 7 | 11 | 15 | 7 |
| # of classes dedicated to BME Design | | 1 | | 5 | 8 | 3 | 1 |
| # of BME courses with Lab | | 2 | | 3 | 2 | 0 | 2 |
| BME Lab/class ratio (calculated) | | 1/3 | | 3/8 | 1/10 | 0 | 1/6 |
| BME Lab Space available to Ug | | | | ~1550 sqf | under construction | 7 labs | |
| Research Expenditures | $1,321,657 | $6,187,000 | | | | $910,000 | $325,369 |
| | | | | | | | |
| BME Concentrations/Tracks (if any) | Pre-med, Biomechanics, Biochemical Engineering, Instrumentation/ Imaging | | | n | Bioinstrumentation, Biocomputing, Biosignals, Biomechanics | Pre-Med | Biochemical, Mechanical, Electrical |
| | | | | | | | |
| Internships available? | | | | y | y | | y |
| Internships required? | | | | y | n | | n |
| % Students involved with internships | | | | 100% | no data | | |
| Offer BME Independent Study? | | y | | y | y | | y |
| Biomed Society? | n | n | | y | | y | |
| | | | | | | | |
| Affiliated with a Hospital? | | | | y | y | | y |
| How Many? | | | | 3 | 1 | | 2 |
| (How?) | | | | research internships, projects, paid internships | faculty + research | | |
| | | | | | | | |
| Accredited Program? | n | n | n | n | n | y | n |
| Date of Accreditation | | | | | | 1988 | |
| # of Other Accred. Eng. Programs | 7 | 5 | 10 | 3 | 13 | 6 | 6 |
| | | | | | | | |
| Job Placement rate for Ug in BME | | | | | | | |
| % graduates who go MD | | | | <1% | no data | | |
| % who go MS/PhD | | | | 15% | | | |
| % who go to Industry | | | | 84% | | | |
| | | | | | first year | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

## 13.0 - Appendix F

| | Accredited | Undisclosed | Unaccredited | Undisclosed | | Total Avg Percentage | Total Undisclosed |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **Percent of Schools with Concentrations?** | 76 | 14 | 50 | 33 | | 63 | 23.5 |
| **Percent that have interships available** | 76 | 10 | 50 | 39 | | 63 | 24.5 |
| **Percent that require interships** | 0 | 19 | 22 | 39 | | 11 | 29 |
| **Percent that offer BME independent study** | 76 | 24 | 56 | 33 | | 66 | 28.5 |
| **Percent that are affiliated with hospital** | 71 | 19 | 50 | 44 | | 60.5 | 31.5 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | yes-accredited | yes-unaccredited | no-accredited | no-unaccredited | undisclosed | |
| | # of schools : | | | | | | |
| **Concentrations?** | | 16 | 9 | 2 | 3 | 9 | |
| **Interships available?** | | 16 | 9 | 3 | 2 | 9 | |
| **Require interships?** | | 0 | 4 | 17 | 7 | 11 | |
| **Offer BME independent study?** | | 16 | 10 | 0 | 2 | 11 | |
| **Affiliated with hospital?** | | 15 | 9 | 2 | 1 | 12 | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| | ACCREDITED | UNACCREDITED | WPI | | a-md | a-ms/phd | a-industry | undisclosed | ua-md | ua-ms/phd | ua-indust. | undisclosed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average:** | | | | | 17 | 27 | 40 | | 33 | 33 | 33 | |
| **MD** | 24.75 | 20.28571429 | | | 10 | 40 | 50 | | 45 | 25 | 30 | |
| **MS/PHD** | 36.4 | 35.14285714 | | | 50 | 8 | | | | | | |
| **INDUSTRY** | 37.31578947 | 38.57142857 | | | 25 | 45 | 30 | | 0 | 90 | 10 | |
| **UNDISCLOSED** | 1.534210526 | 6 | | | 25 | 50 | 25 | | 10 | 20 | 40 | |
| | | | | | 33 | 33 | 34 | | 20 | 30 | 40 | |
| | | | | | 10 | 50 | 50 | | 33 | 33 | 33 | |
| | | | | | 33 | 33 | 33 | | | | | |
| | Actual Value | Rounded Value | | | 40 | 40 | 20 | | | | | |
| Total Average: | | | | | 15 | 35 | 50 | | | | | |
| **MD** | 22.51785714 | 23 | | | 25 | 25 | 50 | | | | | |
| **MS/PHD** | 35.77142857 | 36 | | | 20 | 50 | 30 | | | | | |
| **INDUSTRY** | 37.94360902 | 38 | | | 5 | 50 | 50 | | | | | |
| | | | | | 40 | 20 | 40 | | | | | |
| | | | | | 22 | 22 | 56 | | | | | |
| | | | | | 20 | 60 | 20 | | 1 | 15 | 84 | |
| | | | | | 6 | 41 | 48 | | | | | |
| | | | | | 33 | 33 | 33 | | | | | |
| | | | | | 33 | 33 | 17 | | | | | |
| | | | | | 33 | 33 | 33 | | | | | |
| | | | | | | | | | | | | |
| | | | | **total:** | **495** | **728** | **709** | | **142** | **246** | **270** | |
| | | | | | | | | | | | | |
| | | | | **# of schools** | **20** | **20** | **19** | **1** | **7** | **7** | **7** | **11** |
| | | | | | | | | | | | | |
| | | | | ttest of average percentage of students in MD: accredited vs. unaccredited | | | | | | | | |
| | | | | 0.463049038 | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | ttest of average percentage of students in MS/PhD: accredited vs. unaccredited | | | | | | | | |
| | | | | 0.863216635 | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | ttest of average percentage of students in Industry: accredited vs. unaccredited | | | | | | | | |
| | | | | 0.854583392 | | | | | | | | |

| | ACCREDITED | UNACCREDITED | WPI | | |
|---|---|---|---|---|---|
| Average: | | | | | |
| # of Hospital Affiliations | 3 | 2 | 2 | | |
| Undisclosed | 5 | 8 | | | |
| | | | | | |
| | | | | | |
| | accred. | unaccred. | | | |
| # of Hospital Affiliations: | 5 | 5 | | | |
| | 10 | 1 | | | |
| | 0 | | | | |
| | 5 | 3 | | | |
| | | 0 | | | |
| | 0 | 2 | | | |
| | 1 | 1 | | | |
| | 3 | | | | |
| | 3 | | | | |
| | 5 | | | | |
| | 2 | 1 | | | |
| | 2 | | | | |
| | | | | | |
| | 1 | | | | |
| | 4 | | | | |
| | 1 | 3 | | | |
| | | 1 | | | |
| | 1 | 2 | | | |
| | 1 | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **total:** | **44** | **19** | | | |
| **# of schools** | **16** | **10** | | | |
| **# undisclosed** | **5** | **8** | | | |
| **total # of schools:** | **21** | **18** | | | |
| | | | | | |
| **ttest of average number of hospital affiliations: accredited vs. unaccredited** | | | | | |
| **p=** | **0.354885407** | | | | |
| | | | | | |

| | ACCREDITED | UNACCREDITED | WPI | UNDISCLOSED | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Average: | | | | | | | | | |
| # of other accredited engineering programs | 6 | 5 | 6 | 0 | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | accredited | unaccredited | | | | | | |
| # of other accredited engineering programs: | | 7 | 4 | | | | | | |
| | | 5 | 7 | | | | | | |
| | | 4 | 6 | | | | | | |
| | | 10 | 3 | | | | | | |
| | | 3 | 3 | | | | | | |
| | | 4 | 1 | | | | | | |
| | | 6 | 8 | | | | | | |
| | | 5 | 5 | | | | | | |
| | | 6 | 3 | | | | | | |
| | | 5 | 6 | | | | | | |
| | | 4 | 6 | | | | | | |
| | | 7 | 1 | | | | | | |
| | | 5 | 7 | | | | | | |
| | | 8 | 5 | | | | | | |
| | | 6 | 10 | | | | | | |
| | | 12 | 3 | | | | | | |
| | | 7 | 13 | | | | | | |
| | | 12 | 6 | | | | | | |
| | | 4 | | | | | | | |
| | | 5 | | | | | | | |
| | | 6 | | | | | | | |
| | | | | | | | | | |
| | **total:** | **131** | **97** | | | | | | |
| | **# of schools** | **21** | **18** | | | | | | |
| | | | | | | | | | |
| | **ttest analysis of the number of other accredited engineering programs: accred. Vs. unnaccrd.:** | | | | | | | | |
| | **p=** | **0.342837216** | | | | | | | |

| | ACCREDITED | UNACCREDITED | WPI |
|---|---|---|---|
| Average: | | | |
| Percentage of BME Undergrads Involved in Internships | 27 | 66 | |
| Percent of Undisclosed Scools | 48 | 61 | 0 |
| | | | |
| Total Average Percentage of BME Undergrads Involved in Internships: | percent | undisclosed | |
| | 46.5 | 54.5 | |
| | | | |
| | | accredited | unaccredited |
| Percent involved in internships: | | 7 | 100 |
| | | | 20 |
| | | | |
| | | 10 | 100 |
| | | | 20 |
| | | 90 | 25 |
| | | 0 | 100 |
| | | | |
| | | 20 | |
| | | | |
| | | 70 | |
| | | 3 | |
| | | | |
| | | 20 | |
| | | | |
| | | 20 | 100 |
| | | | |
| | | 50 | |
| | | | |
| | | 9 | |
| | | | |
| | | | |
| | total: | 299 | 465 |
| | # of schools | 11 | 7 |
| | # undisclosed | 10 | 11 |
| | | | |
| | ttest analysis of the percent of undergrads involved in internships: accred. Vs. unaccred.: | | |
| | p= | 0.032940372 | |
| | | | |

| | Accredited | Unaccredited | WPI | | | |
|---|---|---|---|---|---|---|
| **Average Number of BME Undergraduates:** | 263 | 59 | 100 | | | |
| **Number of Undisclosed Schools** | 1 | 8 | 0 | | | |
| | | | | | | |
| | | accredited | unaccredited | | | |
| Number of BME Undergraduates: | | 205 | 23 | | | |
| | | 425 | 50 | | | |
| | | 913 | | | | |
| | | 230 | 23 | | | |
| | | 55 | 30 | | | |
| | | 400 | 115 | | | |
| | | 82 | 120 | | | |
| | | 170 | | | | |
| | | 300 | | | | |
| | | 160 | | | | |
| | | 240 | 88 | | | |
| | | 120 | | | | |
| | | 101 | | | | |
| | | 316 | | | | |
| | | 250 | | | | |
| | | 185 | 20 | | | |
| | | 112 | 24 | | | |
| | | 550 | 100 | | | |
| | | 180 | | | | |
| | | 270 | | | | |
| | | | | | | |
| | | | | | | |
| | total: | 5264 | 593 | | | |
| | # of schools | 20 | 10 | | | |
| | # undisclosed: | 1 | 8 | | | |
| | | | | | | |
| | ttest analysis of number of undergrads: accred. Vs. unaccred.: | | | | | |
| | p= | 0.003310695 | | | | |
| | means that there is a significant difference | | | | | |

| | Accredited | Unaccredited | WPI | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Average Number of Undergraduate BME Courses:** | 22 | 13 | 12 | | | | | |
| **Number of Undisclosed Schools** | 1 | 6 | 0 | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | accredited | unaccredited | | | | | |
| **Number of undergrad. BME courses:** | | 18 | 15 | | | | | |
| | | 30 | 25 | | | | | |
| | | 25 | | | | | | |
| | | 19 | 4 | | | | | |
| | | 20 | 6 | | | | | |
| | | 10 | 14 | | | | | |
| | | 16 | 15 | | | | | |
| | | 11 | | | | | | |
| | | 30 | | | | | | |
| | | | 12 | | | | | |
| | | 25 | 20 | | | | | |
| | | 46 | | | | | | |
| | | 22 | | | | | | |
| | | 48 | 6 | | | | | |
| | | 23 | | | | | | |
| | | 24 | 8 | | | | | |
| | | 20 | 20 | | | | | |
| | | 13 | 12 | | | | | |
| | | 15 | | | | | | |
| | | 13 | | | | | | |
| | | 17 | | | | | | |
| | | | | | | | | |
| | **total:** | **445** | **157** | | | | | |
| | **# of schools:** | **20** | **12** | | | | | |
| | **# of undisclosed:** | **1** | **6** | | | | | |
| | | | | | | | | |
| | **ttest analysis of the number of undergrad bme courses offered: accred. Vs. unaccred.** | | | | | | | |
| | **p=** | **0.009070041** | | | | | | |
| | **this means that there is a significant difference** | | | | | | | |

| Distribution of Concentrations: | Accredited | Unaccredited | WPI Track Terminology |
|---|---|---|---|
| **The number of schools that have:** | | | |
| Biomechanics | 11 | 8 | Mechanical |
| Bioinstrumentations | 4 | 4 | Electrical |
| Imaging | 2 | 3 | Electrical |
| Computers | 4 | 1 | Electrical |
| Signals | 0 | 2 | Electrical |
| Pre-Med | 6 | 2 | Clinical |
| Materials | 7 | 0 | Mechanical |
| Cell/Tissue | 2 | 1 | Chemical |
| Rehab | 1 | 0 | Mechanical |
| Chemical | 3 | 3 | Chemical |
| Physiology | 1 | 0 | Clinical |
| Electrical | 7 | 1 | Electrical |
| Transport | 1 | 0 | Mechanical |
| Medical Device | 1 | 0 | Electrical, Mechanical |
| Biotech | 1 | 1 | Clinical |
| Biosystems | 0 | 1 | |
| Regular | 4 | 4 | |
| Undisclosed | 3 | 6 | |
| | | | |
| Total # of Schools That Support: | Number of Schools: | Total Percent of Schools: | |
| Mechanical | 22 | 56 | |
| Electrical | 21 | 54 | |
| Chemical | 10 | 26 | |
| Undisclosed | 9 | 23 | |
| Pre-Med | 14 | | |

| | Accredited | Unaccredited | WPI |
|---|---|---|---|
| | | | |
| Average Number of Required Undergrad BME Courses | 12 | 9 | 7 |
| Number of Undisclosed Schools | 7 | 7 | 0 |
| | | | |
| | | | |
| | | | |
| | | accredited | unaccredited |
| Number of Required Undergrad. BME courses: | | | 11 |
| | | 8 | 10 |
| | | 13 | |
| | | | 4 |
| | | 10 | 5 |
| | | | 7 |
| | | 11 | 12 |
| | | | |
| | | 9 | |
| | | | 7 |
| | | | 14 |
| | | 13 | |
| | | 20 | |
| | | 8 | |
| | | 15 | |
| | | | 7 |
| | | 10 | 11 |
| | | 11 | 7 |
| | | 15 | |
| | | 10 | |
| | | 15 | |
| | | | |
| | total: | 168 | 95 |
| | # of schools: | 14 | 11 |
| | # of undisclosed: | 7 | 7 |
| | | | |
| | ttest analysis of the number of required undergrad bme courses: accred. Vs. unaccred. | | |
| | p= | 0.017904724 | |

| | Accredited | Unaccredited | WPI |
|---|---|---|---|
| | | | |
| **Average Number of BME Courses Dedicated to Design** | 3 | 5 | 1 |
| **Number of Undisclosed Schools** | 1 | 9 | 0 |
| | | | |
| | | | |
| | | accredited | unaccredited |
| Number of BME courses dedicated to design: | | 2 | 5 |
| | | 3 | 1 |
| | | 6 | |
| | | 2 | 0 |
| | | 5 | |
| | | 0 | 2 |
| | | 2 | 2 |
| | | 2 | |
| | | 2 | |
| | | | |
| | | 7 | 20 |
| | | 4 | |
| | | 5 | |
| | | 1 | |
| | | 1 | |
| | | 1 | 5 |
| | | 3 | 6 |
| | | 2 | 1 |
| | | 4 | |
| | | 1 | |
| | | 3 | |
| | | | |
| | **total:** | **56** | **42** |
| | **# of schools:** | **20** | **9** |
| | **# of undisclosed:** | **1** | **9** |
| | | | |
| | **ttest analysis of the number of undergrad courses dedicated to design: accred. Vs. unaccred.** | | |
| | **p=** | **0.216855644** | |

| | Accredited | Unaccredited | WPI |
|---|---|---|---|
| | | | |
| **Average Number of BME Courses With Labs** | 4 | 2 | 5 |
| **Number of Undisclosed Schools** | 1 | 7 | 0 |
| | | | |
| | | | |
| | | accredited | unaccredited |
| Number of BME courses with lab: | | 4 | 3 |
| | | 8 | 5 |
| | | 2 | |
| | | 5 | 0 |
| | | 2 | 3 |
| | | 1 | 1 |
| | | 3 | 2 |
| | | 2 | |
| | | 5 | |
| | | | |
| | | 5 | 4 |
| | | 4 | |
| | | 15 | |
| | | 7 | 2 |
| | | 4 | |
| | | 2 | 3 |
| | | 6 | 2 |
| | | 2 | 5 |
| | | 7 | |
| | | 2 | |
| | | 0 | |
| | | | |
| | **total:** | **86** | **30** |
| | **# of schools:** | **20** | **11** |
| | **# of undisclosed:** | **1** | **7** |
| | | | |
| | **ttest analysis of the number of undergrad courses with lab: accred. Vs. unaccred.** | | |
| | **p=** | **0.151324542** | |

| | Accredited | Unaccredited | WPI |
|---|---|---|---|
| | | | |
| **Average BME Lab/Class Ratio** | 0.18 | 0.14 | 0.17 |
| **Number of Undisclosed Schools** | 1 | 7 | 0 |
| | | | |
| | | | |
| | | accredited | unaccredited |
| BME Lab/Class Ratio: | | 0.22 | 0.33 |
| | | 0.27 | 0.2 |
| | | 0.08 | |
| | | 0.26 | 0 |
| | | 0.1 | 0.5 |
| | | 0.1 | 0.07 |
| | | 0.19 | 0.15 |
| | | 0.18 | |
| | | 0.17 | |
| | | | |
| | | 0.2 | 0.2 |
| | | 0.09 | |
| | | 0.68 | |
| | | 0.15 | 0.33 |
| | | 0.17 | |
| | | 0.08 | 0.38 |
| | | 0.3 | 0.1 |
| | | 0.15 | 0.17 |
| | | 0.15 | |
| | | 0.15 | |
| | | 0 | |
| | | | |
| | **total:** | **3.69** | **2.43** |
| | **# of schools:** | **20** | **11** |
| | **# of undisclosed:** | **1** | **7** |
| | | | |
| | **ttest analysis of the BME Lab/Class Ratio: accred. Vs. unaccred.** | | |
| | **p=** | **0.498032498** | |

**14.0 - Appendix G**

**From:** gms3@po.cwru.edu <gms3@po.cwru.edu>
**To:** Colleen <corourke@WPI.EDU>
**Date:** Monday, January 18, 1999 1:54 AM
**Subject:** Re: in need of your assistance...

