This chapter presents an innovative framework for a mechanical engineering program of study termed desegregated learning. The goal is not desegregation but rather to promote a higher level of learning and to look for opportunities where desegregating the learning environment yields optimal results with reasonable costs and complexity.

Desegregated Learning: An Innovative Framework for Programs of Study

Arturo A. Fuentes, Robert Freeman, Stephen Crown, Javier Kypuros, Hashim Mahdi

Engineering education must be realigned to address complex and dynamic pedagogical-cultural issues in order to provide the knowledge base and intellectual capability for career-long learning. A common theme of several studies on undergraduate education since the 1980s is that engineering is an integrative process and that curriculum innovation therefore should serve this end (Bordogna, 1989; Bordogna, Fromm, and Ernst, 1993; David, 1987; Ernst, 1989; Lohmann, 1991; National Science Board, 1986; Quinn, 1993). This chapter presents an innovative framework for an integrated mechanical engineering (ME) program of study, which we term desegregated learning. The goal is to promote a higher level of learning and to look for opportunities where desegregating the learning environment yields optimal results with reasonable costs and complexity. A higher level of learning implies that students are able to explain what they have learned in their own terms and apply it to problems that are out of the context in which the concepts were learned. The goal is also to make the study and teaching of engineering more attractive and fulfilling.

Reforming current programs of study into effective programs requires consideration of desired learning outcomes, student and faculty needs, and desegregated learning. Desegregated learning involves tearing down an existing pedagogy and culture of segregation prevalent in higher education. Segregation in current learning environments, which may be detrimental,
includes the following important aspects: course content, educational programs, educational setting, student involvement, faculty involvement, and student and faculty demographics.

**Segregation of Course Content.** The segregation of course content into single, semester-long classes is the norm for the delivery of course content in higher education. This segregated structure allows students greater flexibility in scheduling courses and enables faculty to focus course content on their area of expertise. There are, however, disadvantages to segregating course content to the extent that is currently practiced. Students have difficulty retaining and integrating concepts from one course to another and have difficulty looking at problems holistically. It is possible to satisfy the needs of flexibility and focus while not sacrificing the benefits of desegregation by striking a balance. Integration should increase student awareness that many of the fundamental principles are the same across domains (for example, First Law of Thermodynamics and Work-Energy as applied in Dynamics) and that all domains are involved simultaneously in real engineering problems.

**Segregation of Educational Programs.** The majority of educational programs have clear boundaries, and students are generally not encouraged to cross those traditional boundaries. However, a significant amount of the innovative design and research in industry and academia is taking place at the boundaries of the traditional science and engineering fields (for example, bioengineering and nanotechnology). Furthermore, most real-world problems are multidisciplinary in nature. Universities need to expose and prepare students to work in multidisciplinary teams and to feel comfortable crossing traditional boundaries. They need to enhance student capabilities to build connections between different fields of endeavor.

**Segregation of Educational Setting.** Most of the current programs in higher education focus only on the hours that students spend in the classroom and laboratories, overlooking the many opportunities for guided learning in other settings. Having a diversity of educational settings not only provides flexibility in the locations and times for learning, but also allows faculty to instruct students in different mental or emotional states. Universities need to develop ways to link learning to other aspects of students' lives.

**Segregated Student Involvement.** Students are almost exclusively grouped and taught by classification (first-year, sophomore, junior, and senior). Although segregation by classification is viewed as a practical solution for courses that assume prerequisite skills, introducing interaction among these groups could be beneficial. At a minimum, interaction can engage students in engineering beginning in their first year and encourage upper-division students to practice “learning through teaching.” Furthermore, immersing students in a diverse academic environment will enhance student transition into the engineering workplace, since diversity in terms of knowledge and level of experience is a common situation.

