

# Defining and Assessing the Competencies of Olin Graduates

by

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**Executive Summary.** An important step in the completion of the academic program at Olin College is the definition and assessment of over-arching competencies of all Olin graduates. These competencies flow from our educational mission and serve to help define and differentiate Olin graduates from others. This paper outlines our current definition of competencies, our plan for assessment of each student's level of achievement of these competencies, and the involvement of external evaluators through the Olin Expo, an innovative all-College event held at the end of each semester in which each student makes a public presentation in which competencies are evaluated by external members of the professional engineering community and others. The questions at the end of the paper are intended to obtain feedback on our list of competencies and our assessment plan from important members of our extended community.

**Background.** By starting from a clean slate, Olin College has had the rare opportunity to rethink the way engineers are prepared, from the ground up. Among the most important aspects of this project is the opportunity to examine the definition of an engineer and to redefine this to better align with the needs of the profession for the foreseeable future. From the beginning, our community has been wrestling with the vision for the type of engineering graduate the College should aspire to produce, and how best to describe this graduate.

We followed a very deliberate process in pursuing these fundamental questions, outlined in our first strategic plan entitled *Invention 2000*. Our earliest founding faculty spent two years without teaching courses, first reviewing best practices at other institutions (about 35 colleges and universities here and abroad, and 20 corporations), working to invent a fresh comprehensive approach to engineering education, then experimenting and developing pedagogical methods and materials, and finally testing of this approach with 30 young student "partners" during the 2001-02 academic year<sup>1,2</sup>. Our mission and educational objectives have been shaped from the beginning by this deliberate process of reflection and reinvention, and by the calls for systemic change in engineering education from the National Science Foundation and corporate leaders. The mission statement for Olin College is: "*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.*"

At the heart of our emerging educational program is our vision for graduates. Few questions are asked more frequently by visitors to the College than what characteristics will distinguish our graduates from those of other excellent engineering schools, and what our graduates will be doing five years after graduation. Most visitors assume this question is much more important to the success of an upstart new program like Olin than it is to more established schools which have the benefit of a long record of successful graduates. Most visitors also assume that the answers must have been crystal clear from the start, and that they must be crisply articulated in some founding document. It is natural to assume that our "engineering product" must be clearly

<sup>1</sup> "*The Olin Curriculum: Thinking Toward the Future*," M. Somerville, D. Anderson, H. Berbeco, J. Bourne, J. Crisman, D. Dabby, H. Donis-Keller, S. Holt, S. Kerns, D. Kerns, Jr., R. Martello, R. Miller, M. Moody, G. Pratt, J. Pratt, C. Shea, S. Schiffman, S. Spence, L. Stein, J. Stolk, B. Storey, B. Tilley, B. Vandiver, and Y. Zastavker, **IEEE Trans. On Education**, Vol. 48, No. 1, pp. 198-205 (Feb. 2005).

<sup>2</sup> "*Designing from a Blank Slate – The Development of the Initial Olin College Curriculum*," S. Kerns, R. Miller, and D. Kerns, Jr., **Educating the Engineer of 2020: Adapting Engineering Education to the New Century**, National Academy of Engineering, Washington, DC, (to appear, 2005).

differentiated in the educational market place by some obvious focus or defining characteristic. When we tell them that no single defining characteristic differentiates us from all others, their level of concern often increases visibly.

Our vision for engineering education is broad, not narrow or confining, and our mission is more centered on people than things. We intend to prepare leaders who are able to predict, create, and manage the technologies that will shape the future. Furthermore, we view the study of engineering more as an education for life in the 21<sup>st</sup> century than training for a specific technical career. We want our education to open more doors of opportunity for our graduates than it closes. We believe that creativity and design are at the heart of all true engineering enterprise, and we believe that entrepreneurial thinking, or the process of taking initiative to bring new ideas to life, is essential to the development of our nation's economic future. We think engineers must think of themselves not as technicians with specialized training who invent "things," but as capable and well rounded leaders who are equally comfortable working with the forces of nature and with such human forces as economics, sociology, and political science. While these aspirations may not be unique within the engineering education community, the intensity and scope with which we are pursuing them is certainly a differentiating characteristic of our program.