Colleen:

(1) Approximately what is the total lab space you offer the undergraduate student?
BME undergraduate students not only use a BME instructional lab of 2000 sq ft., but also of BME faculty research labs (about 30,000 ft sq) for BME courses.

(2) Approx. percentage of student that concentrate in each specialty area you offer ?
30% in the biomaterials related sequences
30% in the biomechanics and prosthetic related sequences
20% in the computer and imaging related sequences
20% in the instrumentation related sequences

(3) Does your program have interships? Yes. Are they required? No.
Percent of undergrads involved? 5-10% but increasing

(4) Date of Accreditation? I think about 1975 originally. Please confirm with ABET.

(5) Job placement rate for undergrads in BME:
>Percent who go MD? 25%
>Percent who go MS/PhD? 45%
>Percent who go to industry? 30%

>Hi! My name is Colleen O'Rourke. I am a junior at Worcester Polytechnic
>Institute currently working on a project. This project involves
>comparing accredited institutions with non-accredited and discovering
>what makes a program solid and successful. I observed that your program
>is accredited and hoped that you could answer some quick questions.
>

>
>I would greatly appreciate any information you can provide me. I want
>to thank you for your time!
>
>Colleen

Prof. Gerald M. Saidel
Dept. of Biomedical Engineering
Wickenden 504
Case Western Reserve University
Cleveland, OH 44106-7207

TEL 216/368-4066
FAX 216/368-4969
WWW http://convolve.ebme.cwru.edu/bmehome.html

**From:** rbarr@potassium.egr.duke.edu <rbarr@potassium.egr.duke.edu>
**To:** corourke@WPI.EDU <corourke@WPI.EDU>
**Cc:** gtruskey@acpub.duke.edu <gtruskey@acpub.duke.edu>; eray@acpub.duke.edu <eray@acpub.duke.edu>
**Date:** Monday, January 18, 1999 1:54 AM
**Subject:** Re: in need of your assistance...

---

Colleen,
I've put in some comments among the questions. What I've said
is true for our program, I believe, but it is not

>Date: Wed, 09 Dec 1998 23:52:03 -0500
>From: Colleen <corourke@wpi.edu>
>X-Mailer: Mozilla 4.02 [en]C-DIAL (Win95; U)
>Mime-Version: 1.0
>Content-Type: text/plain; charset=us-ascii
>Content-Transfer-Encoding: 7bit
>
>Hi! My name is Colleen O'Rourke. I am a junior at Worcester Polytechnic
>Institute currently working on a project. This project involves
>comparing accredited institutions with non-accredited and discovering
>what makes a program solid and successful. I observed that your program
>is accredited and hoped that you could answer some quick questions.
>
>Approximately what is the total lab space you offer the undergraduate
>student?

We have about 75 undergraduates per class,
and they use a number of different labs, so it is hard to pin this
number down. There are four lab rooms, totalling about 3000 sq ft,
that are used more or less exclusively by undergraduates, but they
also are in lots of other lab spaces in ones and twos.

>Do you know the approx. percentage of student that concentrate in each
>specialty area you offer?

The BME undergraduate program is not divided into speciality areas
at this time.

>Are internships available? If so, percent of undergrads involved?

Internships are available, but not exclusively for BME students nor
through the department office. Most all of the undergraduates who
are interested find some sort of internship opportunity.

>Are you affiliated with hospitals? If so, how may?

Then, what is your relationship with them?

The Duke University Medical Center and Duke Hospital are a part of Duke University. Individual students work in medical center labs, but not as a group. We have no affiliation with Duke Hospital as a program, but many of our students work there, or for physicians there.

>
>I would greatly appreciate any information you can provide me. I want
>to thank you for your time!
>
>Colleen
>
>
>
>

**From:** Cathy Jancuk <cjancuk@bme.jhu.edu>
**To:** corourke@WPI.EDU <corourke@WPI.EDU>
**Date:** Monday, January 18, 1999 1:54 AM
**Subject:** RE: in need of your assistance...

---

Colleen:

The Director of the BME Dept., Murray Sachs, has forwarded me your email regarding our program. I'll attempt to answer your questions (using ALL CAPS). Please let me know if you need additional clarification.

> >Approximately what is the total lab space you offer the undergraduate
> >student?
THAT QUESTIONS IS A LITTLE TRICKY SINCE OUR STUDENTS TAKE BASIC AND UPPER-LEVEL ENGINEERING COURSES IN TRADITIONAL ENGINEERING DEPARTMENTS, AS
WELL AS IN BIOMEDICAL ENGINEERING. FOR EXAMPLE, A STUDENT WITH AN ELECTRICAL ENGINEERING CONCENTRATION WOULD TAKE COURSES LIKE ELECTRONICS LAB
OR MICROPROCESSOR LAB, OR INTEGRATED ELECTRONICS LAB, ETC. TOTAL LAB SPACE
FOR BME-ONLY TOTALS ABOUT 1700 SF AND IS SPACE FOR PHYSIOLOGICAL FOUNDATIONS
LAB, MICROFABRICATION LAB, INSTRUMENTATION LAB, SENSORS LAB AND CAPSTONE
DESIGN. KEEP IN MIND THAT MANY OF THESE COURSES "SHARE" SPACE SINCE THEY
ARE OFFERED AT DIFFERENT TIME OF THE YEAR. (IF YOU NEED COURSE DESCRIPTIONS
YOU SHOULD CHECK OUT THE HOPKINS WEB SITE
http://www.jhu.edu/~admis/catalog/engin/biomed/

> >Do you know the approx. percentage of student that concentrate in each
> >specialty area you offer?

IF YOU NEED PERCENTAGES, YOU CAN DO THE MATH... THE NUMBERS BELOW REFLECT
THE TOTAL NUMBER OF GRADUATING BS STUDENTS IN EACH YEAR.

1998 1997 1996 1995 1994

Chemical 30 19 9 13 3

*Computer Sci 6 7 3 0 1

*EE 29 31 26 36 18

Materials Sci 14 8 8 18 9

MechE 8 10 8 9 2

Life Sci/Phys. 4 2 1 2 1

*New Computer Engineering Concentration is not reflected

> >Does your program have interships?
YES

Percent of undergrads involved?
10-20%

> >Date of Accreditation?
1983

> >Job placement rate for undergrads in BME:

> >Percent who go MD?
35-40% GO TO MED SCHOOL
> >Percent who go MS/PhD?
40% GO TO GRAD SCHOOL OR PROFESSIONAL SCHOOLS (OTHER THEN MED SCHOOL)
> >Percent who go to industry?
CURRENTLY ABOUT 20% OF OUR GRADUATES GO TO INDUSTRY.
> >What is the relationship you have with your affiliations?
I'M ASSUMING THAT YOU ARE REFERRING TO THE OTHER DIVISIONS AT JHU... WE
HAVE COLLABORATIVE PROJECTS WITH JUST ABOUT EVERY DIVISION IN THE UNIVERSITY. IS THAT WHAT YOU MEAN?

Cathy Jancuk
Program Manager
BME Department
(410)516-5260

## Chris Wilson

**From:** Kenneth R. Foster <kfoster@seas.upenn.edu>
**To:** <chrisgw@WPI.EDU>
**Cc:** <gershon@seas.upenn.edu>
**Sent:** Monday, December 14, 1998 5:45 PM
**Subject:** jobs for bioengineering grads at Penn

Prof. Buchsbaum referred your message to me. Here are some data from last year.
There more data from this survey on our career planning website (salaries etc) -- I don't know whether you can access it from outside the university or not.

http://www.upenn.edu/CPPS/seas/ugrad/index.html

Out of 32 respondents (ASBS and BE):
Employ = 18 (56%)
Med Sch = 7 (22%)
Oth Grad = 7 (22%)
Of those going to work, sample of companies hiring BE graduates:
American Management Systems, Inc., Fairfax, VA; Technical Consultant
Andersen Consulting, Philadelphia, PA ; Analyst
Andersen Consulting, Washington, DC; Analyst
Carl Zeiss, Inc., Thornwood, NY; IGS Project Engineer
Friedman, Billings, Ramsey, & Co., Inc. Rosslyn, VA; Analyst
Industrial Light & Magic, San Rafael, CA; Programmer
Inovax Limited, Indonesia; Consultant
Price Waterhouse LLP, New York, NY; IT Consultant
Sapient Corporation, New York, NY; Assistant Project Manager
U.S. Military, Ft. Sill, OK; Second Lieutenant
Univeristy of California, San Diego, CA; Staff Research Associate
University of Pennsylvania, PA; Research Specialist
ZS Associates, Evanston, IL; Business Information Specialist

Kenneth R Foster
Department of Bioengineering
University of Pennsylvania
220 S. 33rd St.
Philadelphia PA 19104-6392
215-898-8534
fax 215-573-2071
President IEEE Society on Social Implications of Technology 1997-8
Chair, EMBS Committee on Man and Radiation 1997-
**********
SSIT Website: http://www4.ncsu.edu/unity/users/j/jherkert/
COMAR website http://homepage.seas.upenn.edu/~kfoster/comar.htm
Blurb for latest book http://homepage.seas.upenn.edu/~kfoster/book.htm
Recent Papers http://homepage.seas.upenn.edu/~kfoster/papers.htm

## Chris Wilson

**From:** Rob Linsenmeier <r-linsenmeier@nwu.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Sent:** Sunday, December 13, 1998 7:28 PM
**Subject:** Re: project

>Prof. Linsenmeier-
> I am a junior at Worcester Polytechnic Institute (Worcester,
>Mass.) studying biomedical engineering, and I am researching the current
>trends in undergraduate BE programs. My project partner and I are trying
>to gather information on how different schools integrate engineering
>design into their programs, and where graduates of those programs go. We
>would greatly appreciate any help you could give us on answering the
>following questions.
>
>How many undergrad classes are dedicated to biomedical engineering design?

You should look at the engineering web at NU to learn about Engineering Design and Communication, a freshman program in which two quarters contain design, but not necessarily BME design per se. Otherwise we currently have a one quarter course called BME design for seniors that is the only pure design course. Of course, ABET requirements have been that all accredited engineering programs have a certain amount of design, and we have design built in to many other courses. Can't tell you how many offhand, but enough to meet that requirement.

>How many of the undergrad BE courses include a lab?

There is one full senior course called BME lab, and several others include lab components of varying magnitude: intro to BME, two of the three systems physiology courses, cell and molecular basis of bioengineering, tissue engineering,biofluid mechanics, biomedical signals and images.
>
>How much lab space is available to undergrad BE students?

The teaching lab is about 1700 square feet.

>
>Does Northwestern's undergrad BE program require an internship period?
>
No.

>Does the BE department offer internships?

Not as a department, exactly, but we certainly encourage students to do internships and will help them find one. We do have a full co-op program - again you might look at the engineering web page to learn about this. That has students taking 5 years because they do three quarters at companies. Right now we have about 20% of the BME students in this track, but it will grow.
>
>Does the BE department offer independent studies to undergrads?

Yes.
>
>Is the undergrad BE department affiliated with (a) hospital(s)? If so,
>how is it affiliated?
>
We have a department, not an undergrad department. We have about 30 faculty (half paid through BME). Some of the paid and many of the unpaid faculty are jointly appointed at the NU Med School in basic science or clinical departments. Most of those work at one of the hospitals in the Northwestern system, but the hospitals are not owned by the university. Undergrads can do independent study on the med school campus.

>What % of graduates go on to medical school?

about 40% at the moment.

>
>What % of graduates go on to graduate school (M.S. or Ph.D.)?
>
about 20%

>What % of graduates go directly into industry?
>
The rest. We owe Dr. Peura a more detailed report about this, which we will try to get him one of these days.

>
>Thanks for any help!!

It would be valuable if you distributed the results of your project broadly.
Good luck.
RAL
>
> Christopher Wilson
> Colleen O'Rourke
>
>
>

Robert A. Linsenmeier
r-linsenmeier@nwu.edu
Biomedical Engineering and Neurobiology & Physiology
Chair, Biomedical Engineering Department
Northwestern University
2145 Sheridan Rd.
Evanston, IL 60208-3107
847 491-3043 (phone)
847 491-4928 (fax)
http://www.nwu.edu/bme

## Chris Wilson

**From:** Dina Keratsis <dkera@bu.edu>
**To:** <chrisgw@WPI.EDU>
**Sent:** Thursday, February 04, 1999 2:27 PM
**Subject:** Biomedical Engineering At Boston University

Chris:

I am sorry, but unfortunately the Biomedical Engineering Department here at Boston University does not have up to date numbers on the percentage of its graduates entering grad school, industry, and medical school. We are currently in the process of obtaining and keeping track of statistics such as those, but that project is in its earliest stages. Again I am sorry that we are unable to help you. Good luck with your project.

## Chris Wilson

**From:** Heather Kohler <hkohler@eng.utoledo.edu>
**To:** <chrisgw@WPI.EDU>
**Sent:** Monday, February 01, 1999 5:29 PM
**Subject:** Doctoral Review

As part of a project, I am researching current trends in biomedical engineering education; I would appreciate any help you could give in answering the following questions about the undergraduate BME program at Toledo:
>
>What is the current undergrad BME enrollment? 88
>
>How many full-time faculty does the BME Dept. have? 10
>
>How many undergrad courses are designated BME? 20
>
>How many BME courses are required for the the B.S. BME degree? 14
>
>How much and what kind of BME lab space is available to undergrads? 5
>
>How many undergrad classes are dedicated to BME design? 20
>
>How many of the undergrad BME courses include or are a lab? 4
>
>Does the engineering dept. offer internships for BME's? yes
>
>Are internships required? yes
>
>What % of BME students are involved with intenships? 70%
>
>Does the BME Dept. offer independent studies to BME undergrads? yes
>
>Is the BME dept. affiliated with (a) hospital(s)? yes
>
>If so, how? Through a BME-Premed program
>
>Does the BME program have "tracks" (i.e. course paths of traditional
>engineering disciplines, etc.)? If so, what are those tracks? yes
Calculus I to IV, Engineering Physics I and II, and Chemistry I and II
>
>What % of BME graduates go one to medical school? None yet - we will not graduate our first students until this May.
>
>What % of graduates go on to graduate school (M.S. or Ph.D.)? None yet - we will not graduate our first students until this May.

>What % of graduates go into industry? None yet - we will not graduate our first students until this May.

>
>If you have any questions about this project, please feel free to email
>myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
>corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
>Thanks for your time!
>
> Christopher Wilson
>
**********

Heather Kohler, Academic Program Coordinator
Department of Bioengineering
University of Toledo
5051A Nitschke Hall

## Chris Wilson

**From:** Lee Ostrander <ostral@rpi.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Sent:** Wednesday, December 23, 1998 8:46 PM
**Subject:** Fwd: project

Chris,

Responses are given below.

