Learning to be an Engineer:
The Senior Consulting Project in Engineering at Olin College

by

Richard K. Miller

Executive Summary. A central focus of the engineering program at Olin College is hands on learning and design. From the first semester all students are engaged in the creative enterprise of conceiving, designing, fabricating, and testing a device, system, or process intended to achieve a specific goal. This is done in a team format and in an open-source studio environment where the design process is publicly displayed and forms the dominant mode of social dialogue on campus. The design focus is sustained in all eight semesters, building in complexity and scope, developing substantial skills in teamwork and applied science, reaching a crescendo in the senior year when all students are required to complete a two-semester capstone experience we call the Senior Consulting Project in Engineering (SCOPE). This one project pulls together the preparation across all disciplines and brings it to bear on a technical problem of sufficient importance that a corporate client is willing to pay a substantial fee for its solution. This project serves as the culminating experience in a four-year educational program aimed at preparing students "to be" engineers through direct experience, rather than indirectly through teaching them "about engineering" with courses in applied science. At Olin, we believe engineering is more of a performing art than a passive clinical science. Therefore, it is natural that a realistic performance should play the central role for every student in completing an Olin education. While many engineering schools now include a required senior design project, Olin's SCOPE project pushes the envelope in several ways. It also attempts to address all three major learning objectives of each of our three B.S. degree programs (although other aspects of our educational program also address one or more of these objectives). This paper explains in some detail the philosophy, structure and function of the SCOPE program, including a list of projects and sponsors this fall, its inaugural offering (in appendix A). Also included in appendix B is a list of the major learning objectives for each Olin degree program. The reader is asked to respond to several questions at the end of the paper to help the College understand the significance of this approach and plan future refinements.

Learning "To Be," Not Just Learning "About." Engineering is an activity that inherently requires the creative application of natural science and mathematics to the design of a device, system, or process subject to various constraints. The scale of most modern engineering projects is sufficiently large that a multidisciplinary team is required to achieve a useful result. Sometimes the team may include more than 1,000 members. Furthermore, as globalization proceeds, the demand for turn-key solutions extending well beyond innovative technology to embrace business, manufacturing, and client satisfaction as central features is rapidly increasing. To succeed in this environment, engineering must be able to recognize opportunities, take initiative, and cause the creation of practical and useful solutions. It is no longer adequate to "know about" things or to bring skills that are limited to analytical research. The Internet has ushered in a new era where facts or information are ubiquitous. It is not so much what you know that counts, but your ability to generate the right questions and to use knowledge creatively—it's what you can do that counts.

Furthermore, the emerging culture of learning in the digital age revolves around continuous "productive inquiry" on the Internet in communities or groups that work together openly sharing information electronically. "Meaning" in this new age is rapidly shifting from what you know to what you can contribute to the solution in the group or team environment. It's what you can do that counts and how you can integrate your contribution with that of others whose background is often profoundly different from your own. This not only requires a heightened degree of creativity but also a significant level of social skill. Those who are only able to sit alone in the library and work analytical problems from textbooks are unlikely to be prepared for today's engineering work

environment. In this sense, engineering is shifting from an applied science to a form of "performing art" that requires a firm background in applied science.

Like any performing art, it is impossible to become proficient without direct experience in performance. Musicians begin to perform at an early age with recitals before a small audience. They add the study of music theory along with performance as both skill and knowledge grow simultaneously through the years. A similar process is followed in other performing arts, such as drama, visual arts, or athletics. One cannot become proficient at swimming by reading a book. You must get in the water as a beginner and move your arms and legs, gradually building skill and stamina.