**Segregated Faculty Involvement.** After determination of the curriculum and development of course descriptions and objectives, professors often
demonstrate little coordination or interaction in the practice of teaching courses. In any particular course the instruction is filtered by a single individual, the professor, and students are exposed to one particular style of teaching. Moreover, faculty members generally have limited interaction with one another on issues related to teaching and student learning. Drawing engineering faculty together in the development and delivery of courses and curricular sequence (a strategically organized group of interrelated courses) takes advantage of the faculty’s diverse expertise to provide an improved context for student learning and faculty development.

**Segregation of Student and Faculty Demographics.** Universities struggle to maintain diversity (race, gender, nationality, income, geographical location, and expertise) in their population because of a belief that a diverse student and faculty population improves the educational atmosphere. This quest for diversity, however, typically stops at the admissions and financial aid office, in the case of student diversity, and rarely affects program and curriculum development. For desegregation of demographics to have a positive impact on education, individual programs must promote interaction among segregated groups in the educational process. Immersing students in a diverse academic environment will enhance student transition into the engineering workplace, since diversity in terms of race, gender, and nationality is also a common situation.

Some of the proposed aspects of the desegregated learning environment are well documented in the literature, and their independent effectiveness has been established in similar contexts (Giralt and others, 2000; Olantunji and Desforges, 2000). In the last decade, integrated programs of study have been well established and documented (Bordogna, Fromm, and Ernst, 1993; Quinn, 1993). Furthermore, at least one engineering program successfully has instituted broad structural and cultural changes in integrated engineering education, investing considerable resources and having the collaboration of different educational programs (Quinn, 1993). However, most of the efforts have been limited to aspects of desegregation of course content, faculty involvement, and in a few instances, educational programs. Adding more aspects and dimensions to the desegregated learning environment will prove to be effective in attaining a higher level of learning. This emphasis on desegregation arises from the natural tendency of learning environments to become segregated and the significant opportunities to improve the learning environments that desegregation presents.

The proposed desegregated learning provides a novel umbrella or framework for different integrative educational innovations and experiences. The proposed framework includes the establishment of overlapping curricular sequences and the incorporation of integrative student learning experiences and educational innovations that continue throughout the program. The next section initially outlines the National Academy of Science’s principles for the design of learning environments that have guided the development of the desegregated environment. Then a plan to reform the current ME program of
study at the University of Texas-Pan American (UTPA) is introduced. In this section, the proposed desegregated learning environment includes a cross-linked taxonomy of its elements (desegregation of student and faculty involvement, course content, educational programs, and student and faculty demographics) and the design of learning-environment principles. Specific examples of integrative student learning activities are discussed. A template, adapted from an original developed by the VaNTH Engineering Research Center, is presented as a development tool and dissemination document for the integrative student learning experiences or educational innovations. The final section presents concluding remarks.

How Students Learn and the Implications for Our Practice of Teaching Engineering

Most aspects of the proposed desegregated learning environment are based on the findings of the principles of learning and instruction presented in *How People Learn: Mind, Brain, Experience, and School* (Bransford, Brown, and Cocking, 1999), from the National Research Council Commission on Behavioral and Social Sciences and Education. Among the critical factors we have identified to guide the preliminary design of the desegregated learning environment are the principles for design of learning environments, the principles for the use of new technologies, and the principles for effective teaching. This section presents a brief summary of these principles and important related features of the proposed desegregated learning environment.

**Principles for Design of Learning Environments.** The key conclusions of Bransford, Brown, and Cocking (1999) include four dimensions that can be used in the design of a learning environment: learner-centered, knowledge-centered, assessment-centered, and community-centered. These dimensions have been discussed in depth by different researchers (Bransford, Brown, and Cocking, 1999; Brophy and Bransford, 2001). The dimensions of an effective learning environment are complimentary and should all be present in effective student learning environments. Obtaining a balance of the specific criteria of each dimension is the key to the design of a better learning environment.

