I. Introduction

The reform movement in engineering education is providing several lessons in culture change within the academic setting. From the development of interdisciplinary curricula to the new focus on outcomes-based assessment, faculty, administration, students, alumni, and parents are experiencing the push and pull of these changes. This paper focuses on the need to clearly define the intended institutional outcomes. The process of developing culture change metrics is described and the results from seven engineering schools are explored. The paper includes several samples of aggregate results demonstrating both the benefits and challenges of collecting such information.

Based on the experience of the seven institution members of the Gateway Coalition for Engineering Education, we describe in detail the steps taken to define objectives and the metrics used to measure progress. The goals of the Coalition are derived from the common interests, vision, and expectations of the collective body of individual institutions and supported by the facilitating role and influence of cross-coalition support functions, such as outcome assessment and technology. The Coalition has defined six major functions and related objectives that address those common interests, goals, and vision. The six major objectives are as follows:

Objective 1. Implement and continuously improve innovative and adaptable curricula, driven by the work of the coalition and others, recognizing the needs of students, industry and society.

Objective 2. Imbed a culture in the learning environment for Professional Development of faculty and students.

Objective 3. Broaden Diversity of race, gender and socio-economic status to enlarge the opportunities for development of our human capital and to enhance the respect for, and benefits of, diverse cultures.

Objective 4. Broaden the use of Information Technology to further the learning and educational objectives.

Objective 5. Routinely link and share with others to transcend individual, disciplinary, and intra-institutional and inter-institutional boundaries.

Objective 6. Imbed Assessment and Evaluation, as well as continuous improvement, as a fundamental ingredient of the educational process.
II. Objective Setting Processes

These Coalition-wide objectives were developed through an iterative process involving the Deans and Governing Board Members from each of our seven partner institutions. A multi-step process was established in order to identify and define specific strategies that would be implemented over a multi-year period in order to achieve these objectives. Additionally, measurable outcomes and assessment methods were identified to ensure that these strategies would yield the desired results - attainment of the six stated objectives.

The first step of this process was to define a set of strategies, along with associated outcomes and assessment methods for each of the six objectives for the Coalition as a whole. This was accomplished through a series of iterative discussions and debates among the Deans and Governing Board Members, supported by the counsel of Gateway’s Assessment Director and the local assessment coordinator from each partner institution. The result of this first step was a documented set of strategies to support each of the six major objectives.

The next planning activity was for each partner institution to work through an internal committee to identify specific strategies that would be implemented in order to support the achievement of the six coalition-wide objectives. Driven by the Dean and the Governing Board Member, each institution worked with faculty and the assessment coordinator to identify and define what strategies and actions would be taken in support of each major objective. For each strategy, a measurable outcome and assessment method was identified. In some cases, outcomes were differentiated by time - short vs. long-term targeted accomplishment. The result of this second step was a documented set of institutional strategies to support each of the Coalition’s six major objectives. Figure 1 provides a sample for one of the objectives (Objective 6) at one institution.

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<tr>
<th>Strategies and Actions</th>
<th>Timetable</th>
<th>Outcome Indicators</th>
<th>Benchmarks</th>
<th>Assessment Processes</th>
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<tr>
<td><strong>A1.</strong> Enhance existing course evaluation system based on pilot test Spring 2000</td>
<td>Complete revisions by 10/00</td>
<td>• Increasing student and faculty participation in feedback process on courses</td>
<td>• By the end of year 9, 100% of students will participate in course evaluation system</td>
<td>• Institutional Metrics (A2, A5)</td>
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<td><strong>A2.</strong> Establish system in collaboration with career services to solicit information on student and graduate learning from employers and recruiters</td>
<td>Design system and surveys Fall 2000 Implementation Spring 2001</td>
<td>• Increasing input from external constituents on student learning outcomes</td>
<td>• By the end of year 9, 100% of departments will participate in first administration of employer survey process.</td>
<td>• Institutional Metrics (E6)</td>
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<td><strong>A3.</strong> Continue Program-wide External Review Process</td>
<td>Self-studies due – 12/00 External visits – 6/2001 Reports – 9/01</td>
<td>• Increasing faculty efforts towards program improvement</td>
<td>• By the end of year 9, at least 4 departments will have been reviewed.</td>
<td>• Unit Self Study reports • External Review Team Reports • Unit Improvement Plans</td>
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**A4. Create a comprehensive assessment system, delivered over the web. Systems to include course evaluations, longitudinal tracking, student, faculty, alumni, and employer surveys.**