LeeO

>X-Sender: spilker@mail.its.rpi.edu
>Date: Wed, 16 Dec 1998 08:38:34 -0500
>To: ostral@rpi.edu
>From: "Robert L. Spilker" <spilker@rpi.edu>
>Subject: Fwd: project
>
>>Date: Tue, 15 Dec 1998 16:06:51 -0500
>>From: Chris Wilson <chrisgw@WPI.EDU>
>>MIME-Version: 1.0
>>To: spilker@rpi.edu
>>Subject: project
>>
>>Prof. Harris-
>> I am a junior at WPI studying biomedical engineering. As part
>>of a project, I am researching current trends in undergraduate
>>biomedical engineering education; my project partner and I would
>>appreciate any help you could give on answering the following questions
>>about BME at RPI:
>>
>>What is the current undergrad BME enrollment?
**Between 30 and 40 per class -- typically 35.

>>
>>How many undergrad BME courses does RPI offer?
**RPI is a little different in that it has an Engineering Core taken by engineering students in the first two years. Also some courses are jointly offered between departments in which the course is sometimes listed in BME and sometimes not. Given these qualifications, the general pattern is that each student takes four semesters of common BME courses and two semesters of specialized BME courses. RPI is now on a pattern of mostly 4 credit hour courses.

>>
>>Of those courses, how many offer labs?
**Again, the common core makes a difference. There is one BME lab course in the senior year and an elective in the first year.
>>
>>How many BME courses does RPI require for a BS in Biomedical
>>Engineering?
**See above
>>
>>How many undergrad BME courses are dedicated to Biomedical Engineering
>>Design?
**One course
>>
>>Does the BME dept offer internships to undergrads?
**Occasionally. Also, some students take co-op assignments in industry.
>>
>>If so, what % of undergrads are involved with internships?
**A small percentage. About 15-20% do co-ops.
>>
>>Does the BME Dept. offer independent studies?
**Yes, and this is used by perhaps 20% of students for undergraduate research -- an elective.

>>
>>Is the BME dept. affiliated with (a) hospital(s)?
**Yes.
>>
>>If so, how?
** The second life science course taken by undergraduates is taught at Albany Medical College.
>>
>>What % of BME graduates go on to medical school?
** About 20% go to medical school or one of the other clinical professions.
>>
>>What % of graduates go on to graduate school (M.S., Ph.D.)?
**About 60%
>>
>>What % of graduates go into industry?
**About 20%
>>
>>If you have any questions about this project, please feel free to email
>>myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
>>corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
>>Thanks for your time!
>>
>> Christopher Wilson
>>
>
>Robert L Spilker, Sc. D. Voice: 518-276-2154
>Professor and Chair Fax: 518-276-3035
>Dept of Biomedical Engineering Email: spilker@rpi.edu
>Rensselaer Polytechnic Institute http://www.rpi.edu/~spilker
>110 8th Street
>Troy NY 12180-3590
Lee E. Ostrander, Ph.D.
Biomedical Engineering Department
Tel: (518)276-6293 Fax: (518)276-3035 email: ostral@rpi.edu

## Chris Wilson

**From:** Edward F. Leonard <leonard@columbia.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Cc:** faq <ddw14@columbia.edu>; <jl432@columbia.edu>
**Sent:** Monday, January 04, 1999 7:12 AM
**Subject:** Re: project

At 11:43 PM 1/3/99 -0500, you wrote:
>Prof Leonard-
> I am a junior at WPI studying biomedical engineering. As part of
>a project, I am researching current trends in undergraduate biomedical
>engineering education; my project partner and I would appreciate any help
>you could give on answering the following questions about BME at Columbia:
>
>What is the current undergraduate enrollment in the BME program?

Only juniors and seniors declare their majors at Columbia. We are in a period of rapid expansion. 24 Seniors. 36 Juniors, estimate up to 50 sophomores will declae this year, but that is perhaps a high estimate.
>
>What % of BME graduates go on to medical school?

about 45% (subjective estimate. More talk of it than do it.)
>
>What % go on to an M.S. or Ph.D. program? About 25% in BME. Some others in cognate areas: public health, allied health sciences, etc.
>
>What % go into industry? About 25-30%
>
>What % of BME undergrads participate in the internship program?

Also a changing statistic. Overall, about 40-50% but this includes many who "volunteer" in medical research laboratories. We are working hard to raise industrial and paid internships from about 20% to at least 40% this year. We think it should be 50%

>
>Is the BME department affiliated with (a) hospital(s)?

Not juridically. In fact we interact strongly with our own (Columbia-Presbyterian) medical center and affiliated hospitals.
>
>If so, how?
>
>Research collaboration, experiments for undergraduate courses, faculty teaching participation.

>If you have any questions about this project, please feel free to email
>myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
>corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
>Thanks for your time!
>
> Christopher Wilson
>
>
>

## Chris Wilson

**From:** Kelley, Benjamin S. <kelley_bs@mercer.edu>
**To:** 'Chris Wilson' <chrisgw@WPI.EDU>
**Sent:** Monday, January 11, 1999 2:25 PM
**Subject:** RE: project

Benjamin S. Kelley, Ph.D., P.E.
Acting Dean, Mercer Univ. School of Engineering
(912) 752-2459 Macon, GA 31207

----Original Message----
From: Chris Wilson [mailto:chrisgw@WPI.EDU]
Sent: Monday, January 11, 1999 12:54 PM
To: Kelley_BS@ACADMN.MERCER.EDU
Subject: project

Prof Kelley-
I am a junior at WPI studying biomedical engineering. As part
of
a project, I am researching current trends in undergraduate biomedical engineering education; my project partner and I would appreciate any
help
you could give on answering the following questions about BME at Mercer:

What is the current undergrad enrollment in the BME program at Mercer?
About 115

How many (if any) of the undergraduate courses are dedicated to BME design?
Two are dedicated to design, but all have a design content.

How much and what kind of lab space is available to undergrad BME students?
There are two primary BME educational labs, one dealing with bioinstrumentation and the other of a more general nature. Students may also use these two labs, along with other labs for their senior design projects.

Does the BME dept offer internships to undergrads?
The department per se does not offer internships, but through our co-op and placement office, internships, co-op positions and other experiential learning opportunities are available to BME students.

If so, what % of undergrads participate in the internship program?
I would estimate that about 25% of our students take advantage of these opportunities.

Is the BME dept affiliated wiht (a) hospital(s)?
On an informal basis we have a relationship with the Medical Center of Central Georgia and the Mercer University School of Medicine.

If so, how?
We have two standing co-op slots at the Medical Center of Central Georgia and their physicians and technical staff have been the client to numerous senior design projects.

What % of BME graduates go on to medical school?
About 20%

What % go on to an M.S. or Ph.D. program?
About 30%

What % go into industry?
About 40%

If you have any questions about this project, please feel free to email myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
Thanks for your time!

Christopher Wilson

## Chris Wilson

**From:** Michael D. Nowak <nowak@mail.hartford.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Sent:** Monday, January 11, 1999 3:29 PM
**Subject:** Re: project

-----Original Message-----
From: **Chris Wilson** <chrisgw@WPI.EDU>
To: nowak@mail.hartford.edu <nowak@mail.hartford.edu>
Date: **Monday, January 11, 1999 12:05 PM**
Subject: project

>Prof. Nowak-
> I am a junior at WPI studying biomedical engineering. As part of
>a project, I am researching current trends in undergraduate biomedical
>engineering education; my project partner and I would appreciate any help
>you could give on answering the following questions about BME at
>University of Hartford:
>
>What is the current undergraduate enrollment in the BME program? 23
>
>How many full-time faculty are part of the BME dept? There are three full
time faculty, shared by other Engineering Departments
>
>What % of BME graduates go on to medical school? 0 (but some current
students plan to do so)
>
>What % go on to an M.S. or Ph.D. program? 90%
>
>What % go into industry? 10%
>
>Is the BME dept affiliated with (a) hospital(s)? Univ. of Conn. Health
Center, Hartford Hospital, Connecticut Children's Hospital
>
>If so, how? Placement of students to perform senior undergraduate
research.
>
>
>If you have any questions about this project, please feel free to email
>myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
>corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
>Thanks for your time!
>
> Christopher Wilson
>
>
>

## Chris Wilson

**From:** Jerome S Schultz <jssbio+@pitt.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Sent:** Monday, January 11, 1999 8:02 PM
**Subject:** Re: project

Chris,

Here is some information on our Department. Our Department just started an undergraduate 2 years ago, so we don't have a lot of experience in some areas.

Jerome S. Schultz
Chairman, Department of Bioengineering
Director, Center for Biotechnology and Bioengineering
University of Pittsburgh
300 Technology Drive
Pittsburgh PA 15219
Phone: 412-383-9700
Fax: 412-383-9710

On Mon, 11 Jan 1999, Chris Wilson wrote:

> Dr. Shultz-
> I am a junior at WPI studying biomedical engineering. As part of
> a project, I am researching current trends in undergraduate biomedical
> engineering education; my project partner and I would appreciate any help
> you could give on answering the following questions about BME at
> Pittsburgh:
>
> What is the current undergraduate enrollment in the BME program?
Our program is Bioengineering not Biomedical Engineering. Thus some students can take electives in biotechnology.

We currently have 30 students per year and expect to grow to 50 seniors per year.
>
> How many full-time faculty are part of the BME dept?
>
Currently we have 3 full time and 12 part time faculty. We expect to grow to 10 full time faculty.

> Does the BME dept at Pittsburgh offer independent studies to undergrads?
Yes all students are required to take at least one course (3 credits) of an internship with one of the faculty.

>
> Is the BME dept affiliated with (a) hospital(s)?
>
Yes

> If so, how?
>
About 2/3 of our bioengineering faculty have tenure-track appointments in the clinical departments of the medical school/hospital.

> What % of BME graduates go on to medical school?
No graduates yet, we expect it to be 1/3
> What % go on to an M.S. or Ph.D. program?
>
We expect it to be 1/3
> What % go into industry?

>
We expect it to be 1/3
> If you have any questions about this project, please feel free to email
> myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
> corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
> Thanks for your time!
>
> Christopher Wilson
>
>
>

## Chris Wilson

**From:** <PPTarjan@aol.com>
**To:** <chrisgw@WPI.EDU>
**Cc:** <Oozdamar@miami.edu>; <Sperdomo@miami.edu>
**Sent:** Monday, January 11, 1999 10:06 PM
**Subject:** Re: project

In a message dated 1/11/99 8:04:44 PM Eastern Standard Time, chrisgw@WPI.EDU writes:

<< How many undergrad BME courses include or are laboratories?
There are at least four courses with dedicated lab activities: A course in optics and lasers, BME Measurements, Senior Design 1 and 2.

How much and what kind of lab space is available to undergrad BME students?

We have one dedicated u.g. lab, it is about 700 ft2. It has benches, lockers, it can be used for informal lectures. It is well equipped with computers and electronic instrumentation. They also work in various research labs, such as the Neuro Engineering, Tissue Eng., Cardiovascular Hemodynamics Lab, Optics, etc.

Does Miami offer internships to BME undergrads?

We try and we have a proposal pending at The Whitaker to expand it.

If so, what percentage of BME undergrads participate in the internship program?

It depends on how you count them. During the academic year we may have one or two students per year, that amounts to about 2-3% of our juniors and seniors. However, many take summer internships. Those may amount to 20%.

Is the BME dept affiliated with (a) hospital(s)?
Yes, we are part of the U. of Miami and we have close ties with Jackson Memorial Hospital which is the county hospital under the management of the UM School of Medicine. We also have ties with Miami Children's Hospital and the local VA, among others.

If so, how? Students often work on projects at the Med. School. They may be short-term or take as long as a year. We have had a series of students work on Extracorporeal Membrane Oxygenator related projects at MCH. We have undergraduate outings to visit the cardiac cath lab and other facilities, including the Miami Project to Cure Paralysis, at the UM Medical Campus, where they work with spinal cord injured subjects.

What % of BME graduates go on to medical school?
I don't know from year to year, but it came down from 80% in 1993 (4 of 5) to something like 20% in more recent years as our program changed from a medical school feed program to a full-blown BME program for people who want to be engineers.

What % go on to an M.S. or Ph.D. program?

I'd say that half of them go on to an M.S. We are too young to have PhDs among our graduates. The first class graduated in 1993, only 5 years ago.

What % go into industry?

The rest.

If you want more official numbers than mine, please, contact either Dr.

Ozdamar or Ms. Perdomo.

Best wishes,

Peter Tarjan

P.S. If you produce a report on your survey, I'd appreciate receiving a copy of it.
>>

## Chris Wilson

**From:** Richard L. Magin <rmagin@uic.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Sent:** Tuesday, January 12, 1999 7:59 PM
**Subject:** Re: project

Chris:
Here are some responses to your questions.

At 01:06 PM 1/12/99 -0500, you wrote:
>Prof Magin-
> I am a junior at WPI studying biomedical engineering. As part of
>a project, I am researching current trends in undergraduate biomedical
>engineering education; my project partner and I would appreciate any help
>you could give on answering the following questions about BME at UIC:
>
>How much and what kind of lab space is available to undergraduate BME
>students? 4 labs, 1500 sq. ft.
>
>Is UIC's BME dept. affiliated with (a) hospital(s)? Yes, the UIC hospital
is part of the UIC medical school.
>
>If so, how? Faculty can have cross campus appointments. About half of
the bioE faculty have their primary appointments in medical departments.
Many of the BioE faculty have adjunct appointment in the medical school.
>
>What % of BME graduates go onto medical school? 5-10
>
>What % pursue graduate school (M.S. or Ph.D.)? 50
>
>What % go straight into industry? 50
>
>If you have any questions about this project, please feel free to email
>myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
>corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
>Thanks for your time!
>
> Christopher Wilson
>

Richard L. Magin, Professor and Head
Bioengineering Department (MC 063)
University of Illinois at Chicago
851 South Morgan Street, Room 212
Chicago, Illinois 60607-7052
(312) 996-2335
(312) 996-5921 Fax

## Chris Wilson

**From:** Corrine Bahr <corrine@engr.wisc.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Sent:** Wednesday, January 20, 1999 1:52 PM
**Subject:** Re: project

Chris, The biomedical engineering degree program at the University of Wisconsin is new. The B.S. and Ph.D. programs just started Fall 1998. The M.S. was reactivated Fall 1997. We don't have a lot of statistics for you. I will provide as much as I can in your message below. We also have a website that provides additional information about the BME program at the UW. http://www.engr.wisc.edu/interd/bme/

Corrine Bahr
Assistant to the Chair
Biomedical Engineering
University of Wisconsin
1513 University Ave. #456
Madison, WI 53706-1572

At 11:19 AM 1/20/99 -0500, you wrote:
>To the BME Chairperson-
> I am a junior at WPI studying biomedical engineering. As part of
>a project, I am researching current trends in undergraduate biomedical
>engineering education; my project partner and I would appreciate any help
>you could give on answering the following questions about BME at
>University of Wisconsin-
>
>What is the current enrollment in the undergraduate BME program?
24
>
>How much and what kind of lab space is available to undergrads?
We are currently setting up the labs.
A new building is going to be built within the next three years that will house the BME department and will provide lab space for undergrad and graduate students.

>What % of undergrads participate in the internship program?>
Since we are so new, we do not have any students participating right now.

>Is the BME dept affiliated with (a) hospital(s)?
Yes, the University of Wisconsin hospital and clinics (Clinical Science Center).
>
>If so, how?
The Biomedical Engineering degree program fosters interdisciplinary engineering research in medicine and biology that involves faculty from theCollege of Engineering, the Medical Science Center, and the Clinical Science Center. We have 35 professors affiliated with the BME program.
>
>What % of BME graduates go on to medical school?
Right now we do not have any.
>
>What % go on to other graduate strudies (M.S. or Ph.D.)?
We don't have a track record to respond to this question.
>
>What % go straight into industry?
No track record to respond.
>
>If you have any questions about this project, please feel free to email
>myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
>corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
>Thanks for your time!

## Chris Wilson

**From:** Debbie Lockledge <lockledge@ie.tamu.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Sent:** Wednesday, January 20, 1999 2:36 PM
**Subject:** Re: project

I'd be glad to. My answers follow your questions. Holler back if you have additional ones. Good luck with your project!!! -DLL

At 10:24 AM 1/20/1999 -0500, you wrote:
>Mrs. Lockledge-
> I am a junior at WPI studying biomedical engineering. As part of
>a project, I am researching current trends in undergraduate biomedical
>engineering education; my project partner and I would appreciate any help
>you could give on answering the following questions about BME at Texas
>A&M:
>
>What is the current enrollment in the undergrad BME program?

You didn't specify graduate or undergraduate so I'll answer both. We have approximately 550 undergraduates and 75 graduate students
>
>How many BME courses are required for the BME B.S.?