But probably the most important yet hidden feature of our vision for engineering education is the centrality of the students themselves in defining and evolving our educational process. Perhaps the most profound lesson learned in our two year invention process is the value added by involving students in the invention of their own educational program. We believe that bright students are far more capable, even at an early stage in their development, than most educators would imagine. Not only are they able to achieve academically more than we would expect if they are challenged and encouraged to explore on their own, but they are also able to contribute beyond their years in planning and administrative problem solving as true colleagues with faculty and staff. As a result, we have involved students in more responsible roles in the development and operation of our institution than some would think is wise, or even possible. Developing the full potential of every student is our highest priority, and encouraging them to aim high and not limit their goals and expectations is one of our most fundamental messages to them. As a result, we believe our students may mature faster and develop independence and leadership abilities more quickly than those in more traditional environments. We believe that embracing this expansive educational vision will help produce engineers who will excel as technical contributors and become indispensable members of the senior staff responsible for planning and shaping the future of our technology enterprise. In addition, some of our graduates may never intend to practice engineering in a traditional corporate setting, but rather they may choose to pursue other fields, like medicine, business, law, or education, or they may choose to start their own enterprise. We do not make them feel uncomfortable about such aspirations, but instead encourage them to realize their full and unique potential.

**Competencies of Olin Graduates.** Since our first commencement is scheduled for next year, we do not yet have any graduates. Therefore, any attempt to describe our graduates is necessarily speculative based upon our vision and plans, not on evidence or fact. Nevertheless, it is urgent at this point for several reasons that we propose useful and detailed descriptions of the graduates of our program. We have begun by developing a set of defining characteristics, or competencies, of all Olin graduates. This set of competencies was developed by a committee of key faculty, staff, and students last year, working from our mission and educational vision, together with the list of competencies required by our accreditation agency, the Accreditation Board for Engineering and Technology (ABET). Since Olin College has been committed from the start to providing ABET accredited degrees, we have been firmly focused on designing a program that meets all of the ABET requirements in each program, including these competencies. A copy of the list of Olin competencies together with a list of the required ABET competencies is provided as an attachment to this paper. The list of Olin competencies includes nine general competencies, including: qualitative analysis, quantitative analysis, teamwork, communication, lifelong learning, understanding of context, design, diagnosis, and opportunity assessment. This list and the accompanying brief descriptions represents our best thinking at this point as a

community on what the baseline competencies for all Olin graduates should be. In choosing this particular set of competencies our intent is to do our best to prepare our graduates to excel in life and in their careers. We have assumed that this list of competencies is central to the success of our graduates as engineers and also as leaders in many fields, and we are building our academic program to provide for growth and assessment in each area.

A major purpose of this paper and the associated meeting of the President's Council is to obtain feedback from many constituencies off campus about our proposed competencies. In particular, we need to hear from many different perspectives whether this list does the best job of addressing the competencies that our graduates will need in their careers. If some important competencies are missing from the list, we need to learn this as soon as possible. Equally important, we need to know whether some of the competencies currently listed are much less important than the others, or are likely to become much less important in the years ahead. Focusing on the best possible list is of central importance at this stage as we continue to build our academic program.

It is important to understand that a "competency" is not the same thing as a passing grade in a course. Competencies are broad capabilities that extend well beyond the goals and objectives of a single course. They involve developing enduring knowledge, skills, attitudes, and experience in a sufficiently wide array of contexts that enable the graduate to reliably employ these strengths in problem solving in a professional environment. In addition, the development of competencies, like the development of proficiency in a new language, is a cumulative process, and should show growth over an extended period of time, measured in years.

In explaining the concept of competencies to our students, we note that when faculty members are asked to write a letter of reference for employment or graduate school, they naturally focus on describing the special strengths or competencies of the student, and not simply recite the grades in courses. This personalized reference provides very important insight into whether the student works well in teams, communicates well at conferences and in small groups, is an independent thinker with a high degree of creativity, is entrepreneurial with a special knack for identifying opportunities and taking the initiative to create and manage new solutions, is committed to lifelong pursuit of learning and scholarship, etc. Thus, there is a sense in which we are helping our students focus early on building those enduring traits that we think will be most meaningful in pursuing the next stage in their professional development.