As described by Bransford, Brown, and Cocking (1999), learner-centered environments help students make connections between their previous knowledge and their current academic tasks. The proposed desegregated learning environment pays attention to the knowledge, skills, attitudes, and beliefs that students bring to the educational setting. Knowledge-centered environments help students develop organized knowledge that is accessible, applied appropriately, and enables learning with understanding. Among the new approaches in the proposed desegregated framework that support learning and encourage “sense making” is progressive formalization. Such formalization begins with the informal ideas of students and gradually helps them see how these ideas can be transformed and formalized. Assessment-centered
DESEGREGATED LEARNING environments provide students with opportunities to revise and improve the quality of their thinking and understanding. Assessment in the desegregated learning environment will reflect the ultimate learning goals, for instance, understanding and applicability of knowledge. Finally, community-centered environments promote a sense of community. The proposed desegregated learning will encourage students to learn how to use their peer students, teachers, and other members of the community as resources for their own learning. It also will encourage faculty to support each other's intellectual and pedagogical growth.

Principles for the Use of New Technologies. Bransford, Brown, and Cocking (1999) list a number of ways for using technology to help establish an effective learning environment, including bringing real-world problems to class, providing scaffolding support (for example, use of computational tools providing clear visualization of mathematically complex phenomena) to augment what learners can do and reason about on their path to understanding, and increasing opportunities for learners to receive feedback. The technologies emphasized in the proposed framework will provide access to a vast array of information and help students visualize difficult-to-understand concepts.

Principles of Effective Teaching. Key conclusions of Bransford, Brown, and Cocking (1999) include that faculty need expertise in both subject matter and teaching. Faculty need a knowledge base of pedagogy, including knowledge of how cultural beliefs and the personal characteristics of learners influence learning. Effective faculty also need pedagogical content knowledge—that is, knowledge about how to teach in a particular discipline. Desegregated learning addresses faculty pedagogy and pedagogical content knowledge needs and interests by providing a continuum of coordinated efforts that include specific opportunities for faculty to continue their learning and lifelong development as professionals (for example, integrative learning projects). Furthermore, the proposed integrated program of study will facilitate developing “expert faculty” who know in detail the structure of the ME degree program and have a highly developed concept map of the ME curriculum and taxonomy. This knowledge also will allow them to be sensitive to aspects of the discipline that are especially hard or easy for new students to master.

Reform Plan for ME Desegregated Learning Environment

The faculty members of the ME Department at UTPA are determined to provide the best possible educational experience for their students. They have decided to reform the undergraduate ME curricula through the development of a desegregated learning environment to promote higher learning and provide students the knowledge base and intellectual capability for career-long learning. Desegregated learning will address complex dynamic
pedagogical-cultural issues, rapid growing demand, optimal use of infra-
structure and resources, diversity in engineering, student interest in gradu-
ate school, and faculty pedagogy and pedagogical content, knowledge, 
needs, and interest. The desegregated learning environment components are 
holistic treatment of core competencies; further desegregated treatment of 
subject, educational program, student and faculty involvement, and faculty 
and student demographics; and continuous assessment and accountability 
processes with measurable outcomes for feedback to improve the process. 
Among the expected long-term student outcomes are increased student 
retention and diversity (race and gender), improved student motivation for 
the subject and self-direction, increased student retention of information, im-
proved integration of knowledge and development of adaptive expertise, 
 Improved student performance in projects and evaluations, motivation for 
lifelong learning, and an increased interest in graduate school. Furthermore, 
the reform process needs to summarize and prioritize the infrastructure 
needs. Figure 2.1 shows the partial list of issues to address, reform out-
comes, and long-term student outcomes. Student outcomes will be accom-
 plished by establishing overlapping and cross-linked curricular sequences 
and their taxonomies and by incorporating integrative student learning 
experiences and educational innovations that continue throughout the pro-
gram. Taxonomy as used here refers to the hierarchical categorization of 
curricular sequence concepts or fundamentals.