We require many courses that are not specifically BME courses, but I am leaving those out because you specified BME courses. We have 11 BME courses required in our curriculum. Students routinely take additional BME courses as part of 18 technical elective credits they must have to graduate. Supporting courses required in this major include courses in electrical engineering, mechanical engineering, physiology, math, physics, statistics, chemistry and general engineering.
>
>How many of the undergrad BME courses include or are a laboratory?

Of the 11 BME courses, 2 have a laboratory component. Many of the supporting courses include laboratory components as well.
>
>Are there "tracks" (coursework that is focused in one area of BME) within
>the biomedical engineering program?

The technical elective component of our curriculum, comprised of 18 credit hours, has tracks that a students can choose from.
>
>What % of undergrads participate in the internship program?

If co-op is included, at least 50% of our students participate. We have a large pre-med group, and these typically do not co-op.
>
>Does the BME dept offer independent studies to undergrads?

Absolutely! Students can register for independent study with one of our professors, or even professors outside the program, and use those credits toward their technical elective requirement. Independent studies is an excellent stepping stone to graduate school, so our students are encouraged to participate in this.
>
>Is the BME dept affiliated with (a) hospital(s)?

No, there is no official affiliation. However, one of our courses is taught by a full-time hospital clinical engineering at the local hospital here. The course is taught at the hospital and gives students an excellent view of "where the rubber meets the road" in this major, especially for those wanting to take the clinical track.

>
>If so, how?
>
>What % of graduates from the BME program go on to medical school?

1/3 go to industry, 1/3 go to medical school, and 1/3 go to graduate school.
>
>What % go on to other graduate work (M.S. or Ph.D.)?

See above.
>
>What % go straight into industry?

See above.
>
>If you have any questions about this project, please feel free to email
>myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
>corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
>Thanks for your time!
>
> Christopher Wilson

Chris,

Hope this information helps. If you come up with additional questions as your project progresses, I'll be happy to address them. Good luck!!

Debbie L. Lockledge '82
Academic Advisor
Biomedical Engineering Program
Texas A&M University
(409) 847-8509

## Chris Wilson

**From:** Eric J. Guilbeau <eric.guilbeau@asu.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Sent:** Thursday, January 28, 1999 8:50 PM
**Subject:** Re: project

Chris, The site visit is over and it went well. Thanks for your patience.
Please see my answers in CAPs below. thanks, Eric

>Prof. Guilbeau-
> I'm just reminding you of the email I sent a couple weeks ago on your
>undergrad BME program. I would appreciate any help you could give!
>
> -chris wilson
>
>Eric J. Guilbeau wrote:
>>
>> Chris, I will be pleased to reply but I am currently preparing for a big
>> site visit for a grant. After the site visit scheduled for Jan. 25th I
>> will respond. Please send me a reminder. thanks, eric
>>
>> >Prof Guilbeau:
>> > I am a junior at WPI studying biomedical engineering. As part of
>> >a project, I am researching current trends in undergraduate biomedical
>> >engineering education; my project partner and I would appreciate any help
>> >you could give on answering the following questions about BME at Arizona
>> >State:
>> >
>> >How man undergraduate BME courses does ASU offer?
>>
WE HAVE 18 COURSES LISTED AS UNDERGRADUATE COURSES IN BME.
>
>> >How many of those courses are dedicated to BME design?

TWO OF THESE 18 COURSES ARE 100% DESIGN. AT LEAST THREE OTHERS HAVE SIGNIFICATN DESIGN COMPONENTS. IN ADDITION THERE ARE TWO ENGINEERING CORE CLASSES THAT ARE DESIGN COURSES.
>> >
>> >How many undergrad BME courses include or are laboratories?

THREE BME COURSES HAVE THREE HOUR LABORATOIES. ONE COURSE HAS A SIX HOUR LABORATORY EXPERIENCE.
>> >
>> >How much and what kind of lab space is available to undergrad BME
>> >students?

BME HAS A TOTAL OF 21,000 SQUARE FEET OF COURSE. OF THIS, ABOUT 2000 SQUARE FEET IS DEDICATED TO INSTRUCTIONAL LABS FOR UNDERGRADUATES.
>> >
>> >Does ASU offer internships to BME undergrads?

YES, WE HAVE A WHITAKER FUNDED INTERNSHIP PROGRAM.
>> >
>> >If so, what percentage of BME undergrads participate in the internship
>> >program?

IN THE LAST THREE YEARS, 41 STUDENTS HAVE HAD INTERNSHIP EXPERIENCES AT 19 DIFFERENT COMPANIES.
>> >
>> >Does the BME dept at ASU offer Independent Studies to undergrads?

YES.
>> >

>> >Is the BME dept affiliated with (a) hospital(s)?

NOT OFFICIALLY. WE DO HAVE SIGNIFICANT COLLABORATIONS IN RESEARCH WITH CLINICIANS AND SCIENTISTS AT LOCAL HOSPITALS AND MEDICAL CENTERS LIKE THE MAYO CLINIC SCOTTSDALE AND THE BARROW NEUROLOGICAL INSTITUTE.
>> >
>> >If so, how?
SEE ABOVE.
>> >
>> >What % of BME graduates go on to medical school?
17%
>> >
>> >What % go on to an M.S. or Ph.D. program?

27%
>> >
>> >What % go into industry?
40%
>> >
>> >If you have any questions about this project, please feel free to email
>> >myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
>> >corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
>> >Thanks for your time!
>> >
>> > Christopher Wilson
>>
>> Eric J. Guilbeau, Ph.D.
>> Chair, Department of Chemical, Bio & Materials Engineering
>> Arizona State University
>> Tempe, Arizona 85287-6006
>> Phone: (602)965-3676
>> FAX: (602)965-0037

Eric J. Guilbeau, Ph.D.
Chair, Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, Arizona 85287-6006
Phone: (602)965-3676
FAX: (602)965-0037

## Chris Wilson

**From:** Steve Schreiner, Ph.D., P.E. <sschrein@wnec.edu>
**To:** 'Chris Wilson' <chrisgw@WPI.EDU>
**Sent:** Tuesday, February 02, 1999 9:13 AM
**Subject:** RE: project

Chris:

Here is your survey, sorry it took longer than I promised.

The program is changing significantly this year and the survey reflects these changes (the current Western New England catalogue is not up to date), except for the historical information.

Best wishes, and please keep me informed of the results.

Steve Schreiner, Ph.D., P.E.
Coordinator, Biomedical Engineering Program
Western New England College
413.782.1727 Office
413.782.1258 Laboratory
413.796.2116 Fax

On Tuesday, January 12, 1999 1:17 PM, Chris Wilson [SMTP:chrisgw@WPI.EDU] wrote:
> Dr. Masi-
> I am a junior at WPI studying biomedical engineering. As part of
> a project, I am researching current trends in undergraduate biomedical
> engineering education; my project partner and I would appreciate any help
> you could give on answering the following questions about BME at WNEC:
>
> What is the current undergraduate enrollment in the BME program? 20
>
> How many full-time faculty are part of the BME dept. at WNEC? 3 (not including a new hire next Fall)
>
> How many undergraduate BME courses does the dept offer? 8
>
> How many BME courses are required for a BME degree? 7
>
> How many undergrad courses are dedicated to BME design? 5; 4 required
>
> How many BME courses include or are laboratories? 3
>
> How much and what kind of lab space is available to BME undergrads? 550 sq ft dry; 1000 sq ft wet; Plus all ME & EE & IE labs are open to all engineering students about 12,000 sq ft in addition to BME engineering labs.
>
> Does the BME dept offer independent studies to undergrads? Yes
>
> Does the BME dept offer internships to undergrads? Yes
>
> If so, what % of students participate in such a program? It has been 100 % (required component)
>
> Is the BME dept affiliated with (a) hospital(s)? Yes – Baystate Medical Center, Mercy Hospital, and Shriners Hospital for Children
>
> If so, how? Research Internships, Projects, Paid Internships.
>
> What % of BME graduates go on to medical school? < 1%
>

> What % go onto graduate studies (M.S. or Ph.D.)? 15 % (full time)
although most go on to at least an MS part time
>
> What % go straight into industry? 84%
>
> If you have any questions about this project, please feel free to email
> myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
> corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
> Thanks for your time!
>
> Christopher Wilson
>

## Chris Wilson

**From:** Gassert John <gassert@msoe.edu>
**To:** <chrisgw@WPI.EDU>; <kohles@WPI.EDU>
**Sent:** Tuesday, February 02, 1999 12:37 PM
**Attach:** gassert.vcf
**Subject:** project

Christopher:

I received the following from "Prof. Ray W. Palmer" <Palmer@admin.msoe.edu> at Milwaukee School of Engineering and he asked me to reply. Additional information is available at www.msoe.edu. If you have any more questions about our undergraduate BE program or about our Master of Science in Perfusion, please let me know.

John Gassert, P.E., Ph.D.
Professor Biomedical Engineering
Vice-Chairman EECS Department

>------ Forwarded Message Follows ------
>Date: Mon, 01 Feb 1999 14:32:50 -0500
>From: Chris Wilson <chrisgw@WPI.EDU>
>To: palmer@msoe.edu
>Subject: project
>
>Prof Palmer-
> I am a junior at WPI studying biomedical engineering. As part
>of a project, I am researching current trends in biomedical engineering

>education; I would appreciate any help you could give in answering the
>following questions about the undergraduate BME program at MSOE:
>
>What is the current undergrad BME enrollment?
101 BE students
>How many full-time faculty does the BME Dept. have?
7
>How many undergrad courses are designated BME?
22
>How many BME courses are required for the the B.S. BME degree?
20
>How much and what kind of BME lab space is available to undergrads?
all labs are undergraduate, there is one lab specifically for BE students
>How many undergrad classes are dedicated to BME design?
Design project begins in freshman year with five courses specifically designated for design.
>How many of the undergrad BME courses include or are a lab?
15
>Does the engineering dept. offer internships for BME's?

Currently there is no formal program but internships are available.
Students are allowed to take an internship elective in their senior
year.
>Are internships required?
No.
>What % of BME students are involved with intenships?
>
>Does the BME Dept. offer independent studies to BME undergrads?
One undergraduate independent study course is allowed as an elective.
>Is the BME dept. affiliated with (a) hospital(s)?
Yes.
>If so, how?
MS Perfusion Program, Clinical Engineering Internships.
>Does the BME program have "tracks" (i.e. course paths of traditional
>engineering disciplines, etc.)? If so, what are those tracks?
No, there is a specific curriculum for the BE students.
>What % of BME graduates go one to medical school?
Less than 5%
>What % of graduates go on to graduate school (M.S. or Ph.D.)?
about 50%
>What % of graduates go into industry?
about 50%

>If you have any questions about this project, please feel free to email

>myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
>corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).

>Thanks for your time!
>
> Christopher Wilson

## Chris Wilson

**From:** Mary Verstraete <mary@brain.biomed.uakron.edu>
**To:** <chrisgw@WPI.EDU>
**Sent:** Thursday, January 21, 1999 2:55 PM
**Subject:** Re: project (fwd)

> --------- Forwarded message ---------
> Date: Wed, 20 Jan 1999 10:08:18 -0500 (EST)
> From: Chris Wilson <chrisgw@WPI.EDU>
> To: stan@biomed.uakron.edu
> Subject: project

Chris,

Glad to hear of your interest. I'm responding, as I am the Department Chair and recently looked into several of these same issues prior to the development of our new undergradaute program just last year. If you would be interested in that data, just let me know and I will mail it to you.

>
> Prof Rittgers-
> I am a junior at WPI studying biomedical engineering. As part of
> a project, I am researching current trends in undergraduate biomedical
> engineering education; my project partner and I would appreciate any help
> you could give on answering the following questions about BME at the
> University of Akron::
>
> What is the current undergraduate BME enrollment?

We just offered our first freshman class last fall and 12 were enrolled. This semester 23 are enrolled, 9 are sophomores, the rest freshmen.

>
> How much and what kind of lab space is available to undergrad BME
> students?
>
We just completed our undergraduate computer lab for classroom and individual student use. We will be using research labs in conjunction with several undergraduate classes, Bioinstrumentation, Imaging Detectors and Sensors, Cardiovascular Dynamics, Motion Analysis, Biomechanics and rehabilitation Engineering.

> Does the BME dept offer independent studies to undergrads?
>

Not at this time.

> What % of graduates from the BME program go on to medical school?
>
>From my study, one third typically go to med school

> What % go on to othe graduate work (M.S. or Ph.D.)?
>
1/3

> What % go straight into industry?
>
1/3

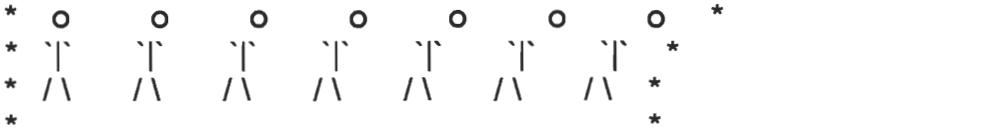
Several also go into MBA or Law programs as well

> If you have any questions about this project, please feel free to email
> myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at
> corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
> Thanks for your time!
>
> Christopher Wilson

Let me know if al can be of any further help.

McV

**********
* Mary C. Verstraete, Ph.D. Motion Analysis Laboratory *
* Dept. of Biomedical Engineering Dept. Biomedical Engineering *
* The University of Akron The University of Akron *
* Akron, OH 44325-0302 Akron, OH 44325-0302 *
* (330) 972-7691 (330) 972-5222 *
*



**********

**Chris Wilson**

**From:** Sina Y Rabbany <EGGSYR@Mail1.Hofstra.edu>
**To:** <chrisgw@WPI.EDU>
**Sent:** Friday, February 05, 1999 12:40 PM
**Subject:** project -Reply

Dear Chris,

The answer to your questions are found below:

>>> Chris Wilson <chrisgw@WPI.EDU> 02/01/99 01:37pm >>>
Dear sirs-
I am a junior at WPI studying biomedical engineering. As part of a project, I am researching current trends in biomedical engineering education; I would appreciate any help you could give in answering the following questions about the undergraduate BME-option program at Hofstra:

What is the current undergrad BME enrollment?
30 students

How many undergrad courses are designated BME?
six courses

How many of those BME courses are required for the biomedical option?
five

How much and what kind of BME lab space is available to undergrads?
teaching lab (biomedical instrumentation), research lab (biomechanics and biosensors), Ultrasound and imaging facility (under construction).

How many of the undergrad BME courses include or are a lab?
3 courses including the design component

Does the engineering dept offer internships for BME's?
Yes

What % of BME students are involved with intenships?
20% of the upperclassman

Does the engineering Dept. offer independent studies to BME undergrads?
Yes

Is the engineering dept. affiliated with (a) hospital(s)?
Not officially

If so, how?

What % of BME graduates go one to medical school?

less than 10%

What % of graduates go on to graduate school (M.S. or Ph.D.)?
20%

What % of graduates go into industry?
Not known ~ 40%
If you have any questions about this project, please feel free to email myself (at chrisgw@wpi.edu), my project partner Colleen O'Rourke (at corourke@wpi.edu), or our project advisor Sean Kohles (kohles@wpi.edu).
Thanks for your time!

Christopher Wilson

**Chris Wilson**

**From:** Steve Chamberlain <Steve_Chamberlain@isr.syr.edu>
**To:** Chris Wilson <chrisgw@WPI.EDU>
**Sent:** Friday, December 11, 1998 8:40 AM
**Subject:** Syracuse Data

Chris,

Here are the data for the undergraduate program in bioengineering at Syracuse University:

5-year summary (Classes of '94, '95, '96, '97, '98)
Optometry School 1%
Law School 1%
Dental School 3%
Medical School 6%
Graduate School 41%
Industry 48%
n = 88

Class of 1994 Optometry School 6%
Medical School 11%
Graduate School 33%
Industry 50%
n = 18

Class of 1995
Dental School 6%
Law School 6%
Medical School 12%
Graduate School 47%
Industry 29%
n = 17

Class of 1996
Medical School 7%
Graduate School 20%
Industry 73%
n = 15

Class of 1997
Dental School 10%
Graduate School 55%
Industry 35%
n = 20

Class of 1998
Graduate School 44%
Industry 56%
n = 18

In all of the above data, there are a total of 13 graduates for whom we have no information.

Hope this tells you what you want to know.