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<th>System Design</th>
<th>Fall 00 Pilot Test Fall 01 Full implementation and dissemination Fall 02</th>
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<td>• Increasing use of assessment data for School-wide feedback and continuous improvement.</td>
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<td></td>
<td>• Product fully applicable to other universities and colleges.</td>
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<td>• Increasing use of system by external institutions.</td>
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<td></td>
<td>• By the end of year 9, 100% of students and faculty will participate in course evaluation system.</td>
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<td>• Year 10 – full system implemented.</td>
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<td>• Product development milestones.</td>
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<td>• User feedback.</td>
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<td>• Internal and External product usage metrics.</td>
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**Product Realization**
- WCES – Web-based Course Evaluation System
- Compendium of all surveys conducted
- Web-based Comprehensive Assessment System
- Manual for External Academic Review Process

The third step was to have each of our partner institutions use these committees to work with administrators, faculty, and external constituents to define departmental and course-level objectives, strategies and measurable outcomes. The Departmental level focuses on the learning objectives, strategies, and outcomes of academic programs and the effect these have on graduates as a result of the curriculum offered. Course-level objectives, strategies, and outcomes help to define what learning outcomes are expected as a result of a specific course.

The Gateway objectives served as a catalyst and driving force for the identification of institutional, program, and course objectives. Our partner institutions tended to focus on the departmental and course levels in support of their ancillary needs to address ABET 2000 accreditation activities and the associated eleven student learning outcomes. However, institutional level objectives cannot be overlooked and were critical to measures that were of interest to identify Coalition program outcomes. In fact, most accreditation bodies also require a clear linkage between the program/course objectives and College-wide mission and goals. Thus, the Gateway objectives became an integral part of the planning process at all levels of the College – institutional, program, and course.

In order to support these formal-planning efforts, Gateway Central developed workbooks for departmental and course-level planning. All participating staff and faculty received copies of these workbooks. Additionally, these workbooks were placed on our web site [http://www.gatewaycoalition.org/assessment/faculty_tools.cfm](http://www.gatewaycoalition.org/assessment/faculty_tools.cfm) and are downloadable for those, within and external to the Coalition, requiring additional copies.

As a Coalition, we are committed to providing a leadership role in inculcating this type of planning and objective-setting process in our schools as a model for higher education. We have taken a major step by facilitating and supporting the identification and definition of objectives, strategies, outcomes, and assessment methods at each of our partner institutions at the departmental and course level.

**III. Developing Quantitative Metrics to Measure Objectives**

Early steps focused on taking each of the Coalition’s major objectives and creating lists of potential measures that would clearly operationalize each objective. The purpose was to clearly...
define what the outcome should look like when the objective is achieved. This was a very important part of the work. It is not uncommon to uncover a real disconnect among the various faculty and administrators across institutions during this process. Many times, this process helped to uncover poorly articulated objectives and faulty expectations. One of the benefits of this process was to help make it clear to all involved administrators and faculty what each Coalition objective meant in terms of implementation and institutionalization.

The process of identifying these metrics was iterative as well. First, all Gateway Board members were asked to work with their deans and faculty to produce a potential list of metrics for each of the Gateway objective areas. The authors of this paper supplied a template that included a list of potential measures as a model to facilitate the institutional discussions. Once all the institutional meetings occurred, gateway administrators and governing board members selected a final list based on commonalties across the schools. This list was also sent to select members of our National Visiting Committee as well as to our Dean’s Council.