**Assessing Competencies at Olin.** In order to insure that our graduates demonstrate the competencies that we feel are important, a comprehensive assessment program is necessary. We have found that developing such a program is remarkably difficult. It involves several important and independent steps. First of all, reaching a common understanding of exactly what is meant by each of the competencies is inherently subjective, requiring a great deal of discussion. Next, defining a minimum standard of competence in each area is equally challenging, for the same reason. At the next level, developing clear metrics for inherently subjective competencies, and reaching a solid community understanding of these metrics is also difficult. Finally, developing a systematic method for implementing the standards and metrics and tracking the progress of each individual student in each competency is another complex task.

We have developed an assessment plan that we believe meets these challenges, and also is designed to address the expectations of ABET in this regard. However, since we do not have long experience with our plan, we are also interested in feedback from others on how the process may be improved, and this is an important purpose for this paper.

Our competency committee last year proposed the framework for a comprehensive competency assessment system, and we have begun to implement it during this academic year. The system includes regular assessment of all students in competency development both inside and outside of academic courses, and involves students in creating their own reflective portfolios that document their competency development from year to year. Students are required to create and

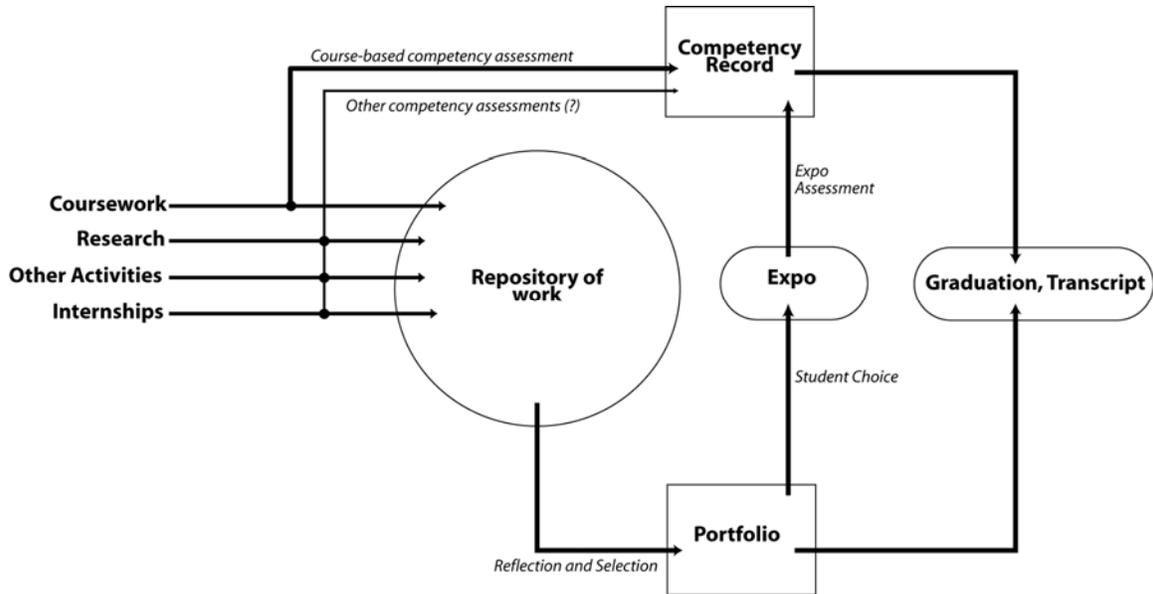
maintain an electronic “repository” of their work at Olin College. This private repository contains materials selected from their coursework, research, summer internship activities, extra-curricular activities, etc., as shown in Figure 1. From this repository, examples of work are selected out, accompanied by a self-reflection that explains how the selected example demonstrates a particular competency, and placed in a separate electronic “portfolio” of work. The student and his/her academic advisor regularly review the materials in the portfolio to monitor individual progress on development of competencies.

Independently from this student-maintained portfolio, the College maintains a separate confidential “competency record” for each student. This record includes competency assessments based on performance in academic courses, letters from employers, and other evidence of competency development.