In the Olin curriculum, the subject of design often plays a role analogous to a "performance." Students begin in the first semester to build their skills at creating useful solutions to design problems in an open teamwork environment, and this experience is blended with the study of natural science, mathematics, and non-technical subjects. Each semester they learn more about the design process and build proficiency and confidence in their ability to perform in this way. They learn how to identify product needs from clients through active listening. They learn how to identify entrepreneurial opportunity, and the process of group discovery and brainstorming to create candidate solutions. They learn how to research unfamiliar topics in the library and on the Internet through independent study. This involves identifying and verifying sources of information, learning the new concepts without the benefit of a structured learning environment, learning when to quit researching and how to apply the new knowledge. They learn practical ways to assess preliminary technical approaches and designs, and how to use modern tools to conceive and fabricate prototypes. They learn the limitations of theory and measurements and how to test and improve prototypes and select a final concept. They also learn how to organize and manage their collective time, knowledge, and financial resources in order to deliver a successful solution to an interested client, on time and within budget. Finally, they learn the ultimate importance of exceeding the client's expectations and maintaining long-term client relations. In short, they learn "to be" engineers.

SCOPE Project. The SCOPE project is the culminating experience in design in the Olin curriculum. It plays the role of a master performance, or final recital, in which students draw on all they learned in their four year college career. The project typically involves all the features outlined above, and includes several aspects that we believe significantly push the envelope in engineering education.

Level of Effort. The minimum duration of Olin's required SCOPE project is two consecutive semesters, with a level of effort of 4 semester credit hours per semester. (Due to excessive demand from industry for these projects, we recently developed a significant augmentation to the SCOPE project which we have named the MicroSCOPE program. This new optional program allows a team of 4-6 juniors to begin work on a future SCOPE project in the spring of their junior year, with the potential to continue work full time during a portion of the summer before the senior year. The MicroSCOPE is then followed by a regular 2-semester SCOPE project in the senior year, providing the opportunity for a sustained effort of 3 semesters plus a summer devoted to a single project effort.)

While most engineering schools now require a senior design project, and a few offer an exceptional project experience with many of the features of our SCOPE program[1], most of these are one semester in duration at a level of effort of 3 semester credit hours. Relatively few require

[1] Notably, Harvey Mudd College has long required the distinctive "Clinic" program that also involves 2-semester projects with financial support from clients, and the Worcester Polytechnic Institute whose commitment to project-based learning is unusual in American higher education. However, the HMC Clinic projects typically involve 4-5 students for 2 semesters at 3 semester credit hours per semester, for a total effort of 24-30 credit hours/project. Olin's projects involve a total effort of 32-48 credit hours/project. WPI's projects do not require an external client.

two consecutive semesters, and rarely do these projects involve an external client with a financial investment in the outcome.

The expanded level of effort that characterizes the Olin SCOPE program allows students to become involved in projects that are significantly more challenging and more ambitious in scope.

Multidisciplinarity. Olin's SCOPE projects derive from proposals directly from industry, and inherently involve a realistic blend of technical and non-technical requirements that span several disciplines of engineering as well as applied math, science, and non-technical subjects. Each project has a goal of developing a useful solution to a real problem, and these problems don't arrive with neatly packaged components with labels such as electrical engineering or mechanical engineering. Olin's SCOPE project is unusual for its focus on multidisciplinary projects, particularly for students majoring in electrical and computer engineering or mechanical engineering. It is more common for students studying these disciplines to engage in capstone design projects that are more narrowly focused on topics that remain in the mainstream of technical subjects in their discipline, and with team members who are all majoring in the same discipline. At Olin, not only do projects typically involve students majoring in all three of our engineering degree programs, but also several students from Babson College majoring in business, including graduate students in the MBA program. This multidisciplinarity of both project requirements and team members provides a rich learning environment that we believe is unavailable at any other engineering school. The involvement of Babson business students on project teams provides a rare linkage between engineering and business that insures a dialogue which includes the commercialization of technology.