The above process generated a final list of 39 quantitative metrics (See Appendix A) that the institutions have been using to track the institutionalization of curricular and pedagogical innovations. Once each objective had its set of related metrics, the schools initiated the data collection phase of the project. This included the gathering of current data as well as information since the inception of the Coalition program. Types of data collected included mostly archival information in such areas as enrollment, retention, and graduation rates. Other data was derived from program records and faculty recollection regarding participation rates and use of technology in the classrooms. Several local surveys were developed to support the collection of metric related data, especially in areas of technology use and outcome assessment methods implemented by faculty. Each institution also projected outcomes for future years, including one-year post the Gateway award. These projections became an integral part of each year’s planning process to support the validity of both the plans and intended outcomes.

The final stages of the metric program include the analyses, reporting, and use of the data derived from the 39 measures for continuous improvement purposes. Finally, each institution created a system diagram illustrating for all stakeholders the full closed loop assessment process indicating interconnections from the start of the process of definition setting through data collection, analysis, feedback, and process for feedback impact. Selected results from our analyses are provided below.

IV. Selected Results

Objective: Innovative Curricula – Metric F1.

We used a straightforward method to measure and monitor our progress regarding the institutionalization of freshman design experiences. One can see that the various programs are increasing in the number of participants (students and faculty) as more modules or models from among the prior developments are integrated into existing courses and we move the number of existing pilot projects into the mainstream of the curriculum. The majority of first year students, enrolled in Gateway institutions, participate in freshman design experience. Nearly 3000 undergraduates impacted in Fall 1999/Spring 2000 as illustrated in Figure 2.

There are a number of metrics focusing on the professional development activities of engineering faculty at each of our partner schools. By keeping track of how many faculty attended ASEE, PIE, and other educationally-related conferences, we could measure the influence that Gateway was having on faculty culture (Fig. 3).

Objective: Underrepresented Populations – Metrics C.

The Coalition has collected baseline data, and has a historical record for each year beginning with the 1987/88 academic year of each Partner institution for such variables as persistence rates for each cohort year, enrollment, and graduation rates. For each of these measures, data is further segmented by gender and ethnicity. While it is difficult to judge cause and effect relationships with many of these metrics, general directionality and trends can provide inference of program effectiveness. Looking at selected retention and graduation rates below (Fig. 4 and Fig.5), trends appear to demonstrate support for the effectiveness of the many mentoring and advising programs implemented through Gateway efforts.
Objective: Technology – Metric D1 & 2.

Monitoring the number of courses that are using new learning technologies is one means to see to what extent faculty are integrating these tools into the curriculum. It was important to supply faculty with a standard definition of what was meant by new learning technologies. For this metric, use of the Internet and multimedia presentations or tutorials were considered new technologies. Use of email was not, while web conferencing was counted.
Objective: Assessment – Metric A1

In order to support and monitor our objective setting and assessment processes, we monitored each institution’s progress in developing both program and course objectives. Over 75 engineering and non-engineering programs are following the structured assessment program with 100% dean and department chair participation.

Objective: Linking & Sharing – Metric E.

Through our Academic Associates Program, our schools have partnered with several non-coalition universities, community colleges, and K-12 schools in support of technology transfer. Our objective is to establish relationships where both parties commit to work together to transfer the innovation. The activities go beyond the dissemination of materials and include direct facilitation by members of the Coalition with these institutions’ Deans, Department Chairs, and
Faculty. We asked each school to quantify the number of non-coalition schools in which direct facilitation occurred. Direct facilitation was defined as having one or more meetings to transfer specific program elements to the receiving school. Additionally, some follow up mechanism had to be in place.

![Figure 8 - Gateway Coalition Non-Coalition Institutions Adapting Gateway Innovations](image)

V. Monitoring Coalition-Wide Activities and Programs

To support and monitor the achievement of our coalition-wide objectives, described earlier, we have established and implemented three formal mechanisms: Quarterly Reports, the Gateway Review Process, and the National Visiting Committee.