Cheers,
Steve

| **Company Profiles** | | | | | | |
|---|---|---|---|---|---|---|
| **Descriptors** | | | contacted (left message) | | contacted | |
| Name | **AbioMed** | **ACT Medical** | **Adv. Instrum.** | **AliMed** | **Boston Scientific** | **Cambridge Heart** |
| Phone | **508-777-5410** | **617-964-9100** | **617-320-9000** | **617-329-2900** | **508-650-8000** | |
| Location | 33 Cherry Hill Drive Danvers, MA 01923 | 150 California St. Newton, MA | Two Technology Way Norwood, MA 02062 | 297 High Street Dedham, MA 02026 | One Boston Scientific Place Natick, MA 01760-1537 | 1 Oak Park Drive Bedford, MA 01730 |
| Product Line | cardiac surgery products (ex: artificial heart) | catheters, irrigation devices, retrators, inflation devices | osmometers, analyzers, cryoscopes, fluorophos test systems | joint support | minimally invasive therapy | noninvasive cardiac diagnosis |
| **Personnel** | | | | | | |
| Total Employees | | | | | | 40 |
| # Engineers | | | | | | 12 |
| % Engineers | | | | | | 30% |
| % w/ U.G. Engineering Degree | all engineers | all engineers | | | all engineers | all engineers |
| # of "Biomedical" Engineers | 0 | | | | | 0 (but will hire BE if exper. In another displince (EE) as well) |
| **BME's Job** | | | | | | |
| Synthesis of Solutions | | yes | | | | |
| Analysis (qual + quant) | | | | | | yes |
| Construction | | yes | | | | yes |
| Testing | | yes | | | | yes |
| Evaluation/Interpretation | | yes | | | | yes |
| Interaction w/ Clinicians | | | | | | yes |
| Project Leadership | | yes | | | | yes |
| Marketing | | | | | | |
| Intellectual Property Law | | | | | | |
| Addressing Regulatory Issues | | | | | | |
| **Tools** | | | | | | |
| Design tools | CAE schematic capture, PC layout tools, C language, ProE, test equip. | CAD and 3D modeling tools | | | | CAD/CAM |
| Physician Partnership | yes | | | | | yes |
| Industry on Education | | yes | | | | |
| Favored Programs/Schools | | | | | | |
| Internships/Co-ops for Undergrads | | yes | | | | yes |
| **Design Training Most Valuable** | | | | | | |
| Academic | | | | | | |
| Industrial | | | | | | |
| Other | | | | | | |

| **Company Profiles** | | | | | | |
|---|---|---|---|---|---|---|
| **Descriptors** | | | | | | |
| Name | **CardioTech** | **Genzyme Tissue Repair** | **Hologic** | **Johnson&Johnson** | **Luxtec** | **Matritech** |
| Phone | | **617-252-7500** | | | | **617-928-0820** |
| Location | 11 State Street. Woburn, MA 01801 | 64 SIDNEY STREET CAMBRIDGE, MA 02139 | 590 Lincoln St. Waltham, MA 02451 | 1 Johnson&Johnson Plaza New Brunswick, NJ 08933 | 326 Clark Street Worcester, MA 01606-1215 | 330 Nevada St. Newton, MA 02160 |
| Product Line | small bore vascular graft devices | cell therapy products for knee injuries, neurodegenerative diseases, and severe burns | x-ray and ultrasound bone analyzer systems | endoscopic surgery, health care | specialty med. Devices (ill. Telscopes, surgical endoscopes) | innovative cancer diagnostic products |
| **Personnel** | | | | | | |
| Total Employees | | | 165 | | | 50 |
| # Engineers | | | | | | |
| % Engineers | | | | | | |
| % w/ U.G. Engineering Degree | | all engineers | | | | |
| # of "Biomedical" Engineers | | | | | No BE's | 0 |
| **BME's Job** | | | | | | |
| Synthesis of Solutions | | yes | | yes | | |
| Analysis (qual + quant) | | yes | yes | yes | | |
| Construction | | yes | | yes | | |
| Testing | | yes | yes | | | |
| Evaluation/Interpretation | | | | | | |
| Interaction w/ Clinicians | | | | | | |
| Project Leadership | | yes | | yes | | |
| Marketing | | | | | | |
| Intellectual Property Law | | | | | | |
| Addressing Regulatory Issues | | | | | | |
| **Tools** | | CAD | C, C++ lang., Lab View, MFC, Microsoft Visual C++, DICOM, HL-7 | PLC?, AutoCAD | | |
| Design tools | yes | | | yes | | |
| Physician Partnership | | | | yes | | yes |
| Industry on Education | | | | | | |
| Favored Programs/Schools | | | | no (for grads) | | |
| Internships/Co-ops for Undergrads | | | | | | |
| **Design Training Most Valuable** | | | | | | |
| Academic | | | | | | |
| Industrial | | | | | | |
| Other | | | | | | |

| **Company Profiles** | | | | | |
|---|---|---|---|---|---|
| **Descriptors** | | | | | |
| Name | **Medtronic Cardiovascular** | **Mitek Products** | **Organogenesis** | **Smith+Nephew Endoscopy** | |
| Phone | **508-777-0042** | | | **508-749-1000** | **<-wrong #?** |
| Location | 37A Cherry Hill, Danvers, MA | 60 Glacier Drive Westwood, MA 02090 | 150 Dan Road Canton, MA 02021 | 160 Dascomb Rd. Andover, MA 01810 | |
| Product Line | implantable and interventional therapies | innovative medical devices for surgery, with focus on sports medicine and reconstruction | living tissue replacements, cell-based organ assist devices, tissue-engineered products | arthroscopy, visualization, and minimally-invasive surgery | |
| **Personnel** | | | | | |
| Total Employees | | 270 | 185 | | |
| # Engineers | | 24 | | | |
| % Engineers | | 9% | | | |
| % w/ U.G. Engineering Degree | | all engineers 9% | | | |
| # of "Biomedical" Engineers | | 2 | | | |
| **BME's Job** | | | | | |
| Synthesis of Solutions | | yes | | | |
| Analysis (qual + quant) | | yes | yes | | |
| Construction | yes | | yes | | |
| Testing | | | yes | | |
| Evaluation/Interpretation | | yes | yes | | |
| Interaction w/ Clinicians | | | | | |
| Project Leadership | yes | yes | | | |
| Marketing | | | | | |
| Intellectual Property Law | | | | | |
| Addressing Regulatory Issues | | | | | |
| **Tools** | C/C++ lang.,circuit emulators-simulators, Hspice, Cadence | AutoCAD, Pro Engineer | | | |
| Design tools | yes | yes | | yes | |
| Physician Partnership | yes | no | | | |
| Industry on Education | | | | | |
| Favored Programs/Schools | yes (summer) | no fomal thing: summer positions possible | | | |
| Internships/Co-ops for Undergrads | | | | | |
| **Design Training Most Valuable** | | | | | |
| Academic | | | | | |
| Industrial | | | | | |
| Other | | | | | |

| **Company Profiles** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Descriptors** | | | | | | tried | | |
| Name | **Medical Industry Technology** | **Microwave Medical** | **Performance Surg. Instrum.** | **Siemens Medical** | **Surginsedex** | **Caldio Vascular Instr. Corp** | **New England Surg. Instr. Corp.** | **Solartron Instr. Schlumberger** |
| Phone | | | | **508-750-6300** | | **617-245-7799** | | |
| Location | 195 Falmouth Rd. Hyannis, MA 02601 | Acton, MA | 40 Norfolk Ave South Easton, MA 02375 | Danvers, MA | 3 Industrial Park Rd Medway, MA 02053 | 134 Water St. Wakefield, MA 01880 | 83 E. Water St. Rockland, MA 02370 | 20 North Ave Burlington, MA 01803 |
| Product Line | | medical hardware | | | | | | |
| **Personnel** | | | | | | | | |
| Total Employees | | | | | | | | |
| # Engineers | | 8 | | | | | | |
| % Engineers | | | | | | | | |
| % w/ U.G. Engineering Degree | | 100 | | | | | | |
| # of "Biomedical" Engineers | | 1 | | | | | | |
| **BME's Job** | | | | | | | | |
| Synthesis of Solutions | | Y | | | | | | |
| Analysis (qual + quant) | | Y | | | | | | |
| Construction | | | | | | | | |
| Testing | | | | | | | | |
| Evaluation/Interpretation | | | | | | | | |
| Interaction w/ Clinicians | | Y | | | | | | |
| Project Leadership | | | | | | | | |
| Marketing | | Y | | | | | | |
| Intellectual Property Law | | | | | | | | |
| Addressing Regulatory Issues | | Y | | | | | | |
| **Tools** | | | | | | | | |
| Design tools | | AutoCAD, | | | | | | |
| Physician Partnership | | Y | | | | | | |
| Industry on Education | | | | | | | | |
| Favored Programs/Schools | | | | | | | | |
| Internships/Co-ops for Undergrads | | Y | | | | | | |
| **Design Training Most Valuable** | | | | | | | | |
| Academic | | | | | | | | |
| Industrial | | | | | | | | |
| Other | | | | | | | | |

| **Company Profiles** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Descriptors** | | | | | | | | | | |
| Name | **Stryker Instr.** | **Taj Medical** | **Tekscan** | **Vista Medical Tech** | **Coopersurgical Inc** | **Wallach Surg. Devices inc** | **Atrium Medical Corp** | **Zoll** | | |
| Phone | | | | | | | **603-880-1433** | **617-229-0020** | | |
| Location | 24 Pilgrim Rd. Wellesley, MA 02181 | 251 Tremont St. Duxbury, MA 02332 | | | 15 Forest Pkwy Shelton, CT 06484 | 291 Pepes Farm Rd. Milford, CT 06460 | 5 Wentworth Drive Hudson, NH 03051 | Burlington, MA | | |
| Product Line | | | | | | | | defribrillators, patient monitoring | | |
| **Personnel** | | | | | | | | | | |
| Total Employees | | | | | | | | | | |
| # Engineers | | | | | | | | 35 | | |
| % Engineers | | | | | | | | | | |
| % w/ U.G. Engineering Degree | | | | | | | | 100 | | |
| # of "Biomedical" Engineers | | | | | | | | 6 | | |
| **BME's Job** | | | | | | | | | | |
| Synthesis of Solutions | | | | | | | | | | |
| Analysis (qual + quant) | | | | | | | | | | |
| Construction | | | | | | | | | | |
| Testing | | | | | | | | | | |
| Evaluation/Interpretation | | | | | | | | | | |
| Interaction w/ Clinicians | | | | | | | | Y | | |
| Project Leadership | | | | | | | | Y | | |
| Marketing | | | | | | | | | | |
| Intellectual Property Law | | | | | | | | | | |
| Addressing Regulatory Issues | | | | | | | | | | |
| **Tools** | | | | | | | | | | |
| Design tools | | | | | | | | CAD, simulations, data recording | | |
| Physician Partnership | | | | | | | | Y | | |
| Industry on Education | | | | | | | | | | |
| Favored Programs/Schools | | | | | | | | | | |
| Internships/Co-ops for Undergrads | | | | | | | | no, summer maybe | | |
| **Design Training Most Valuable** | | | | | | | | | | |
| Academic | | | | | | | | | | |
| Industrial | | | | | | | | | | |
| Other | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | BE's are primarily product developers. | | |
| | | | | | | | | Donald Boucher | | |
| | | | | | | | | VP R&D | | |
| | | | | | | | | MS Biomedical Engineering | | |
| | | | | | | | | Product Development | | |

| **Company Profiles** | | | | | |
|---|---|---|---|---|---|
| **Descriptors** | | phone not in service | | chris whalen... message | |
| Name | **Integrated Med. Devices** | **Apple Medical Corp** | **Gerard Medical Inc** | **Ranfac Corp** | **Holmed Corp** |
| Phone | | **508-779-2926** | | **508-588-4400** | **508-238-3351** |
| Location | 120 E. Washington Street, Suite 100 Syracuse, New York 13202 | 580 Main Street Bolton, MA 01740 | 6 City Depot Rd. Medway, MA 01507 | Avon Industrial Park Avon, MA 02332 | 40 Norfolk Ave South Easton, MA 02375 |
| Product Line | cardiac event detection (arrhythmia monitoring), and pacemaker follow-up equipment | | | | don't use BE's |
| **Personnel** | | | | | |
| Total Employees | | | | | |
| # Engineers | | | | | |
| % Engineers | | | | | |
| % w/ U.G. Engineering Degree | | | | | |
| # of "Biomedical" Engineers | | | | | |
| **BME's Job** | | | | | |
| Synthesis of Solutions | | | | | |
| Analysis (qual + quant) | | | | | |
| Construction | | | | | |
| Testing | | | | | |
| Evaluation/Interpretation | | | | | |
| Interaction w/ Clinicians | | | | | |
| Project Leadership | | | | | |
| Marketing | | | | | |
| Intellectual Property Law | | | | | |
| Addressing Regulatory Issues | | | | | |
| **Tools** | | | | | |
| Design tools | | | | | |
| Physician Partnership | | | | | |
| Industry on Education | | | | | |
| Favored Programs/Schools | | | | | |
| Internships/Co-ops for Undergrads | | | | | |
| **Design Training Most Valuable** | | | | | |
| Academic | | | | | |
| Industrial | | | | | |
| Other | | | | | |

| functions | | | | | tools | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Development | Design | Test | Regulatory | Talk w/ Phys. | DOE | CAD | Pro E | C Pro. | Min Experience | location | DOE= Design of Experiments |
| n | y | n | n | n | y | y | y | n | 5 | CA | |
| y | y | n | y | n | n | n | n | n | 2 | CA | |
| y | y | y | n | y | n | n | n | n | 2 | CA | |
| y | y | y | y | n | n | n | n | n | 1 | MA | |
| y | y | y | n | y | n | n | n | n | N/A | IN | |
| y | y | y | y | n | y | n | n | n | 5 | CA | |
| y | y | n | y | y | n | y | n | n | 3 | IN | |
| y | y | y | y | n | n | y | n | n | 1 | NJ | |
| y | y | y | n | n | n | n | n | y | N/A | TX | |
| n | n | y | n | n | y | n | n | n | 3 | MI | |
| n | n | n | n | y | n | n | n | n | 5 | IL | |
| y | y | y | n | y | n | n | n | n | 2 | MA | |
| n | y | n | y | n | n | y | y | n | 3 | IL | |
| y | y | y | n | n | n | n | n | n | 5 | IL | |
| y | y | y | n | n | y | n | n | n | N/A | CA | |
| y | y | n | n | n | n | y | n | n | 8 | MD | |
| y | y | y | y | y | n | n | n | n | 2 | WA | |
| n | n | y | y | n | n | n | n | n | 1 | MA | |
| y | y | n | y | n | n | n | n | n | 4 | MA | |
| y | y | n | n | y | n | y | n | n | 8 | MD | |
| y | y | y | y | n | n | n | n | n | 5 | IL | |
| n | y | n | y | n | n | y | y | n | 3 | IL | |
| n | y | n | y | n | n | y | y | n | 3 | IL | |
| n | n | y | y | n | n | n | n | n | 1 | MA | |
| n | n | n | n | n | n | n | n | n | 4 | IL | Maintenance |
| y | y | y | n | n | n | n | n | n | 0 | MA | |
| y | n | n | n | n | n | n | n | n | 3 | MA | |

| functions | | | | | |
|---|---|---|---|---|---|
| Development | Design | Testing | Addressing Regulatory Issues | Direct Interaction with Physicians | Design of Experiments |
| y | y | y | y | y | y |
| y | y | y | y | y | y |
| y | y | y | y | y | y |
| y | y | y | y | y | y |
| y | y | y | y | y | n |
| y | y | y | y | y | n |
| y | y | y | y | y | n |
| y | y | y | y | n | n |
| y | y | y | y | n | n |
| y | y | y | y | n | n |
| y | y | y | y | n | n |
| y | y | y | y | n | n |
| y | y | y | y | n | n |
| y | y | y | n | n | n |
| y | y | y | n | n | n |
| y | y | n | n | n | n |
| y | y | n | n | n | n |
| y | y | n | n | n | n |
| n | y | n | n | n | n |
| n | y | n | n | n | n |
| n | y | n | n | n | n |
| n | n | n | n | n | n |
| n | n | n | n | n | n |
| n | n | n | n | n | n |
| n | n | n | n | n | n |
| n | n | n | n | n | n |
| n | n | n | n | n | n |
| 67 | 78 | 56 | 48 | 26 | 15 |

| tools | | | | | | | |
|---|---|---|---|---|---|---|---|
| Computer Aided Design | Pro E | C Programming | Min Experience | location | | DOE= Design of Experiments | |
| y | y | y | 5 | WA | w | | |
| y | y | n | 2 | TX | w | | |
| y | y | n | 2 | NJ | w | 22.22222222 | west |
| y | y | n | 1 | MD | w | | |
| y | n | n | | MD | w | | |
| y | n | n | 5 | MI | w | | |
| y | n | n | 3 | MA | s | 3.703703704 | south |
| y | n | n | 1 | MA | ne | | |
| n | n | n | | MA | ne | | |
| n | n | n | 3 | MA | ne | | |
| n | n | n | 5 | MA | ne | | |
| n | n | n | 2 | MA | ne | | |
| n | n | n | 3 | MA | ne | 37.03703704 | northeast |
| n | n | n | 5 | IN | ne | | |
| n | n | n | | IN | ne | | |
| n | n | n | 8 | IL | ne | | |
| n | n | n | 2 | IL | ne | | |
| n | n | n | 1 | IL | mw | | |
| n | n | n | 4 | IL | mw | | |
| n | n | n | 8 | IL | mw | | |
| n | n | n | 5 | IL | mw | | |
| n | n | n | 3 | IL | mw | 37.03703704 | midwest |
| n | n | n | 3 | CA | mw | | |
| n | n | n | 1 | CA | mw | | |
| n | n | n | 4 | CA | mw | | |
| n | n | n | 0 | CA | mw | | |
| n | n | n | 3 | CA | mw | | |
| 30 | 15 | 4 | 3 | | | | |

**17.0 – Appendix J**

**From:** Renee Capachione <renee@cambridgeheart.com>
**To:** 'corourke@wpi.edu' <corourke@WPI.EDU>
**Date:** Tuesday, January 12, 1999 4:05 PM
**Subject:** FW: request assistance...