Projects That Matter to an External Client. Each of Olin's SCOPE projects is sponsored by an external client[2] who is usually a corporation or government laboratory with a serious commitment to technology and/or product design and development. The sponsors range from Fortune 500 companies to research laboratories to small entrepreneurial companies. While most projects involve the design and development of a physical device or system, some focus on the design of software, human-machine interfaces, or marketing strategies and business solutions. Each sponsor provides funding in the amount of $50,000 per project[3], and also supplies a liaison engineer who works closely with the student team for the duration of the project. At this level of support, each project clearly matters to the sponsor, and this has a major effect on the project team. It is difficult to overstate the importance of this fact. Because the projects are of significant importance to a professional client, the level of effort and professionalism that students devote to the project is greatly increased over that which is common for projects that are generated internally by faculty members. The difference is similar to the effect that a scheduled performance of an athletic team in a major post-season bowl game has on its team members, as opposed to the alternative of an on-campus scrimmage with team mates.

Typical sponsored SCOPE projects involve the development of a new or improved product of significant potential financial value to the sponsor. However, the project is not of sufficient internal priority within the sponsoring company that immediate assignment of their professional engineering staff is warranted. Most technology companies have a long list of potential projects of this type that must wait for a time when sufficient engineering staff are available to work on them. Projects of this type are capable of generating intellectual property or patents that are of significant potential financial value. (Olin's approach to intellectual property generated from these projects differs from that of some other colleges or universities in that we offer all rights to the newly generated IP to the corporate sponsor. Our principal objective in creating the SCOPE

[2] One SCOPE project this year was reserved for philanthropic purposes, and does not have an external corporate sponsor. Instead the College funded the project from internal sources. The project is focused on developing a portable tuberculosis testing device for use in the Third World.
[3] The project fees from all sponsors are combined and used to support the entire SCOPE program learning experience, rather than used separately to support individual projects.

program is the development of a challenging and realistic educational experience for our students.)

Appendix A to this paper provides a list of all project titles and descriptions, sponsors, student team members, and faculty advisors. Also included is an organization chart that shows how each project is organized and staffed. Note that each student team has a designated student project coordinator and this student leader interacts directly with the company liaison officer. The Olin faculty advisor, along with all other faculty resources, including any angel faculty advisors and expert technical advisors, do not carry primary responsibility for driving the project. This feature increases the expectations for student performance, and enhances the learning opportunity and professionalism for students.

Program Learning Objectives. Appendix B to this paper provides a list of program learning objectives for each of the three B.S. degree programs at Olin College. These objectives express the high level aspirations for the impact an Olin educational experience will have on our students and their capabilities. These objectives serve as a bridge between the College's mission statement and the intended specific outcomes of each educational program.

The SCOPE program provides a learning experience that addresses all three objectives for each degree program. By carefully matching students in different degree programs together with projects that include appropriate technical challenges for each degree program as required by the Accreditation Board for Engineering and Technology (ABET), the SCOPE program provides an important opportunity to build and demonstrate the intended skills and behaviors.

Summary and Conclusions. The SCOPE program is emerging as a potentially distinctive feature of the Olin educational experience. It plays a central role in the senior year and is the culmination of four years of instruction and performance in design and team problem solving. Because of the importance of the SCOPE program in our educational philosophy and the high degree of effort and resource allocation involved, it is important to obtain external advice and guidance to insure alignment between our program and the needs of engineering practice and graduate education. Therefore, the reader is asked to take the time to provide us with your thoughts on each of the following questions. This feedback is very important to us and will help guide our decisions as we continue to evaluate and modify our curriculum in the months ahead. It is also required by ABET as a necessary component of our preparation for accreditation.

1. Consider the program objectives for each of the three B.S. degree programs as provided in Appendix B. If you have professional experience in one or more of these disciplines (or are otherwise qualified to comment on these objectives), please provide your advice/comment on the appropriateness of these objectives. Your feedback on this question is explicitly sought to enable the College to continually revise and improve the learning experience for our students, as required by ABET.

2. In your judgment, how valuable is the project experience provided by the SCOPE program to the education of future engineers, as compared to more traditional course work?

3. What are your thoughts on the value of adding one or more business students from Babson College to the SCOPE project teams?