**The “Olin Expo”.** An innovative aspect of our assessment system is the use of the “Olin Expo” for selecting material from the portfolio and presenting it twice each year for assessment and inclusion in the competency record. Under this plan, after final exams each semester, every student must select one example of work from the portfolio for presentation to the entire Olin community in a two-day special *expo* event. The presentations consist of either a solo presentation to an audience for assessment by evaluators in a classroom, or preparation of a poster and solo performance in answering questions from evaluators at a special session designed for this purpose. The first experience at Olin College of the Expo was last December. Within a two-day period, more than 200 individual student presentations were conducted and evaluated by our faculty, staff, students, and more than 50 external evaluators, mostly from local corporations. A copy of the detailed schedule for the December Expo is included as an attachment to this paper. The event had the feel of a combination of a major technical meeting and a sophisticated engineering project fair. It was a major College undertaking to organize and sponsor this event, but nearly all who attended were very positive about its value to our educational program.

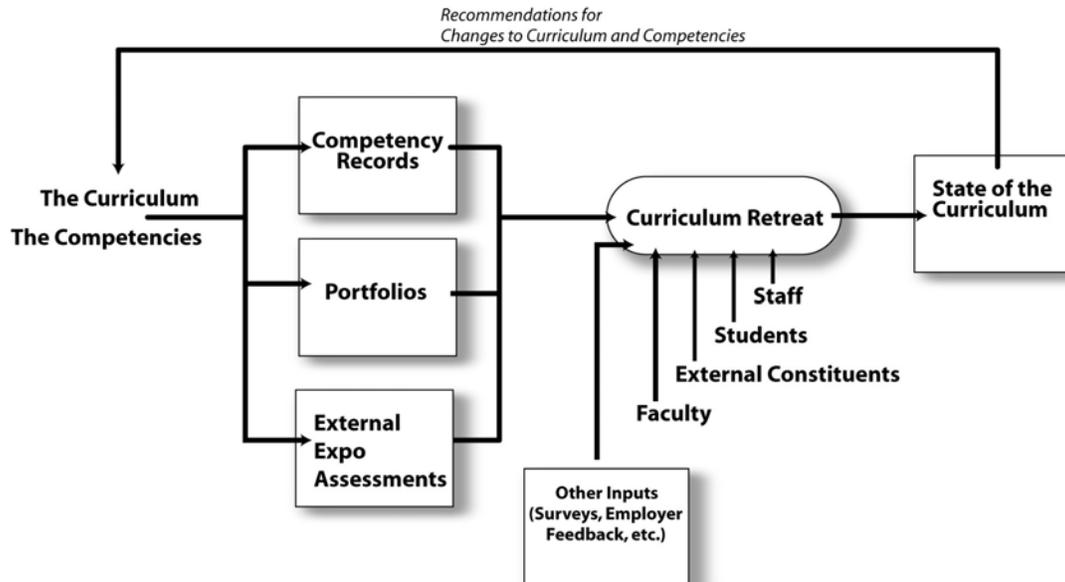
We learned a great deal about working with external evaluators from our experience with the first Expo event. As a result, we changed the form used by external evaluators for assessing competencies of individual students. A copy of the revised form to be used in the second Expo event on May 18-20, 2005, is also attached to this paper. The changes in the form involved a shift toward more qualitative and descriptive overall assessment and less numerical assessment of individual competencies. The second Expo event is scheduled for May 18-20, 2005.

Finally, the assessment system includes a competency certification process as part of the requirements for graduation. Student portfolios and competency records will be used by a certification committee to determine the students’ final levels of competency attainment, and certify that these levels exceed the standards required for graduation in each competency. Our plan is to report these final levels of competency on the student transcript.



**Figure 1: Illustration of major components of competency system from the perspective of an individual student. Competency is assessed both inside and outside coursework; meeting minimum competency requirements is necessary for graduation.**

The system also provides an important opportunity for the College to assess the overall effectiveness of the curriculum in preparing students for graduation, and identifying needs for improvement and innovation. An annual curriculum retreat after the spring semester is held to review the evidence across the College of development of competencies, and to develop recommendations for changes to the curriculum and to the competencies or assessment system. This is illustrated in Figure 2.



**Figure 2: Illustration of curricular feedback mechanism from the institutional perspective. Portfolios and Competency Records form the basis for discussion of curricular strengths and weaknesses, which in turn informs curricular reform annually.**

**External Advice.** We suspect that many industrial colleagues have a significant interest in assessing and fostering competencies similar to ours among their employees and have developed various means for accomplishing this. For example, determining which employees are highly competent at opportunity assessment, teamwork, communication with clients and colleagues, diagnosis and solution of problems, etc., most likely involves similar concerns about definitions of the desired competencies, standards and metrics, and systems of assessment which are accurate, objective, and fair. Therefore, we hope that those who attend the meeting with a corporate background will help provide advice and recommendations based on best assessment practices from industry.