Cambridge Heart, Inc.
Renée Capachione
Mgr., HR & Administrative Services
1 Oak Park Drive
Bedford, MA 01730
888-226-9283
781-271-1200, ext. 223
e-mail: renee@cambridgeheart.com

-----Original Message-----
From: Colleen [SMTP:corourke@wpi.edu] <mailto:[SMTP:corourke@wpi.edu]>
Sent: Friday, January 08, 1999 11:27 PM
To: renee@cambridgeheart.com <mailto:renee@cambridgeheart.com>
Subject: request assistance...

Colleen O'Rourke
21 Mildred Ave
Worcester, MA 01603

Phone: (508) 753-2112
E-mail: corourke@wpi.edu <mailto:corourke@wpi.edu>

Hi, my name is Colleen O'Rourke and I am a junior in Biomedical Engineering with a specialty in EE at WPI. Currently, I am researching current industrial and educational trends in biomedical engineering for a project. This project aims to explore the strengths and weaknesses of undergraduate programs across the country and how companies use biomedical engineers, particularly in the area of medical device design. Ultimately, the project will tie the two together by highlighting ways of improving WPI's BME program to meet the needs of local companies. Biomedical engineering (BME) is a somewhat elusive discipline because it is exceptionally broad and continually evolving at both the industrial and academic levels. I have checked your website and observed your annual reports as well as press releases. They helped me a great deal. Yet, I still have a few unanswered questions that I was hoping you could answer for me. I hope that Human Resources can answer these questions, or will direct them to another appropriate audience. Your response would be greatly appreciated and your questions are welcomed (my email address is included above).

1. How many of those employees are titled engineers (including all

specialties)? 12

2. How many engineers are "biomedical" engineers (if any)? 0

3. If no biomedical engineers are employed at the time, then would you hire one if he/she had the
qualifications as an electrical engineer (for example) yet with emphasis/experience in biology as well? yes

4. What is (or if you were to consider to hire) the biomedical engineer's role in medical device design at the
company?
Check all that apply.

Synthesis of solutions ?
Analysis (quantitative and/or qualitative) ? Y
Construction of Devices ? Y
Testing of Devices ? Y
Evaluation of Test Results ? Y
Interaction with Physicians/clinicians ? Y
Project Leadership ? Y

5. If your company were to consider hiring a Biomedical Engineer, what would the job
description and qualifications be?

6. Are there any degree programs (i.e. from different schools) that look better than others on a resume?

7. Does your company offer internships/co-ops to undergraduate students? Y

9. Does the company have any partnerships with physicians or hospitals for the purpose of
design evaluation/development? Y

10. What tools are used to design medical devices at the company? (e.g. computer software) CAD/CAM

I thank you for time and hope to hear your response soon.

Sincerely,

## McCarthy, Catherine [ETHUS]

**From:** Berkeley, Nancy [ETHUS]
**Sent:** Monday, January 11, 1999 10:28 AM
**To:** McCarthy, Catherine [ETHUS]
**Subject:** RE: thanks...

total ees: 270

engineers: 24

biomed degrees: 2?

no formal intern program in place; summer positions possible

we use auto cad, pro engineer, etc.

yes, we have many relationships with physicians and institutions for developing (or enhancing) products

-----Original Message-----
**From:** McCarthy, Catherine [ETHUS]
**Sent:** Monday, January 11, 1999 8:46 AM
**To:** Berkeley, Nancy [ETHUS]
**Subject:** FW: thanks...

-----Original Message-----
**From:** Colleen [SMTP:corourke@wpi.edu]
**Sent:** Saturday, January 09, 1999 9:07 PM
**To:** mitek@ethus.jnj.com
**Subject:** thanks...

I want to thank you for your time in replying to my previous e-mail on questions about your company. Yet, I was wondering if you could help me just a little bit more. I have a few more questions that should not take too much of your time (at Human Resources or appropiate audience). I would appreciate any information that you could provide regarding these questions so that this part of my project can be completed.

1. What is the total number of employees at your company

2. How many of those employees are titled engineers (including all specialties)?

3. How many engineers are "biomedical" engineers or have a degree in biomedical engineering (if any)?

4. Are there any degree programs (i.e. from different schools) that look better than others on a resume?

5. Does your company offer internships/co-ops to undergraduate students?

6. What tools are used to design medical devices at the company? (e.g. computer software)

7. Does the company have any partnerships with physicians or hospitals for the purpose of design evaluation/development?

I want to thank you for your time again. You may respond either by e-mail or by mail... whichever is at your convenience...

## McCarthy, Catherine [ETHUS]

**To:** Berkeley, Nancy [ETHUS]
**Subject:** RE: request assistance...

-----Original Message-----
**From:** Berkeley, Nancy [ETHUS]
**Sent:** Thursday, January 07, 1999 8:58 AM
**To:** McCarthy, Catherine [ETHUS]
**Subject:** RE: request assistance...

We do hire engineers - those with ME or Biomed degrees, to develop innovative devices for surgery. We use nitinol and absorbable materials in our development, so familiarity with these materials is important. Here's a sample job description:

<< File: Engineer.R&D.doc >>

-----Original Message-----
**From:** McCarthy, Catherine [ETHUS]
**Sent:** Thursday, January 07, 1999 8:54 AM
**To:** Berkeley, Nancy [ETHUS]
**Subject:** FW: request assistance...

-----Original Message-----
**From:** Colleen [SMTP:corourke@wpi.edu]
**Sent:** Wednesday, January 06, 1999 7:19 PM
**To:** mitek@ethus.jnj.com
**Subject:** request assistance...

Hi, my name is Colleen O'Rourke and I am a junior in Biomedical Engineering at WPI. I am currently working on a project that involes examining medical companies on the basis of who they hire and what they require of their employees. I can not make it out from your web page... but do you hire engineers? If so, what types? What are the job descriptions and requirements of each? If you could answer these questions... I would greatlly appreciate it. I am going to use the results to improve the current educational program at WPI so that students will be better prepared for their future careers and meet employer expectations. Thanks for your time :).
PS. - If you could send an annual report or some documented materials you may have.. that would also be great.

My address...
Colleen O'Rourke
21 Mildred Ave.
Worcester, MA 01603

Thanks, Colleen O'Rourke

MITEK PRODUCTS
ETHICON, INC., a Johnson & Johnson company

JOB DESCRIPTION

## TITLE: ENGINEER, R&D

## JOB SUMMARY STATEMENT:

The Engineer conducts assignments encompassing complete projects or portions of major projects. Determines methods and techniques to be used or adapts standard methods to meet variations. Coordinates phases of work with outside vendors or other divisional contacts. Reports to R&D Team Leader or a higher level R&D Engineer.

Candidates for the next level, Senior Engineer, must demonstrate successful accomplishments working with a high degree of independence. Candidates should be able to successfully direct and/or coordinate the activities of others assigned to assist in specified projects.

## SAFETY/ENVIRONMENTAL

Comply with all of J&J's safety and environmental rules and regulations.
Attend all safety and environmental training offered throughout the year.

## EDUCATION/TRAINING/EXPERIENCE

A BS, MS or Ph.D. degree with experience or equivalent knowledge and skills to perform the position responsibilities.

_____ _____

APPROVED DATE

C:\WINDOWS\TEMP\Engineer.RD.doc
01/07/99

## 18.0 – Appendix K



# EXPERIENCED PRODUCT DEVELOPMENT ENGINEER

**Posted Date:** 01/18/99
**Position Type:** Full-time
**Department:** Engineering
**Location:** Warsaw, Indiana

**Requirements:** Should at least have a B.S. in Mechanical Engineering or Biomedical Engineering with focus on mechanical design. We are looking for someone who has prior experience as an orthopaedic implant designer. This person should be seeking to take advantage of Biomet's unique style of engineering management. The experienced engineer would have full control of project management, product development and testing, and thrive in a fully empowered environment. The ability to work well with potential and current surgeon customers is a must. This individual would be expected to provide leadership and vision to one of our product development groups. A very exciting and challenging position.

Click here to go back to the Employment Opportunities Menu

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**Position: Project Engineer**

Genzyme

**Location:** Fall River

Submit résumé via email

**Requisition Number:**
98-0000590

Add this job to your list

**Description:**
Coordinate & execute dvlpt. programs within depts. & outside vendors; develop new & modified medical products & alert to patent possibilities; generate project budgets, time schedules, status reports; directs project & process dvlpt.; suggests & implements cost reduction programs.

**Experience/Skills Required:**
3-5 years exp. in medical devices or equipment.

**Desired Education:**
BS degree in Mechanical Engineering or Biomedical Engineering

**Please forward your résumé by postal mail or submit via email:**

Genzyme Corporation
Human Resources
One Kendall Square
Cambridge, MA
02139-1562
Attention:
INTHOME98-0000590

Please include the requisition number in your cover letter. The receipt of your résumé will be acknowledged within two

| RESEARCH ENGINEER |
| --- |
| Entry level position in biomedical research and product development to conduct experiments in the area of hepatic tissue engineering. Design, test, and troubleshoot prototypes for a liver-assist device. Primary duties to include operating perfusion devices and instrumentation to evaluate transport phenomena and cellular responses in biomedical devices. Experience with aseptic techniques, cell culture, and materials and mechanical design a plus. BS in Chemical or Bioengineering with 0-2 years experience. |
| **PART-TIME PAYROLL AND BENEFITS CLERK** |
| Candidate with organizational skills and attention to detail to assist busy Finance Department in processing of documentation for payroll and benefits administration. Must be capable of accurate input of ADP payroll for Windows software package and Stock option processing. HS diploma with knowledge of Microsoft Excel/Word required. |
| **TEMPORARY PART-TIME CLERICAL POSITION** |
| Temporary part-time clerical opportunity for detail-oriented candidate, who would like to work a 20 hour/week assignment(preferably 4 hours a day). Candidate would assist with data management activities including; processing and tracking case report forms, labeling slides, photocopying and filing edit checks and some database entry into Excel and FileMaker Pro. The need is immediate and will run through 5/28/99. |

**The future is being shaped at Organogenesis, and we want you to play a part in it. Organogenesis offers competitive salaries and benefits and a 401(k) plan. Interested candidates, please send or fax your resume to: Director of Human Resources, Organogenesis Inc., 150 Dan Road, Canton, MA 02021. Fax: (781) 575-0440**

**or send your resume via e-mail: Human-Resources@organo.com**

**No phone calls please.**

**We are an equal opportunity employer.**

---

HEWLETT PACKARD

**Title:** Customer Engineer (Medical)
**Cities:** Chicago
**States:** Illinois
**Country:** USA
**Skills/Experience:** Ability to communicate both verbally and in writing. AA degree in Electrical Technology or equivalent education and experience.
**Type:** Full-Time
**Job Number:** 642054 EventCode: 2126

**Job Description/Additional Information:**

USA-Illinois -Customer Engineer (Medical) -642054 EventCode: 2126

Repair and Maintenance of Hewlett-Packard Medical Products. Project installation and implementation management of patient care systems. Maintain effective management within assigned accounts. Maintain very high stand ards of customer satisfaction in accounts. Develop and maintain teamwork within the Service and Sales Districts. Actively pursue new support business opportunities independently and also with t he sales organizations. Work closely with sales to help them achieve their goals. Need to be strong inde pendent worker. Projects assigned by CEDM to improve district performance and productivity. Geographic location is primarily central and southern Illinois. More than 30% overnight travel is required.

Desired Skills: BS in Biomedical Engineering, Computer Science, or Electrical Technology with atleast 4 years experience preferred. Strong independent worker able to manage activities with minimal direct supervision. Strong communication skills required. Windows NT Certification, Certified Novell Engineer, Project Management Skills, strong organizational and time management skills. Previous Medical equipment repair experience is a plus. Knowledge of Microsoft Windows 95 and Windows

# Net-Temps



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**Searching For:** biomedical engineer
Enter one or more words to Narrow your Search.
Search

**Displaying Jobs 1 thru 15, of the 22 jobs currently available**

## QC/QA Engineer

**Date Posted:** Fri Feb 26 1999
**Location:** MA
**Duration:** Direct Placement
**Pay Rate:** $50-60K

**Company:** Management Recruiters, Inc., Apollo Beach
**Phone:**
**Fax:** 813-645-8678
**Email:** Dave Lowe

**Job Description:**
CONTACT INFORMATION: Please don't reply to contact information listed on this job posting, your reply won't reach the right person!!! For more information, please send resume to Garry Routh. Email: Garry@mriapollo.com ; word format preferred. Great Opportunity with a leading medical device manufacturer located on the outskirts of the Boston area. duties include: Responsible for developing quality plans, automated test equipment & procedures for the manufacturing area, with a strong focus on validation testing, rewiew and approval. Conducting failure analysis & corrective action on returned material implementation. Will interface with manufacturing, R&D, and Materials in the development of new processes & enhancements to existing products. Work as part of a team to improve product quality & customer satisfaction.

**Skills Required:**
CONTACT INFORMATION: Please don't reply to contact information listed on this job posting, your reply won't reach the right person!!! For more information, please send resume to Garry Routh. Email: Garry@mriapollo.com ; word format preferred. Requires: BS in engineering (biomedical prefered)/ASCQ, 1+ yrs in QC position for medical devices. GMP/ISO PC literate. US Citizenship Required

**Please Reference:** # gr338 on all replies.

Send this Job to You or a Friend | Add to Clipboard

## Thermal-Mechanical Engineer

**Date Posted:** Fri Feb 26 1999
**Location:** Waltham MA
**Duration:** Direct Placement
**Pay Rate:** Open

**Company:** Triad Engineering Corp.
**Phone:** 781-273-1880
**Fax:** 781-273-1977
**Email:** Lisa Conn

**Job Description:**
Thermal-Mechanical System Design Engineer sought for an established medical device company. Will work with solid state, microprocessor controlled, systems for lab bench top products. Must be capable of product development from system architecture through design, implementation and test. Must have good organizational and excellent communications skills. Significantly work with detailed thermodynamic and

and infra-red links, etc.), Protocols, and architectures for use with biomedical and data management systems. Work also includes the design, development, and technical ownership of databases for communications-related information in support of engineering and technical support. Performs development of specific communications software or hardware subsystems under the direction of project engineering and functional manager. Contributes to the development of communications standards and test programs. May develop and/or provide training for engineering, technical support, and sales/marketing personnel on selected communications topics. Position may involve travel to off site vendor, customer, and field trial sites.

**Skills Required:**

Requires ability to independently plan, execute, and report on test and evaluation of communications systems. Ability to estimate task effort, duration and meet commitments is required. Must possess strong written and verbal communication skills and be capable of creating clear and concise engineering documentation. BSEE or equivalent with a minimum 5 years design experience is also required.

**Please Reference:** # NT514 on all replies. Send this Job to You or a Friend | Add to Clipboard

## Field Service Engineer

**Date Posted:** Thu Feb 25 1999
**Location:** St Petersburg FL
**Duration:** Direct Placement
**Pay Rate:** negotiable

**Company:** Corestaff Services
**Phone:** 813-914-7061
**Fax:** 813-988-3798
**Email:** Colette Victoria Stibich

**Job Description:**

Responsible for initial installation of CompanyBiotech Divisions hardward. Provide on-site service of hardware products at custiomer locations. Provide technical assistance by phone for self-service customers. Establish and maintain positive customer good-will. Provide telephone and on-site assistance to customers and service engineers on unusual or repetative hardware problems. A two year degree in either electronics or biomedical engineering from an accredited educational institution or 4-5 years field service experience on medical electronic instruments. Completed a min. of 2 years as a Field service technician and or demonstrated outstanding competence in hardward service and customer relation skills. Must be authorized to work in the U.S. ! Candidates must be legally authorized to work in the US without needing sponsorship from this company. Apply on-line now!