**Quarterly Reports.** Each Dean/Governing Board Member at our quarterly Governing Board meetings submits a formal report. A major portion of these meetings is dedicated to the presentation and review of each institution’s plan. Strategies to support each of the Coalition’s six major objectives are discussed and advice on implementation and institutionalization provided. These reports serve as the foundation for self-study documents used in the Gateway Review Process discussed below and the discussions serve to share, learn, and disseminate experiences among the Coalition schools.

**Gateway Review Process.** The Coalition has established the Gateway Review Process, an internal peer review process that has been implemented twice since our last NSF review. The main thrust of these internal reviews is to ascertain and provide feedback on the extent to which the institution has made progress towards their stated objectives and outcomes. The internal peer review program (Gateway Review Process) is conducted annually with results discussed extensively by the full Governing Board and recommendations provided to each Dean respectively.

**National Visiting Committee.** At the Coalition level, we have made a concerted effort to establish formal linkages with industry. This is in addition to such initiatives at each institution. The main mechanism for soliciting input from industry is our National Visiting Committee. This
Committee is comprised of senior-level industrial managers as well as recognized leaders from academia. In order to achieve strong linkages between our National Visiting Committee and each of our partner institutions, Deans were asked to select at least one industrial representative currently serving on their local industry advisory board.

The general role of the National Visiting Committee is to provide advice and guidance to the Principal Investigator, the Deans, and Governing Board Members. Committee Members serve as a liaison between the Coalition and the local advisory boards established at each partner institution. Members discuss Coalition activities and accomplishments at the local level. Committee Members provide information and feedback from the local advisory boards to the Coalition.

VI. Conclusion

The objective setting and quantification of intended outcomes through a selected set of metrics has had several advantages. First, these processes have helped each partner school to clarify their objectives and outcomes to all constituents. As noted, many misunderstandings were uncovered during the process. These procedures greatly improved communication both within each school as well as across Gateway partner institutions.

Secondly, by quantifying intended outcomes, the institutions were able to monitor their programs against specific numerical goals. The act of projecting future goals facilitated greater forward planning at each institution than had previously been implemented.

Finally, the quantification, in association with other more qualitative measures, helped to measure and support the impact of Gateway programs both in terms of program effectiveness and culture change.

VII. Appendix A. Metrics by Gateway Objective Area

A. Assessment and Continuous Improvement
   1. Undergraduate programs with explicitly documented mission statements and educational objectives, outcomes, and assessment processes.
   2. Undergraduate courses with explicitly stated educational objectives, outcomes, and assessment processes.
   3. Gateway dollars spent on assessment initiatives for past year and its percent of total assessment expenditures.
   4. Undergraduate courses that apply alternative assessment processes (beyond traditional classroom tests) to measure student learning outcomes.
   5. Undergraduate students that have participated and benefited from the use of alternative assessment processes, such as self and peer evaluation, portfolios, etc.
   6. Is longitudinal tracking in place? If yes, is it done as part of the University’s central student information system or as an independent local process within a department or the College?
   7. Which Cohorts (class of 97, class of 98, alumni, etc.) are being tracked longitudinally?
B. Professional Development
1. Senior (tenured) faculty attending educational-oriented conferences/symposia, such as ASEE and FIE, in the past year.
2. Junior (non-tenured) faculty attending educational-oriented conferences/symposia, such as ASEE and FIE, in the past year.
3. Formal in-house faculty development seminars and workshops conducted during the past year.
4. Senior (tenured) faculty who have attended at least one formal professional development seminar or workshop in the past year.
5. Junior (non-tenured) faculty who have attended at least one formal professional development seminar or workshop in the past year.
6. Gateway dollars spent on faculty development initiatives for past year and its percent of total faculty development expenditures.