**Desegregated Program of Study.** In order to develop the desegregated 
program of study in ME, the courses in the bachelor degree plan have been 
divided into six overlapping curricular sequences: mathematical, physical, 
and chemical foundation sequence; social, ethical, political, and human foun-
dation sequence; design sequence; thermal-fluid science sequence; mechan-
ics and materials sequence; and dynamics and control sequence. Some of the 
ME courses are considered in more than one sequence. An extensive assess-
ment by the ME faculty of the current ME curricular sequences taxonomies 
must be performed. Tools like concept mapping will be used to organize cat-
egories and concepts within the respective taxonomy. Concepts must be 
categorized and organized hierarchically to show sequential and parallel rela-
tionships. That is, program developers must determine how concepts within 
the taxonomy build on one another, how they are grouped into categories, 
and where they reside in the curriculum. The degree program desegregation 
process is summarized in Figure 2.2.

The expected outcomes of the desegregation of the degree program 
includes a refined degree plan that prioritizes course inventory needs and 
course prerequisites changes. It is important to note that the organization 
of these sequences will result from curricular sequence taxonomies rather 
than from individual course taxonomies. The curricular taxonomies iden-
tify and emphasize relationships among courses. The process should be an 
essential part of the department’s quality process for the Accreditation Board 
for Engineering and Technology (ABET) and needs to be well documented.
Figure 2.1. Reform Plan: Partial List of Issues to Address, Outcomes, and Long-Term Student Outcomes

UTPA ME PROGRAM REFORM

Issues to Address

- Student Pedagogical and Cultural Issues
- Rapid Growing Educational Demand/ Optimal Use of Infrastructure and Limited Resources
- Low Diversity in Engineering
- Student Interest in Graduate School and Lifelong Learning
- Faculty Pedagogy and Pedagogical Content Knowledge Needs and Interest

Reform Process

Development of Desegregated Program of Study
Refined Degree Plan and Course Prerequisites, and Optimal Desegregated Curricular Sequences

Desegregated Learning Environment
Optimal Desegregated Course Content, Educational Program and Setting, and Faculty and Student Involvement/Demographics that includes:
* Integrative Student Learning Experiences and Educational Innovations That Continue Throughout the Program
* Continuous Assessment and Accountability Processes with Measurable Outcomes for Feedback

Prioritized Infrastructure Needs

Preliminary Implementation and Assessment

Dissemination

Long-Term Student Outcomes

- Increased Student Retention/Diversity
- Improved Student Motivation for the Subject and Self-Direction
- Increased Student Retention of Information
- Improved Student Integration of Knowledge and Adaptive Expertise
- Improved Student Performance in Projects and Evaluations
- Increased Interest in Graduate School and Lifelong Learning
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and reviewed periodically by all faculty in order to avoid unplanned segregation or content omission.

**Optimal Desegregation of Course Content and Faculty Involvement.** Based on the developed ME curricular sequence taxonomies, the desegregated environment will begin with the progressive learning of nomenclature, equations, analytical tools, and computer software within a curricular sequence. It will emphasize the interconnections among courses while recognizing the unique contributions each course makes to the overall curriculum (an excellent example of a knowledge-centered environment). The holistic treatment of core competencies will be accomplished by effectively integrating the design practices, software tools, and instrumentation used in engineering practice; by emphasizing critical thinking, communication, and interpersonal skills as well as ethics, professionalism, and lifelong learning at different points in the sequence; and by effectively organizing knowledge for students. Desegregating the faculty also will involve facilitating an understanding of the current taxonomy of the discipline
among the faculty and providing opportunities to make regular changes in the curriculum to support that taxonomy. Desegregating also includes opening lines of communication by providing the structure and opportunity for faculty interaction in areas such as successful teaching strategies and perspectives on the strengths and weaknesses of the student body.

Desegregation of course content and involvement of faculty is then extended to integrative applications of knowledge, design and research projects, laboratories, and competitions that continue throughout the program. Introducing a number of individual and repeated projects throughout the curriculum that are connected from the student’s viewpoint will help students strengthen course content connections. These projects, which build in complexity as they are reintroduced in appropriate classes, help students develop a holistic approach to mastering their discipline. The initial integrative projects considered include repeated and individual class projects.