**Skills Required:**

degree from and accredidited educational institution

**Please Reference:** # 0201B on all replies. Send this Job to You or a Friend | Add to Clipboard

## Project Engineer, Mechanical, Pro Engineer or CAD

**Date Posted:** Thu Feb 25 1999
**Location:** IL
**Duration:** Direct Placement
**Pay Rate:** 55 to 80K

**Company:** Martin Management, Inc.
**Phone:** e-mail please cmartin@execpc.com
**Fax:**
**Email:** Carol Martin

**Job Description:**

Involved in precision machining and E/M. assemblies, ProEngineer or Solidworks CAD. DFM, resolving mfg. issues, GMP's and Regulatory Standards and documentation.

**Skills Required:**

BSME of BS Biomedical. 3-5 years in electromechanical product design. Experience in plastic molded products preferred.

**Please Reference:** # SQEng112HC on all replies. Send this Job to You or a Friend Add to Clipboard

## Mechanical Project Engineering Leader

**Date Posted:** Fri Feb 26 1999
**Location:** Northshore Chicago IL
**Duration:** Direct Placement
**Pay Rate:** 55-80K

**Company:** Hire-Power.COM
**Phone:** 651-464-6677
**Fax:** 651-464-1716
**Email:** Patti Yaritz

**Job Description:**
New Plant seeking efficient self- starter to solve medical product performance problems. Improve products and processes. Company is one of Chicagoland's fastest growing Electro-mechanical Manufacturers.
**Skills Required:**
BSME or BS Biomedical Engineer minimum. 3-5 years experience electro-mechanical product design. Prefer experience in medical products mfg, especially infusion pumps, electromedical, electrotheraphy or ultrasonic products. Experience in plastic molded products, precision machining and electro-mechanical assemblies. Pro/Engineer or Solidworks CAD required. DFM, experience resolving Mfg issues, GMP & regulatory standards. Knowledge of engineering documentation desired.

**Please Reference:** # PRJEN-199-920-IL on all replies. Send this Job to You or a Friend Add to Clipboard

## Mechanical Design Engineer

**Date Posted:** Fri Feb 26 1999
**Location:** VA
**Duration:** 6 - 9 months
**Pay Rate:** 33-40 hour

**Company:** Davis National, Inc.
**Phone:** 800-284-5828
**Fax:** 781-273-9058
**Email:** Al Donovan

**Job Description:**
Candidate needs to have 5-7 years experience as a Mechanical Design Engineer using Autocad 14 Software. The ideal candidate needs to have strong machine design and any experience with Mechanical Desktop would be a plus. Also, any experience in the medical industry or biomedical industry would be a plus. This position will act as a Functional Team Coordinator.
**Skills Required:**
5-7 Years ExperienceAutocad 14 Software/Mechanical DesktopMachine DesignBSMERate: 33-40 hourLength: 6-9 monthsStart: ASAPAl Donovan/Scott FaesslerDavis National, Inc.800-482-9494national@daviscos.com

**Please Reference:** # DesEng99 on all replies. Send this Job to You or a Friend Add to Clipboard

## Data Communications Engineer

**Date Posted:** Thu Feb 25 1999
**Location:** Seattle WA
**Duration:** Direct Placement
**Pay Rate:** Open

**Company:** Staffing Options & Solution, LLC
**Phone:** 800-664-7671
**Fax:** 425-7743558
**Email:** SOS Recruiter

**Job Description:**
A perm position with a large development, manufacture, sale and service of medical equipment for hospital care. This position performs engineering work in basic and applied research, development and/or design of new products and systems. Work includes the design, development, and testing of communications equipment (including modems, cellular and satellite telecomm, PC-based products, RF

## Yahoo! Classifieds

**Classifieds : Employment : National : Search Results**

1 - **Echelon Service Company**; **Senior Design Engineer- BioMedical Plastic Disposable Units**; Columbia, Maryland;

**Industry:** Computer Hardware **Function:** Engineer
**Job Code:** 990010201

**Responsibilities:** WORLD WIDE LEADING MEDICAL DEVICE MANUFACTURER LOCATED IN COLUMBIA, MARYLAND SEEKS SENIOR DESIGN ENGINEER. MAIN FUNCTIONS OF POSITION ARE: ASSIST IN DEVELOPMENT, JUSTIFY, AND IMPLEMENT PROJECTS ASSOCIATED WITH: NEW PRODUCT DESIGNS, QUALITY IMPROVEMENT, CAPACITY IMPROVEMENT, COST REDUCTION, AND REGULATORY COMPLIANCE. PERSON WILL ALSO UTILIZE CURRENT INDUSTRY ACCEPTABLE TECHNIQUES TO PROVIDE: PROJECT PREPARATIONS AND ESTIMATION, BUDGET CONTROL (BOTH CAPITAL AND EXPENSE), AND EVENT TRACKING. SPECIFIC RESPONSIBILITIES INCLUDE: INITIATING AND JUSTIFYING MOLD DESIGN CONCEPTS OR MODIFICATIONS TO EXISTING MOLDS AND REQUEST QUOTES FROM OUTSIDE VENDORS, INITIATE ENGINEERING CHANGES, MOLD MAINTENANCE AND MOLD STATUS PROGRAMS AS WELL AS APPROVE ALL MOLD DESIGN AND COMPONENTS, WILL ALSO ASSIST R&D AND MANUFACTURING IN ESTIMATING PRELIMINARY PIECE PRICES AND TOOLING COSTS.

**Desired Requirements:** EDUCATION: BS/MS ENGINEERING DISCIPLINE (MECHANICAL, BIOMEDICAL, CHEMICAL) EXPERIENCE: 8 YEARS PARTS DESIGN EXPERIENCE (W/ 4 YEARS IN THE MEDICAL OR PHARMACEUTICAL INDUSTRIES), AND 2 YEARS PROJECT MANAGMENT EXPERIENCE. PERSON MUST HAVE DESIGNED ATLEAST 5 PLASTIC PARTS (ATLEAST 1 PATENT PREFFERED). SPECIFIC SKILLS: FAMILIARITY WITH CAD/CAM SYSTEMS HELPFUL. FORMAL TRAINING - PROJECT MANAGMENT, MANUFACTURING MANAGEMENT. FEA, FEMA, TOLERANCE ANALYSIS AND STACKUPS. EXCELLENT PERSONAL SKILLS. EXCELLENT WRITTEN AND VERBAL AND COMMUNICATION SKILLS. WILL INTERACT WITH CUSTOMERS FROM TIME TO TIME TO PROVIDE FEEDBACK ON PRODUCT SPECIFICATIONS WHEN NEEDED.

**Contact:** Gordon Barclay , 7400 York Rd. Suite 302 , Towson, Maryland , 21204 **Phone:** (410) 321-8254
**Fax:** (410) 321-8385
**Email:** echelon@yahoo.net-temps.com

## Yahoo! Classifieds

**Classifieds : Employment : National : Search Results**

1 - **R.A. Execusearch, Inc.**; **Senior Product Development Engineer**; Boston, Massachusetts;
**Industry:** Health Care (Pharmaceuticals, Biotech, Devices) **Function:** Engineer
**Job Code:** EXE-SPDE102

**Responsibilities:** Responsible for new product development of specific medical device products from concept to market introduction to ensure that all design and development problems are solved.

**Desired Requirements:** This Design/Product Development job is in the industry Medical Minimum of a BS in Engineering with a preference for Biomedical or Mechanical engineers and 4-5+ years of industry experience or MS degree in the above stated disciplines and 3+ years of medical device industry experience. Must have solid design and development skills developing a product from concept to market intoduction. medical, orthopaedic, implants, fda, product, EXE-SPDE102

**Contact:** Robert Archibald , P.O. Box 112 , Fort Washington, Pennsylvania , 19034 **Phone:** (215) 646-9620
**Fax:** (215) 646-9621
**Email:** 215-646-9620@ron.ipa.com
**Date posted:** 02/24/99 **Ad ID:** employment-919895240-ne0032-6898

[ MORE LISTING DETAIL ]

### Other Employment Resources

[ INDUSTRY RESEARCH | COMPANY PROFILES | INDUSTRY NEWS | TALK ABOUT JOBS | ADVICE ]


# Title: Quality Control Engineer

**Skills:** 1+ yrs in QC for medical devices

**Date Posted:** 02/19/99
**Location:** Boston, MA
**Area code:** 617

**Start:** asap
**Type:** Full-time
**Pay:** $50,000-60,000
**Length:** fte perm

**Email:** garry@mriapollo.com
**Web:** www.mriapollo.com

**Position ID:** gr338
**DICE ID:** mriapfl

**Job Description:**

Great Opportunity with a leading medical device manufacturer located on the outskirts of the Boston area. Duties include:
Responsible for developing quality plans, automated test equipment & procedures for the manufacturing area, with a strong focus on validation testing, rewiew and approval. Conducting failure analysis & corrective action on returned material implementation. Will interface with manufacturing, R&D, and Materials in the development of new processes & enhancements to existing products. Work as part of a team to improve product quality & customer satisfaction.

Requires: BS in engineering (biomedical prefered)/ASCQ, 1+ yrs in QC position for medical devices. GMP/ISO PC literate. US Citizenship Required

Apply for this job  Email to a friend

## Yahoo! Classifieds

**Classifieds : Employment : National : Search Results**

1 - **NCC Executive Search**; **CLINICAL DEVELOPMENT SPECIALIST**; Seattle, Washington;
**Industry:** Computer Hardware **Function:** Engineer
**Job Code:** ncc.jv#14

**Responsibilities:** Great opportunity with the world's leader in robotic medical devices, to work at both sites within the U.S. and internationally. Seeking someone with around 2 years or more experience in medical device development with exposure to operating room environments, especially involving pre-clinical or clinical trials. Excellent communication and interpersonal skills are required as this person must be comfortable and experienced interacting with surgeons, health care professionals and engineers. Detail-oriented, proficient at scheduling, record-keeping, and compiling research data, ability to provide timely, useful feedback on technical performance, clinical issues, and surgeon preferences. Some awareness of Regulatory Affairs and experience with FDA submissions would be considered a plus. Team player who can solve problems while working independently in a loosely structured environment is a high priority. Four year technical degree is required in Biomedical, Electrical or Mechanical engineering.

**Minimum Requirements:** medical device, OR experience, pre-clinical trials

**Contact:** Jennifer Veblen , 1300 B Santa Barbara Street , Santa Barbara, California , 93101
**Phone:** (805) 963-0433
**Fax:** (805) 966-9857
**Email:** ncctech@nccx.com
**Date posted:** 02/23/99 **Ad ID:** employment-919795132-ne0003-68554

[ MORE LISTING DETAIL ]

### Other Employment Resources

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## Find Jobs : Job Details

### R&D Engineers

| | |
|---|---|
| **Details** | |
| **Description:** | World healthcare leader seeks top quality R&D Engineers looking for an outstanding career with unlimited potential and superb benefits package. Min. 5 years exp. in design and development of small mechanical/electro mechanical devices. Medical device exp. preferred. Proven track record of problem solving and product design. In-depth knowledge of and experience with engineering materials.<br>Job Ref.# CAREERSHOP-WH0120 |
| **Requirements:** | Knowledge and experience with DOE, CAD or Pro E skills required. Similar positions in Santa Clara, CA.<br>BS Mechanical, Biomedical or related exp./ MS preferred. Salary $50K DOE. |
| **Required Education:** | None |
| **Required Experience:** | |
| **Required Travel:** | |
| **Job Type:** | Employee-Full Time |
| **Location:** | US-CA-Temecula |
| **Relocation Covered:** | No |
| **Compensation** | |
| **Base Pay:** | N/A |
| **Contact** | |
| **Company:** | General Employment |
| **Apply Online:** | Click here to send your HeadHunter.NET résumé |
| **Contact Information:** | Click here for complete contact information |
| **Miscellaneous** | |
| **Categories:** | Engineering |
| **Last Change:** | 1999/01/26 23:26:18 |
| Additional Job-Seeking Services | |
| **Reference Verification:** | Not getting job offers? Find out what your past employers are saying about you...**click here**. |
| **Career Search Assistance:** | Frustrated? Get your job search or career change on target...**click here**. |
| **Executive Recruiter Contacts:** | For positions above $50k, identify the executive recruiters in your field...**click here**. |

**Find Jobs** : **Job Details**

## Engineer - Medical - Santa Barbara

| | |
|---|---|
| **Details** | |
| **Description:** | Our client, a rapidly growing successful manufacturer of medical devices and implants, seeks a Staff Engineer to apply engineering expertise in the research, design and development of new products and product enhancements. |
| **Requirements:** | BS in Mechanical, Biomedical or Chemical Engineering and a minimum of 2 to 5 years related experience. Knowledge of FDA GMPs and regulatory requirements that relate to process design, medical device or drug manufacturing. Need ability to use word processing, spreadsheet and database applications.<br><br>Prefer resume sent via FAX (707) 541-0230. If sending via emmail, no attachments please. |
| **Required Education:** | 4 Year Degree |
| **Required Experience:** | At Least 3 Years |
| **Required Travel:** | Negligible |
| **Job Type:** | Employee-Full Time |
| **Location:** | US-CA-Santa Barbara |
| **Relocation Covered:** | Yes |
| **Compensation** | |
| **Base Pay:** | $45,000 - $65,000/Year |
| **Other:** | Outstanding benefits and relocation. |
| **Contact** | |
| **Company:** | Pacific Coast Recruiting |
| **Apply Online:** | Click here to send your HeadHunter.NET résumé |
| **Contact Information:** | Click here for complete contact information |
| **Miscellaneous** | |
| **Categories:** | Biotechnology,Engineering,Manufacturing,Mechanical,Quality Control |
| **Last Change:** | 1999/01/27 11:35:47 |
| Additional Job-Seeking Services | |
| **Reference Verification:** | Not getting job offers? Find out what your past employers are saying about you...**click here**. |
| **Career Search Assistance:** | Frustrated? Get your job search or career change on target...**click here**. |
| **Executive Recruiter Contacts:** | For positions above $50k, identify the executive recruiters in your field...**click here**. |

**Please Reference:** # 2003 on all replies. Send this Job to You or a Friend | Add to Clipboard

## Senior Software Engineer

**Date Posted:** Thu Feb 25 1999
**Location:** Chicago IL
**Duration:** 6 - 9 months
**Pay Rate:** negotiable

**Company:** H.L. Yoh Company
**Phone:** 630-990-8800
**Fax:** 630-990-8727
**Email:** Scott Eoff

**Job Description:**
DESCRIPTION: Looking for a Software Engineer, participating in engineering activities related to the development of medical electronic products that are purchased by Anesthesiologists. These products currently include drug infusion pumps for pain control, drug infusion pumps for delivery of anesthetics and other drugs in the operating room, and devices for warming fluid prior to administration to patients. DESIRABLE: M.S. in Computer Science, Electrical Engineering or Biomedical Engineering is preferred. Object oriented design, Java, Visual Basic, HTML.
**Skills Required:**

**Please Reference:** # 154 on all replies. Send this Job to You or a Friend | Add to Clipboard

## Sr. Disposable Engineer - Medical Devices

**Date Posted:** Thu Feb 25 1999
**Location:** Chicago IL
**Duration:** Direct Placement
**Pay Rate:** 60-85K

**Company:** AJI
**Phone:** 847-670-1010
**Fax:** 847-670-7770
**Email:** Don Johnson

**Job Description:**
This person will be responsible for disposable medical device systems design which includes translating needs of customers into requirementsand definition in the area of treatment and storage containers for the products. This includes designing disposable systems that interfaces with treatment instrumentation, materials selection, design for manufacturability, transfer to manufacturing documentation, manufacturing support, tolerance and interference analysis, failure modes and effects analyses, product and process validations, packaging, sterilization and design for favorable cost. Great Company ! Choose to live closer to the city or further out in the suburbs.
**Skills Required:**
Must have a BS Mechanical . Biomedical or related engineering degree with an MS desired. 5-10 years of related experience in the area of medical device disposable development. Should have excellent understanding of medical device regulatory requirements (documentation, GMP, etc.) Must be able to work independently.