4. How can the College make the SCOPE project better known in industry, and attract new potential corporate sponsors? What is the primary benefit that potential sponsors are likely to perceive by participation in the SCOPE program?

We value your advice and urge you to take a few minutes to write your thoughts on these questions. If you have any other comments or advice, we would welcome them as well.

APPENDIX A
SCOPE Projects, Sponsors, and Personnel 2005-06
Olin College

1. Sponsor: ***Boston Scientific Corporation*** (Project #1)

Project Description: This is a confidential project revolving around the development of an instrument to aid in less invasive medicine, medical technologies that provide alternatives to major surgery and other medical procedures that are typically traumatic to the body.

Team Members:
Jacob Basson (E '06)
Ransom Byers (E '06)
Alexander Dillon (E '06)
Tom Kochem (ME '06)
Holly Mead (E '06)

Faculty Advisor: Jessica Townsend (Mech Engr)

Sponsor Liaison: Paul Scopton

---

2. Sponsor: ***PepsiCo Corporation***

Project Description: In this confidential project, Pepsi wants Olin College to help the company expand accessibility of its popular beverage products to new groups of consumers.

Team Members:
Kathleen Dupaya (ECE '06)
Matt Hill (ME '06)
Leighton Ige (ECE '06)
Cheryl Inouye (E '06)
Kim McCraw (ME '06)
Krystin Stafford (ME '06)

Nils Seebach – Babson '06

Faculty Advisor: Benjamin Linder (Mech Engr)

Sponsor Liaison: Marcus Hammonds

---

3. Sponsor: ***Vision Agribotics Corporation***

Project Description: This project will explore the development of a robotic tractor that can perform multiple farm tasks, such as plowing, disking, and spraying, with a view toward increasing productivity while creating a safer work environment in the process. A set of low-cost, adaptive components that could be added on to any tractor will allow any farmer, no matter small of operation, to reap the benefits of robotics technology in the agricultural sector.

Team Members: Kate Blazek (ME '06)
Julie Connelly (ME '06)
Adam Horton (ME '06)
Sarah Oliver (E '06)
Katie Rivard (E '06)
Nicholas Zola (ECE '06)

Chris Cicchitelli -- Babson '06

Faculty Advisor: David Barrett (Mech Engr)

Sponsor Liaison: Bryan L. Aivazian

---

4. Sponsor: ***Dawn Solar Systems, Inc***.

Project Description: The team will develop a computer model of the current Dawn Solar Model 3004 solar thermal system to establish a baseline that accurately defines the current product and to which product development work can then be compared. The team will then undertake design improvements to the product.

Team Members: Jon Chambers (ME '06)
Que Anh Nguyen (E '06)
Bret Richmond (ME '06)
Sara Schwalbenberg (ME '06)
Polina Segalova (ME '06)

Greg Neufeld -- Babson '06

Faculty Advisor: Jessica Townsend (Mech Engr)

Sponsor Liaison: Bill Poleatewich

---

5. Sponsor: ***Nortel Networks, Inc***.

Project Description: New usage models lead to major breakthroughs in software products, from basic operating systems to advanced applications. These usage models are appropriately called metaphors, such as Apple's desktop and Real Player's control buttons. The purpose of this project is to invent one or multiple metaphors that will simplify network management applications both from visualization and control perspectives.

Team Members:
Luis Cabezas (E '07)
Grant Hutchins (ECE '06)
James Krejcarek (E '06)
Steve Shannon (E '06)
Jerzy Wieczorek (E '06)

Faculty Advisor: Allen Downey (Comp Sci)

Sponsor Liaison: Adnan Onart

---

6. Sponsor: ***Boston Scientific Corporation*** (Project #2)

Project Description: This is a confidential project revolving around the development of an instrument to aid in less invasive medicine, medical technologies that provide alternatives to major surgery and other medical procedures that are typically traumatic to the body.