Repeated Class Projects That Span Across Courses. Class projects that are completed over several semesters can be introduced to students as they take courses relevant to the project. Students accomplish measurable tasks on the project in each course and address the project in stages, where the breadth and complexity of the analysis evolves with their expanding knowledge base. This strategy provides an opportunity for desegregation in which segregated class projects are integrated to provide a learner-centered environment in which students can make the connection between previous and current knowledge and tasks. The challenges to introducing group projects that span across multiple courses include the fact that students take courses during different semesters and that successful implementation will require coordination among professors. If a clear benefit in student learning can be demonstrated, it is possible to expect a change in pedagogy that is supported by administrators and the cooperation of faculty. Repeating projects for several years would minimize the development costs to the faculty as they integrate the project with course content and facilitate flexibility for students progressing through the program, as they are not required to stay on a particular track.

Individual Projects That Span Across Courses. Repeated class projects allow the instructor the ability to integrate the project with course content but may not address the individual interests of the student. Individual projects allow the student to explore a personal interest and demonstrate individual capabilities. The primary obstacle to implementing individual projects that span multiple courses is in the proper selection of projects. Using students in upper-level courses that are part of the multicourse sequence is one way to overcome this obstacle and provide an opportunity for desegregation of course content that creates a community-centered environment. Upper-level students, as part of their course responsibilities, would be required to mentor a student in the selection of a project that would be appropriate to the multicourse sequence. The review process and appropriateness of projects would be evaluated by the faculty in the sequence at the
end of the mentoring process. This process provides an additional opportunity for interaction between students at different levels in the program.

Such integrative learning experiences that continue throughout the program will provide the conditions for applying knowledge and be accessible and interesting to students, enabling faculty to stimulate their students. Applied to learning, mental stimulation means a more active engagement with the materials to be learned as well as growth and development of student interest in the material and in their abilities to work with it (Olantunji and Desforges, 2000). These integrative learning experiences are also important because studies have shown that long-term retention of information calls for broader application and use of the information students study (Olantunji and Desforges, 2000) and that the ability to assimilate and use content out of the original context in which it was learned ultimately enhances the students’ ability to integrate material into a broader knowledge base and develop adaptive expertise (Olantunji, 1999).

Finally, in parallel to the efforts mentioned, desegregation of the course content and faculty involvement involves smaller-scale activities, including integrative classroom interactions and active, cooperative experiences (for example, questions, examples, and problems posed in the classroom, and group homework and projects). Faculty committees can design the activities for important aspects of the program. Furthermore, students can help design integrative visualization tools and computer-based instruction and integrative exposure to advanced program materials and elective work. This approach promotes a deeper sense of community. Groups of students develop materials as part of their assignments, different groups of students have the assignment of further refining these materials, and faculty take these materials to a higher level before adopting them.

**Optimal Desegregated Student Involvement.** Desegregating students by classification could take many forms. The initial integrative projects that can be considered include projects involving students from different classes and upper- and lower-level student interaction.

**Student Projects That Involve Students from Several Different Classes.** Group projects can be assigned that involve students from different classes, each with responsibilities relative to the expertise developed in their respective courses. These projects that desegregate course content would promote a comprehensive approach to problem solving and force students to relate new concepts to familiar ones while giving new students a vision and context for their learning. Very few real-world problems simply involve the subject matter of a single course in the curriculum; however, students are generally given projects and homework that focus on particular sections in a chapter of a focused text. Although these focused assignments are indispensable to learning, so is developing a perspective on how a specific concept relates to a broader knowledge base. Interclass projects enable students to broaden their perspective by making connections among concepts learned in various courses and by considering where there is overlap or con-
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Conflict. Students who have not yet taken a particular course involved in the interclass project will be forced to consider the limitations of their incomplete knowledge and will come away with a vision of where their knowledge fits in the broader base. This knowledge-centered environment also allows faculty to mimic real-world design teams comprised of members of varying levels of expertise.