**Please Reference:** # NTSB7 on all replies. Send this Job to You or a Friend | Add to Clipboard

## Biomedical Equipment Field Service Engineer

**Date Posted:** Thu Feb 25 1999
**Location:** MA
**Duration:** Direct Placement
**Pay Rate:** Open

**Company:** Guaranty Employment Agency, Inc.
**Phone:** 703.323-1278
**Fax:** 703.323-6239
**Email:** Murray W. Kliger

**Job Description:**
Field Service Engineer to service biomedical equipment
**Skills Required:**

## Find Jobs : Job Details

### Biomedical Engineer

| | |
|---|---|
| **Details** | |
| **Description:** | Company is a designer, manufacturer, and marketer of advanced medical devices for use in the home, hospital and alternative clinical care settings.<br><br>2,000 employees worldwide with manufacturing facilities in several domestic and international locations.<br><br>This position will perform system and clinical validation, analysis of user preferences. Development of product specification from user input preferred |
| **Requirements:** | Candidate should have a BS/MS in biomedical engineer with 2-10 years experience in the develop in the design and development of biomedical instrumentation. |
| **Required Education:** | 4 Year Degree |
| **Required Experience:** | At Least 3 Years |
| **Required Travel:** | Negligible |
| **Job Type:** | Employee-Full Time |
| **Location:** | US-GA-Atlanta |
| **Relocation Covered:** | Yes |
| **Compensation** | |
| **Base Pay:** | $40,000 - $80,000/Year |
| **Contact** | |
| **Company:** | Lynn Search Consultants |
| **Apply Online:** | Click here to send your HeadHunter.NET résumé |
| **Contact Information:** | Click here for complete contact information |
| **Miscellaneous** | |
| **Categories:** | Electronic,Engineering,Health - Medical |
| **Last Change:** | 1999/02/19 14:56:14 |
| Additional Job-Seeking Services | |
| **Reference Verification:** | Not getting job offers? Find out what your past employers are saying about you...**click here**. |
| **Career Search Assistance:** | Frustrated? Get your job search or career change on target...**click here**. |
| **Executive Recruiter Contacts:** | For positions above $50k, identify the executive recruiters in your field...**click here**. |

## Find Jobs : Job Details

### Biomedical Engineer

| | |
|---|---|
| **Details** | |
| **Description:** | Perm Poistion. Design and develop safe, effective, and user-friendly apheresis systems to collect high-quality blood products. Test and validate new designs to ensure conformance to applicable company, national and international standards. Organize and lead cross-functional project teams to ensure designs meet requirements of all affected departments. |
| **Requirements:** | BS in Biomedical Engineering or related discipline. Please refer to job number in reply. |
| **Required Education:** | 4 Year Degree |
| **Required Experience:** | At Least 1 Year |
| **Required Travel:** | Negligible |
| **Job Type:** | Employee-Full Time |
| **Location:** | US-MA-Canton |
| **Relocation Covered:** | No |
| **Compensation** | |
| **Base Pay:** | N/A |
| **Contact** | |
| **Company:** | Pro Source, Inc. |
| **Apply Online:** | Click here to send your HeadHunter.NET résumé |
| **Contact Information:** | Click here for complete contact information |
| **Miscellaneous** | |
| **Categories:** | Biotechnology,Engineering |
| **Last Change:** | 1999/02/25 15:50:57 |
| Additional Job-Seeking Services | |
| **Reference Verification:** | Not getting job offers? Find out what your past employers are saying about you...**click here**. |
| **Career Search Assistance:** | Frustrated? Get your job search or career change on target...**click here**. |
| **Executive Recruiter Contacts:** | For positions above $50k, identify the executive recruiters in your field...**click here**. |

GUIDANT

# US-CA-Menlo Park - Senior R&D Engineer

Guidant Cardiovascular Systems (CVS) in Menlo Park is a division of Guidant Corporation that researches, manufactures and markets systems for cardiac rhythm management, vascular intervention and minimally invasive surgery worldwide. Our mission is to provide innovative, therapeutic medical solutions of distinctive value for our customers, patients and health care systems around the world.

SENIOR R&D ENGINEER

Dedicating your engineering skills to product development, you will assist in moving our endovascular grafting system through the Screening, Development and Investigation phases to market release. Your BS in Mechanical, Biomechanical, Biomedical Engineering or related technical degree must be supported by 5+ years industry experience (minimum 3 years in medical devices) and solid engineering skills needed for the ISO/FDA regulated product development process. Proficiency with design tools, such as DOE, FMEA and other risk analysis techniques, team leader/project management skills and solid hands-on lab abilities are also needed.

## Additional Information

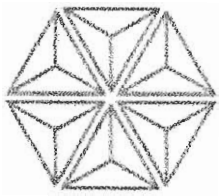
**Position Type:** Full Time, Permanent
**Ref Code:** MB-10860

## Contact Information

Professional Staffing
cvsjobs@guidant.com
Guidant Corporation, CVS
1525 O'Brien Drive
Menlo Park, CA 94025
Fax: (650) 470-6448

Click here to see all "Guidant Corporation" opportunities

**Apply Online**



Bristol-Myers Squibb Company

# US-IN-Warsaw - Engineer

Job Category: ENGINEERING
Division: ZIMMER
Job Location: IN - WARSAW
Relocation Available: No
Number of Positions: 1

Job Responsibilities

Responsible for the design and development of custom and specialty implant products to meet individual customer needs. Responsible for engineering instrument modifications to accommodate surgeon preferences. Job function requires working with surgeons and sales associates to interpret clinical issues and define an implant design that solves patients' needs. Scope includes managing design process through modeling, processing engineering, manufacturing and delivery to customer. Works closely with process engineer and manufacturing personnel to ensure product is completed on schedule and meets delivery dates.

Job Requirements/Education

Bachelor's degree in biomedical engineering, mechanical engineering, other engineering science, or combination of education and experience. Three to five years experience designing/developing orthopaedic implants with special emphasis in at least one product category of hip, knee, or trauma. Ability to utilize design software, experience in manufacturing processing. Excellent written and oral communication required. Ability to interpret and template x-rays is required. Demonstrated experience in complying with design controls, GMPs and OCPs.

Requisition Number: 99-0000734

## Additional Information

**Ref Code:** 99-0000734

Click here to see all "Bristol-Myers Squibb Company" opportunities

**Apply Online**


## US-NJ - Engineer

Position Title: Engineer

Education: BS/MS in Electrical Engineering or Biomedical Engineering

Requirements:
1 to 5 years work experience in the design and development of medical devices or equipment. Knowledge of product development cycles, QSR for the medical industry is essential. Working knowledge of energy instrumentation for surgical applications is desirable. Excellent skills in electronic prototype, failure analysis and electro-mechanic sensors and controls Ability to work in a team environment is essential with oral/written communication skills a priority. Familiarity with electric measurement and/or CAD tools is a plus.

Will be able to apply and comprehend a broad range of electronic instrumentation and conduct engineering/scientific evaluations of new product/technology prototyping.

Responsibilities:
Candidates will perform several or all of the following tasks:

Conduct the design and prototyping of microprocessor based medical, diagnostic and therapeutic devices
Conduct circuit design, utilizing computer aided design tools
Demonstrate research and development techniques and prepare basic reports
Conduct failure analysis to achieve results with minimal impact to program schedule

Fax resume to Jim at 561-243-1622 or
E-mail: jim@mrimed.com

## Additional Information

**Salary:** $40,000 to $65,000 per year

## Contact Information

Jim
jim@mrimed.com
Mulllings Group, The
Fax: 561-243-1622

Southwest Research Institute

# US-TX-San Antonio - BIOENGINEERING

BIOENGINEERING
Design, develop and test software and algorithms for medical devices including microcontroller and microprocessor-based systems. Implement test and evaluation protocols to verify developed software and algorithms; design and implement real-time data acquisition and control software; promote new work with commercial and government clients; prepare technical specifications, software documentation and technical reports; develop program proposals and cost estimates; deliver technical and promotional presentations. Requires a Bachelor's degree in Biomedical Engineering, Computer Science or equivalent, GPA of 3.5/4.0 with formal course work in C, assembly language, embedded systems design, digital signal processing, biomedical instrumentation and physiology is desirable, experience with formal software quality assurance procedures is an asset. Must be able to work under minimal supervision and as a member of a team; write and verbally present reports on project work; deliver promotional presentations.

## Contact Information

Personnel@swri.org
Southwest Research Institute
6220 Culebra Rd
San Antonio, TX 78228-0510
Fax: 210-522-3990

Click here to see all "Southwest Research Institute" opportunities

**Apply Online**


# US-MI-Ann Arbor - Biomedical Device Quality Engineer

Location: Ann Arbor, MI, USA. Pay Rate: DOE. Skills: Biomedical QC Engineer. Duration: 3 - 6 months. Education: BS Mechanical Industrial Chemical Biomedical Engineer. Experience: 3 year(s). Start Date: ASAP. Biomedical Device Quality Engineer, Key Tasks--- Provide quality assurance for disposable medical devices used in open heart surgery. Knowledge of statistical tools. Design of experiments. Problem solving skills, experience with injection molded plastic parts, medical devices. Excellent interpersonal, written and verbal communication.

To submit a resume for this position, you must place 48103/MB/1047 in the subject line of your e-mail. Send your resume to jobs@technical.manpower.com in text format. Do not send e-mail attachments.

## Additional Information

**Ref Code:** 48103/MB/1047

## Contact Information

Technical Recruiter
JOBS@TECHNICAL.MANPOWER.COM

Click here to see all "Manpower Inc." opportunities

**Apply Online**

SIEMENS

# US-IL-Chicago - Sr Principal Systems Engineer

Conceptulize and refine concepts for proposed clinical protocols and equipment to make them suitable for engineering implementation with the written requirement document as a final deliverable. The concepts must be derived from the systems perspective explicitly addressing any tradeoffs in the affected subsystems. Define and drive validation protocols and plans for the above mentioned. Provide high level support to end customers, application specialists and technical support regarding functionality, performance and application of our equipment. Provide engineering input for clinical trials to Marketing - driving the trials. Provide support to QFD team.

Position requires BSEE or BS Physical in BS Biomedical Engineering. 5+ yrs medical imaging industry preferred with experience in design engineering or product management. Must be driven with sense of urgency. Must be able to communicate on a variety of levels. 25% TRAVEL EXPECTED.

## Additional Information

**Position Type:** Full Time

## Contact Information

Engineering Recruiter
recruiter@nmg.sms.siemens.com
Siemens
2501 North Barrington Road
Hoffman Estates, IL 60195
Ph: 847-304-7700
Fax: 847-304-7200

Click here to see all "Siemens" opportunities

**Apply Online**

# US-MA-Boston - Engineer / Sr. Engineer / Principal

Zimmer, Inc., a Bristol-Myers Squibb Company, is a worldwide leader in the development, manufacturing, and marketing of orthopaedic products. Headquartered in Warsaw, Indiana, Zimmer has global facilities.

ENGINEER/SR. ENGINEER/ PRINCIPAL
Job Codes: 98-3989 / 98-3990

As a key member of the Engineering team, the Product Development Engineer will interact with many different functional departments and with surgeons and technical experts outside Zimmer. A Product Development Engineer is responsible for the design, development, and processing of orthopaedic implants and instruments. Good communication, teamwork and organicational skills are essential. An understanding of human physiology and joint mechanics is also required.

Qualifications:
BS in Biomedical Engineering, Mechanical Engineering (or other Engineering Science) or combination of experience and education.
3+ years experience in the development/design/testing/manufacturing of orthopaedic devices.
Excellent communication, teamwork and organicational skills are essential - as is an understanding of human physiology and joint mechanics.
Experience in common manufacturing processes related to metals is preferred.

Please forward your resume to: Zimmer, a division of Bristol-Myers Squibb Company, Ad Code #_____, PO Box 5335, Princeton, New Jersey 08543-5335. Please include the Ad Code on the mailing envelope and on the document text. All resumes are electronically scanned. Please submit on plain white paper, using standard type and fonts (no italics, graphics, or staples please). We offer an excellent compensation and benefits package, as well as a challenging work environment. For consideration, please send or fax your resume: Zimmer Inc., P.O. Box 5335 Princeton NJ. 08543-5335. We are an equal opportunity employer. M/FD/V.

## Additional Information

**Position Type:** Full Time

## Contact Information

Zimmer ad code#
Zimmer - a division of Bristol Myers Squibb Co.
PO Box 5335
Princeton, NJ 08543-5335


## Yahoo! Classifieds

**Classifieds : Employment : National : Search Results**

1 - **Martin Management INC.; Project Engineer (Sr), CAD**; Rockford, Illinois;
**Industry:** Other / Not Specified **Function:** Engineer
**Job Code:** HH_J04KK1MJWYB7TBV95V

**Responsibilities:** 3037 Project Eng. Leader, CAD Involved in precision machining & E/M Assemblies, ProEngineer or Solidworks CAD. DFM, resolving mfg issues, GMP, and Regulatory Standards, documentation. Position may not be in Rockford

**Desired Requirements:** BSME of BS Biomedical. 3-5 years inelectro- mechanical product design. Exp. in plastic molded products preferred. Location, IL, Salary to Pay to 80K e-amil resume please

**Minimum Requirements:** RE32

**Contact:** Carol Martin **Fax:** (920) 261-2999
**Date posted:** 02/24/99 **Ad ID:** employment-919869348-ne0036-10790

[ MORE LISTING DETAIL ]

### Other Employment Resources

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## Yahoo! Classifieds

**Classifieds : Employment : National : Search Results**

1 - **Espo Systems**; **PRINCIPAL ENGINEER**; Chicago, Illinois;
**Industry:** Computer Hardware **Function:** Engineer
**Job Code:** 7399

**Responsibilities:** ENGINEER & COORDINATE DESIGN, VALIDATION, AND IMPLEMENTATION OF FLUID DELIVERY DEVICES & IV CONTAINERS. LEAD & PARTICIPATE WITH CROSS FUNCTIONAL PROJECT TEAMS TO COMPLETE OFTEN COMPLEX & NON-ROUTINE TASKS. INTERFACE WITH MANUFACTURING PLANTS AND OTHER INTERNAL & EXTERNAL CUSTOMERS TO ACCOMPLISH PROJECT GOALS. APPLY STARDARD & ADVANCED ENGINEERING TECHNIQUES TO CARRY OUT CARRY OUT PROJECT OBJECTIVES. BSE REQUIRED (MECHANICAL, CHEMICAL, OR BIOMEDICAL) 5-8 YRS. EXP. IN MEDICAL PRODUCT DEVELOPMENT, OR HIGH VOLUME COMMERCIAL PRODUCTS.

**Contact:** Manny Santos , 855 Midway Drive , Hinsdale, Illinois , 60521 **Phone:** (630) 789-2525
**Fax:** (630) 789-3372
**Email:** esposyst01@yahoo.net-temps.com
**Date posted:** 02/24/99 **Ad ID:** employment-919860045-ne0004-20273

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## Yahoo! Classifieds

### Classifieds : Employment : National : Search Results

1 - **Bell and Associates**; **Process Engineer**; San Jose, California;
**Industry:** Other / Not Specified **Function:** Engineer
**Division:** Process
**Job Code:** Jobtrack# 16765

**Responsibilities:** Leading edge Biomed company seeks a Process Engineer to to design and develop innovative processes for dilation and stent delivery catheters. Will partner with R and D and material and equipment design engineers. Will create protocals, test and analyze data, create conclusions, and document results. Requires Process or Manufacturing engineering experience with a strong background in plastics processing. Prefer design and development experience with medical devices. Should be well versed in engineering statistics and Design of Experiments (DOE). This company offers an exceptional compensation program (25% - 50% bonuses and full company paid two week year end shutdown) and excellent career growth potential.

**Desired Requirements:** For this job we require that you have Process Engineering, Plastics, Polymers, Experiment Design, Mechanical Engineering, Engineer Chemical, Biomedical and Designer.

**Contact:** , 130 Cockeysville Rd. , Cockeysville, Maryland , 21030 **Date posted:** 02/24/99 **Ad ID:** employment-919853699-emp003-2943

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### Other Employment Resources

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## Yahoo! Classifieds

**Classifieds : Employment : National : Search Results**

1 - **Echelon Service Company**; **Design Engineer**; Baltimore, Maryland;
**Industry:** Computer Hardware **Function:** Engineer
**Job Code:** 98062201

**Responsibilities:** Work in the creative design and development of quality and innovative automatic injectors and syringe products and other novel drug delivery systems. Develop, justify and Implement projects associated with new product designs, quality improvement, capacity improvement, cost reduction and regulatory compliance. Utilize current industry acceptable techniques to provide project preperations and estimating, budget control and event tracking. Main Areas of responsibilties shall be: * Justify new plastic molds or modification to existing molds; initiate mold design concepts and request for quotes with outside vendors and vendor selection. Approve all mold design. * Assist plants and QA with regard to vendor quality problems. * Provide liason between PD&D and Mfg. in estimating preliminary piece prices and tooling costs. * Manage and develop documentation systems for development of and release of new and improved drug delivery systems and components. This includes: project and objective sheets, essential characteristics, drawings, project plans, quotations protocols and engineering orders. * Work with all departments to analyze rationale, investment requirements, development timing market potential, and return on investment for new product developments and improvements to existing products.

**Desired Requirements:** * BS/MS Engineering descipline (mechanical, chemical, biomedical) * 8 yrs. parts design experience (4 yrs. in the medical or pharmaceutical industries), 2 yrs. project management experience. * Familiarity with CAD/CAM systems helpful. * Formal training - project management, manufacturing management * Excellent interpersonal skills * Excellent written and verbal communications skills

**Contact:** Gordon Barclay , 7400 York Rd. Suite 302 , Towson, Maryland , 21204 **Phone:** (410) 321-8254
**Fax:** (410) 321-8385
**Email:** echelon@yahoo.net-temps.com
**Date posted:** 02/24/99 **Ad ID:** employment-919860045-ne0004-18750

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