C. Underrepresented Populations
1. Number of engineering degrees awarded annually by gender, minority group, and total.
2. Annual enrollment by gender, minority group, and total per class (i.e. freshman/sophomore, etc.)

D. Educational Technology
1. Undergraduate lower division courses that use multimedia or internet-based materials to supplement student learning.
2. Undergraduate upper division courses that use multimedia or internet-based materials to supplement student learning.
3. Undergraduate lower division courses that incorporate distance learning applications such as videoconferencing or web-based communication with learners/instructors outside classroom.
4. Undergraduate upper division courses that incorporate distance learning applications such as videoconferencing or web-based communication with learners/instructors outside classroom.
5. Meetings conducted with external institutions, faculty, staff, industry, etc., using technology-enhanced communication such as videoconferencing and other collaborative software.
6. Gateway dollars spent on technology for classroom/educational delivery initiative for past year and percent of total educational technology expenditures.

E. Linking and Sharing
1. Papers presented at educational-oriented conferences, such as ASEE and FIE, in the past year.
2. Papers published based on Gateway-related technical and educational initiatives.
3. Faculty and administrators who interacted with local advisory board members during the past year.
4. Presentations describing Gateway and its activity to visitors to your institution during the past year.
5. Formal linkages with other institutions for the purpose of exporting your Gateway initiatives.

F. Curriculum Innovation
1. Freshman students having engineering design experience or course during past year.
2. Undergraduate freshman/sophomore courses with cooperative team learning integrated into classroom experience during past year.

3. Undergraduate junior/senior courses with cooperative team learning integrated into classroom experience during past year.

4. Junior/Senior undergraduate courses that are interdisciplinary – team-taught by faculty from different engineering or other disciplines.

5. Freshman/Sophomore course credits in which the course encompasses an integrated approach among several disciplines of engineering.

6. Freshman/sophomore course credits in which the course encompasses an integrated approach of engineering and math, physics, chemistry or biology with engineering as the core topic.

7. Freshman/sophomore course credits in which the course encompasses an integrated approach of engineering and the humanities or social sciences.

8. Freshman/sophomore engineering students participating in formal instruction involving oral and written communications.

9. Freshman/sophomore engineering students participating in formal instruction involving professional issues of ethics and social responsibility.

10. Courses represented by items F1-F9 are a part of the regular (institutional issued) course/program catalog.

11. Gateway dollars spent on curriculum innovation and institutionalization initiatives for past year and percent of total curriculum innovation-related expenditures.

12. Freshman/sophomore courses taught by engineering faculty.

13. Senior (tenured) faculty teaching freshman/sophomore engineering course.

ELI FROMM
Eli Fromm is the Roy A. Brothers University Professor and Director of the Center for Educational Research in the College of Engineering of Drexel University. He has held a number of academic leadership positions and included among them are Vice President for Educational Research, Vice Provost for Research and Graduate Studies, and interim Dean of Engineering at Drexel. He has also held positions with the General Electric and DuPont companies, has been a staff member of the Science Committee of the U.S. House of Representatives as a Congressional Fellow, a Program Director at NSF, and a Visiting Scientist with the Legislative Office of Research Liaison of the Pennsylvania House of Representatives. He has been Principal Investigator of a number of bioengineering research projects involving implantable transmitters and sensors and their use in physiologic measurements. He was the Principal Investigator of the Drexel E4 educational reform project and is Principal Investigator of the Gateway Engineering Education Coalition. He is a Fellow of the IEEE, a Fellow of the AIMBE, and recipient of a number of other awards and honors.

JACK MCGOURTY
Jack McGourty is an Associate Dean at the Fu Foundation School of Engineering and Applied Science, Columbia University. He is also the Director of Assessment for the Gateway Coalition, supporting the partner institutions in the development and implementation of formal assessment programs. Jack holds visiting and research professorships at several institutions including Drexel University, New Jersey Institute of Technology, and Stevens Institute of Technology. His
research focuses on how assessment processes can enhance student learning, academic program effectiveness, and curricular innovations.