In addition, our current assessment plan involves external evaluators in the Expo program, as previously discussed. We would appreciate your help in recommending how we may make best use of the time and effort of our external evaluators in the Expo program to bring corporate views and standards to bear on our assessment process.

Of course we are equally interested in learning best practices at other academic institutions in assessment of competencies. If you are associated with another college or university we hope you will provide us with advice and recommendations on how we might improve our assessment program.

**Questions for Discussion.** The College could benefit most from a focused discussion during the break-out sessions at the meeting around the following questions:

1. Can we improve on the list of competencies we have defined for our graduates, given the career paths we envision for our students? Are any major competencies obviously missing from this list? Are any that are listed much less important than the others?
2. How does your organization assess similar competencies among employees? How do you foster growth and development of these competencies among your staff?
3. How can we make best use of the time and effort of external visitors as student evaluators at our Expo event (and similar activities)? To what extent do external visitors require training before engaging in the assessment process?

Your comments on these questions are important to us, and will be given serious consideration.

## **Olin College Student Competency Requirements**

1. **Qualitative Analysis:** Students are able to analyze and solve problems in engineering and other disciplines qualitatively, including estimation, analysis with uncertainty, and qualitative prediction and visual thinking.

2. **Quantitative Analysis:** Students are able to analyze and to solve problems in engineering and other disciplines quantitatively, including use of appropriate tools, quantitative modeling, numerical problem solving, and experimentation.

3. **Teamwork:** Students are able to contribute effectively in a variety of roles on teams, including multi-disciplinary teams.

4. **Communication:** Students are able to convey information and ideas effectively, to a variety of audiences, using written, oral, and visual and graphical communication.

5. **Lifelong Learning:** Students are able to identify and address their own educational needs in a changing world, including awareness of personal attributes, fluency in use of information sources, career planning, and self-directed learning.

6. **Understanding of Context:** Students are able to demonstrate understanding of the ethical, professional, business, social, and cultural contexts of engineering and other disciplines, and able to articulate his or her own professional and ethical responsibilities.

7. **Design:** Students are able to develop creative, effective designs that solve real problems through concept creation, problem formulation, application of other competencies, balancing tradeoffs, and craftsmanship.

8. **Diagnosis:** Students are able to identify and resolve problems within complex systems through problem identification, formation and testing of a hypothesis, and recommending solutions.

9. **Opportunity Assessment and Development:** Students are able to identify opportunities, to predict challenges and costs associated with the pursuit of opportunities, and to muster resources in response to opportunities.

## Accreditation Board for Engineering and Technology

2005-06 Engineering Evaluation Criteria  
Criteria for Accrediting Engineering Programs

### **“Criterion 3. Program Outcomes and Assessment**

*Although institutions may use different terminology, for purposes of Criterion 3, program outcomes are statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.*

*Each program must formulate program outcomes that foster attainment of the program objectives articulated in satisfaction of Criterion 2 of these criteria. There must be processes to produce these outcomes and an assessment process, with documented results, that demonstrate that these program outcomes are being measured and indicates the degree to which the outcomes are achieved. There must be evidence that the results of this assessment process are applied to the further development of the program.*

*Engineering programs must demonstrate that their students attain:*

- (a) an ability to apply knowledge of mathematics, science, and engineering*
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data*
- (c) and ability to design a system, component, or process to meet desired needs within realistic constraints such as economical, environmental, social, political, ethical, health and safety, manufacturability, and sustainability*
- (d) an ability to function on multi-disciplinary teams*
- (e) an ability to identify, formulate, and solve engineering problems*
- (f) an understanding or professional and ethical responsibility*
- (g) an ability to communicate effectively*
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context*
- (i) a recognition of the need for, and an ability to engage in life-long learning*
- (j) a knowledge of contemporary issues*
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.*

*In addition, an engineering program must demonstrate that its students attain any additional outcomes articulated by the program to foster achievement of its educational objectives.”*