Team Members:
Joles Arnold (E '06)
Jay Gantz (E '06)
Emma Goodman (ME '06)
Jacob Graham (E '06)
Dylan Sanders-Garrett (ME '06)

Faculty Advisor: Gill Pratt (Elec and Comp Engr)

Sponsor Liaison: Kurt Geitz

---

7. Sponsor: ***MITRE Corporation***

Project Description: In support of MITRE's Innovation and Harvesting work program, the team will perform a feasibility study and technology assessment of a Digital Diary concept for meeting support and social interaction mapping. The goal is to better understand social interaction within an enterprise environment and identify ways of capturing, measuring and disseminating potentially rich information that results from such encounters.

Team Members:
Mike Curtis (ECE '06)
Ben Donaldson (E '06)
Jesus Fernandez (ECE '06)
Frances Haugen (ECE '06)
Seth Heltsley (E '06)

Faculty Advisor: Mark Somerville (Elec Engr and Physics)

Sponsor Liaison:
Michal Cenkl
Beth Lavendar
Doug Phair

---

8. Sponsor: ***Motorola, Inc***.

Project Description: This project encompasses three potential directions: 1) Build a high fidelity prototype collecting, transmitting, and viewing information about what music other people are playing—both on desktop computers and mobile phones; or 2) Design, build, field and test an application for mobile blogging that combines text, media and location; or 3) Design, build, field and evaluate a system for tracking the location of friends and family.

Team Members:
Michael Crayton (E '06)
Sutee Dee (E '06)
Drew Harry (ECE '06)
Sean Munson (E '06)
Kevin Tostado (ECE '06)

Adam Chasen -- Babson '06

Faculty Advisor: Mark Chang (Elec and Comp Engr)

Sponsor Liaison: Larry Marturano

---

9. Sponsor: ***John Deere Corporation***

Project Description: The team will undertake to bring unmanned vehicle technology, now in use by the military, to the agricultural market in a much shorter time frame than is now envisioned. The team proposes to develop a precision navigation and perception system. These new systems will become more-and-more cost effective until they are affordable on virtually all agricultural vehicles.

Team Members:
Tom Cecil (ECE '06)
Sarah Leavitt (ECE '06)
Dan Lindquist (ECE '06)
Chris Murphy (ECE '06)
Ann Marie Rynning (ECE '06)

Faculty Advisor: Mark Chang (Elect and Comp Engr)

Sponsor Liaison: David Johnson

---

10. Sponsor: ***Acumentrics Corporation***

Project Description: In this project, the team will design an ethanol reformer for Solid Oxide Fuel Cells, a promising, renewable source of energy.

Team Members:
Amanda Blackwood (E '06)
Etosha Cave (E '06)
Clara Cho (E '06)
Susan Fredholm (ME '06)
Jeff Satwicz (ME '06)
Molly Trombley-McCann (ME '06)

Faculty Advisor: Benjamin Linder (Mech Engr)

Sponsor Liaison: Tom Philbin

---

11. Sponsor: ***Franklin W. Olin College of Engineering***

Project Description: In its campaign against TB, the World Health Organization has identified a major need in the area of diagnostics: an improvement to the smear microscopy test. As simple as the smear test is, it is beyond the abilities of those treating the poorest patients. The project involves using the latest advances in technology to develop a small, portable, robust system that allows the latest advances in technology to develop a small, protable, robust system that allows clinics in remote areas to diagnose TB while the patient remains in the clinic.

Team Members:
Kate Cummings (ECE '06)
Caitlin Foley (E '06)
Nicole Hori (E '06)
Erin McCusker (E '06)
Kate Walsh (ME '06)

Nathan Fox – Babson MBA '06
Mohsin Khan – Babson MBA '07 (non-credit)

Faculty Advisor: Mark Somerville (Elect Engr and Physics)

Sponsor Liaison: J. Garland O'Connell

---

12. Sponsor: ***SAIC Corporation***

Project Description: The goal of this project is to drive a robot vehicle autonomously on dirt paths, avoiding obstacles that it finds along the way. Demonstrations will occur on a robot vehicle that SAIC is providing Olin for testing. Through this project, students will gain experience at refurbishing and maintaining hardware, developing infrastructure for testing, optimizing software, developing new algorithms, system integration and calibration, debugging, testing and evaluation.