**Integrative Coordinated Upper-Level and Lower-Level Student Interactions.** The evaluation of student work by other students assists the development of an assessment-centered environment that is an exceptional opportunity for learning and for the reinforcement of previously learned concepts. This opportunity, however, is generally wasted on overburdened faculty or teaching assistants who do not need to learn or reinforce concepts. Using upper-level students to evaluate work done by students in courses that they have recently completed gives those students an opportunity to reinforce previous learning and likely challenges them to consider different approaches to a problem. Removing the repetitiveness of evaluating the same work some thirty or more times likely will improve the level and timeliness of feedback. The knowledge that in a semester or two students will be evaluating and mentoring others in their current courses may improve interest in and retention of course content. Also, communicating knowledge as a teacher or mentor requires a deeper understanding because the teacher must understand the concept as well as the perceptions of the student. Finally, lower-level students are more comfortable engaging with upper-level students than with faculty, and upper-level students are closer to lower-level students in knowledge level and are more likely to recollect what it was that helped them see the light. Placing students in this role as a regular part of the program will bring students to a higher level of learning.

**Optimal Desegregation of Educational Programs.** Based on the developed curricular sequence taxonomies, the proposed framework will allow and encourage faculty to make recommendations to the supporting departments for the integration of the basic mathematics and sciences, not strictly for themselves but around engineering and engineering issues. Integrative projects to promote educational program desegregation should include increased multidisciplinary senior design projects in which the engineering students are required to work with students in different fields, developing an even broader sense of community.

**Optimal Desegregation of Educational Setting.** ME faculty at UTPA have already begun the reform process in the area of desegregating the educational setting through the involvement in different educational research projects, including collaborations with the National Science Foundation (NSF) VaNTH Engineering Research Center for Biomedical Engineering Educational Technologies and the Learning Technology Center at Vanderbilt University. The authors have developed interactive computer tutorials, games, and quizzes for a first-year engineering graphics course (which has been recognized and awarded regionally and nationally for excellence in...
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instructional courseware) and for three upper-level courses (Measurements and Instrumentation; Kinematics and Dynamics of Machines; and System Dynamics and Finite Element Analysis). These interactive computer tools have desegregated the educational setting by linking guided learning to other aspects of students’ lives.

**Optimal Desegregation of Student and Faculty Demographics.** Student and faculty access to interactive communication tools via the Internet, available at almost every educational institution, provides a wealth of opportunity for desegregating demographics in the educational process. What is lacking is the vision and plan for how this interactivity could become part of the educational process. One implementation to promote demographic desegregation could include the development of a chat site or e-mail list developed around a class project, where participants represent a diverse group and the solution to the selected project requires a diverse perspective. The projects can be shared by different programs or universities in one or more countries. This implementation not only could balance the minority enrollment in a program but also could expand the sense of community. One example of this interaction currently at UTPA is the manufacturing engineering course titled Product Design/Mass Customization, where groups of students from two U.S. universities (Michigan State University and UTPA) and one Mexican university (ITESM) address together different real-life design challenges.

All efforts to desegregate the learning environment must have the collaboration of experts in the fields of learning, pedagogy, and assessment. This collaboration is a critical component for the development of effective curricula and could be accomplished by having a design team for each educational innovation comprised of a learning scientist (LS), an assessment and evaluation expert (AE), a learning technology expert (LT), and a domain expert. The tentative design sequence of the integrated program of study cross-linked to learning environment principles is shown in Figure 2.3. The sequence is initially composed of the following classes: Introduction to Engineering, Engineering Graphics, Statics, Dynamics, Solids, Kinematics and Dynamics of Machines, Machine Elements, Electrical/Electronic Systems, System Dynamics, and Finite Element Analysis.