Team Members:
Ben Bloom (E '06)
Will Clayton (E '06)
Mike Foss (ECE '06)
Kathy King (E '06)
Sarah Zwicker (ECE '06)

Faculty Advisor: Allen Downey (Comp Sci)

Sponsor Liaison: Jill Crisman

---

13. Sponsor: ***Draper Laboratory***

Project Description: This project seeks to address the problem of mobile robot navigation in GPS-denied environments (indoors, deep canopy, urban canyons, etc.). Given a mobile platform and a collection of sensors to be integrated on the platform, the team should explore/develop hardware configurations and navigation schemes. The SCOPE team should also characterize the performance of various sensor configurations and navigation algorithms.

Team Members: Steve Krumholz (E '06)
Joy Poisel (E '06)
Mikell Taylor (ECE '06)
Janet Tsai (ME '06)

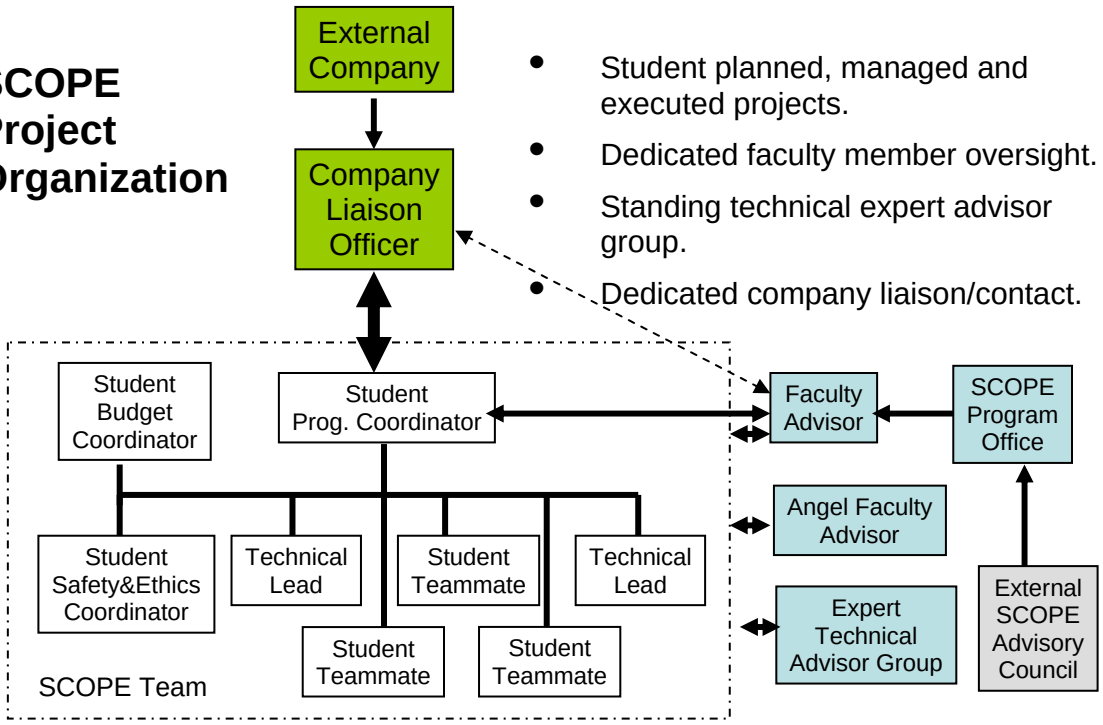
Faculty Advisor: David Barrett (Mech Engr)

Sponsor Liaison: Scott Rasmussen

Degree Programs:

E Engineering
ECE Electrical and Computer Engineering
ME Mechanical Engineering

SCOPE Project Organization



- Student planned, managed and executed projects.
- Dedicated faculty member oversight.
- Standing technical expert advisor group.
- Dedicated company liaison/contact.