A template, adapted from an original template developed by the NSF VaNTH Engineering Research Center for Bioengineering Educational Technologies, can be used as a development tool and dissemination document for the sequence-wide educational innovation (EI) or student learning experience (SLE), as shown in Exhibit 2.1.

The template provides a workspace to articulate the response to the many driving questions concerning sequencing interrelated projects, laboratories, and competitions; computer-based instruction; advanced material and elective work; and integration of research and education. It provides a structure for defining important information necessary for the other faculty members and consultants to provide input about the design. For instance,
Figure 2.3. Design Sequence of Expected Integrated Program of Study with Cross-Link to Learning Environment Principles

**UPTA ME Program of Study**

- Design Sequence*
  1. Introduction to Engineering
  2. Engineering Graphics
  3. Statics
  4. Dynamics
  5. Mechanics of Solids
  6. Kinematics and Dynamics of Machines
  7. Machine Elements
  8. Electrical/Electronic Systems
  9. Finite Element Analysis

- Thermal-Fluid Science Sequence*
- Mechanics and Materials Sequence*
- Dynamics and Control Sequence*
- Mathematical, Physical, and Chemical Foundation Sequence*
- Social, Ethical, Political, and Human Foundation Sequence*

**Holistic Treatment of Core Competencies**
- Knowledge of Mathematics, Science, and Engineering – LC, KC
- Design and Conduct Experiments and Interpret the Results – LC, KC
- Design of Mechanical Devices, Systems, or Processes – LC, KC
- Communication Skills, Ethics and Professionalism, and Lifelong Learning – LC, KC
- Knowledge of State of the Art Instrumentation and Software – LC, KC

**Further Desegregated Treatment of Subject, Educ. Program, and Faculty and Student Involvement/Demographics**
- Integrative Applications of Knowledge, Design, and Research Projects, Labs, and Competitions That Continue Throughout the Program – LC, KC, AC, CC
- Integrative Upper- and Lower-Level Student Interactions – LC, AC, CC
- Integrative Interactions, and Active, Cooperative Learning Exp. – LC, KC, AC, CC
- Integrative Visualization Tools and Computer-Based Instruction – LC, KC, AC
- Integrative Exposure to Advanced Materials and Elective Work – LC, KC
- Chat Sites for Demographic Diversity – KC, AC, CC
- Multidisciplinary Senior Design Projects – LC, KC, AC, CC

*Sequences are not exclusive

**LC** = Learner-Centered Environment
**KC** = Knowledge-Centered Environment
**AC** = Assessment-Centered Environment
**CC** = Community-Centered Environment
objectives will be defined in explicit measurable terms describing what a student will be able to do during and at the end of the innovation or experience. In addition, this template provides a tool for faculty to share ideas for how the innovation or experience can be expanded for inclusion in other courses/sequences.
courses or sequences (point A3.3 in the template). Both knowledge and ABET core competencies are considered. This information is important to future users of these materials and future designers of similar materials.

Concluding Remarks
Opportunities to improve the learning environment are likely to be found in areas with significant segregation. Desegregated learning will increase both the relevance of undergraduate engineering curricula to modern engineering practice and student retention rates. Desegregated learning provides a new perspective of a growing set of educational innovations whose elements combine and complement one another to produce an enhanced learning experience. It allows for making incremental adjustments or rearrangements toward a broad structural and cultural change, even if programs have limited resources and start without the cooperation of supporting departments. It represents an innovative framework for programs of study to provide an ideal context for learning that encourages student confidence and faculty development.

We are assessing the impact of preliminary implementation of the desegregated learning environment, including integrative student learning experiences and integrative educational innovations within an abbreviated course sequence. For the cognitive domain goal (“higher level of learning”), students will be assessed by tracking their ability to develop concept maps as they progress through the program as well as by their performance on exams designed and scored according to an adaptive expertise rubric. The affective domain goals (“to make study and teaching of engineering more attractive and fulfilling” and “to increase student confidence”) will be assessed with different surveys at different times in the program, including an exit survey for graduating students or students who drop out.

References