APPENDIX B

Program Objectives for the B.S. in Engineering, B.S. in Electrical and Computer Engineering, and B.S. in Mechanical Engineering at Olin College

B.S. in Engineering

Objective I:

Our graduates will be recognized as individuals who can make a positive difference within their profession and their community.

They will demonstrate the ability to recognize opportunity and to take initiative. They will be able to communicate effectively and to work well on teams. They will understand the broad social, economic and ethical implications of their work, and will be cognizant of their professional responsibilities.

Objective II:

Our graduates will demonstrate technical competence and creative problem-solving skills that foster success in a variety of postgraduate environments, including professional practice and graduate school.

They will have a solid grounding in fundamental principles of science and engineering and the ability to apply this knowledge to analyze and diagnose engineering systems. They will be able to develop creative design solutions that are responsive to technical, social, economic and other considerations.

Objective III:

Our graduates will be prepared for social, technical and global changes over their lifetimes.

They will demonstrate the results of a broad education that spans engineering, the arts, humanities , social sciences, and entrepreneurship. They will build on this foundation by engaging in independent learning in order to identify and respond to emerging technical and social developments.

B.S. in Electrical and Computer Engineering

Objective I:

Our graduates will be able to make a positive difference within their profession and their community.

Elaboration: Our graduates will demonstrate the ability to recognize opportunity and to take initiative. They will be able to communicate effectively and to work effectively on teams. They will understand the broad social, economic, and ethical implications of their work, and will be cognizant of their professional responsibilities.

Objective II:

Our graduates will demonstrate technical competence in electrical and computer engineering and will demonstrate creative problem-solving skills that foster success in a variety of postgraduate environments, including professional practice and graduate school.

Elaboration: Our graduates will have a solid grounding in fundamental principles of mathematics, science, and electrical and computer engineering, and the ability to apply this knowledge to the design, analysis, and implementation of engineering systems. They will be able to develop creative solutions that are responsive to technical, social, economic and other realistic constraints and considerations.

Objective III:

Our graduates will be prepared for, and capable of appropriate response to, social, technical and global changes throughout their careers.

Elaboration: Our graduates will possess a broad understanding of math, science, engineering, the arts, humanities, social sciences, and entrepreneurship. They will build on this foundation throughout their careers by engaging in independent learning in order to identify and respond to emerging technical and social developments.

B.S. in Mechanical Engineering

Objective I:

Our graduates will be able to make a positive difference within their profession and their community.

Elaboration: Our graduates will demonstrate the ability to recognize opportunity and to take initiative. They will be able to communicate effectively and to work effectively on teams. They will understand the broad social, economic, and ethical implications of their work, and will be cognizant of their professional responsibilities.

Objective II:

Our graduates will demonstrate technical competence in mechanical engineering and will demonstrate creative problem-solving skills that foster success in a variety of postgraduate environments, including professional practice and graduate school.

Elaboration: Our graduates will have a solid grounding in fundamental principles of mathematics, science, and mechanical engineering, and the ability to apply this knowledge to the design, analysis, and implementation of mechanical engineering systems. They will be able to develop creative solutions that are responsive to technical, social, economic and other realistic constraints and considerations.

Objective III:

Our graduates will be prepared for, and capable of appropriate response to, social, technical and global changes throughout their careers.

Elaboration: Our graduates will possess a broad understanding of math, science, engineering, the arts, humanities, social sciences, and entrepreneurship. They will build on this foundation throughout their careers by engaging in independent learning in order to identify and respond to emerging technical and social developments.

MISSION STATEMENT FOR OLIN COLLEGE

Olin College prepares future leaders through an innovative engineering education that bridges science and technology, enterprise, and society. Skilled in independent learning and the art of design, our graduates will seek opportunities and take initiative to make a positive difference in the world.