2006-1119: DESIGNING A PROCESS FOR DEPARTMENT CURRICULAR REFORM

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Designing a Process for Department Curricular Reform

Abstract

Given pressures from various directions to improve engineering education, department curricular renewal is an important and timely topic. Often, renewal efforts focus first upon content, e.g., What topics should be added? What topics should be revised? What topics should be removed? While content receives considerable attention, recent studies of curricular reform have suggested that increased attention to the process of curricular reform might lead to broader, deeper, and more lasting improvements. With these studies in mind, the Departments of Chemical Engineering at Texas A&M University, Texas A&M University Kingsville, and Prairie View A&M University, as they begin their journeys of curricular renewal, are constructing a process through which they hope to achieve sweeping and durable improvements. The paper reports on how well the process has been realized, how faculty members have responded to the initiatives, and how prospects for continued progress appear.

Introduction

The importance of departmental curricular reform is being increasingly recognized and many departments are engaged in this area. In some cases, the National Science Foundation (NSF) has supported their efforts through Department-Level Reform (DLR) planning and implementation grants. Typically, curricular reform efforts focus on content. This is understandable since faculty members are passionate about critical content mastery that they hope to see from their students. However, while increasing overall content knowledge merits such attention, there is more than content to be considered. How the content is presented, what students are expected to do with that content, and how the learning process is designed, modeled, and assessed are all issues pertinent to curriculum reform. Recent studies of curricular reform have suggested that increased attention to the process of curricular reform might lead to broader, deeper, and more lasting improvements. With these studies in mind, the Departments of Chemical Engineering at Texas A&M University, Texas A&M University Kingsville, and Prairie View A&M University, as they began their journeys of curricular renewal in September 2005 with support from the NSF DRL program, are constructing a process through which they hope to achieve sweeping and durable improvements.

Challenges to sustainable departmental curricular reform are manifold. First, there is tension between the perspective of a curriculum as a unified whole that is intended to shape the characteristics of its graduates and the perspective of the curriculum as a collection of individual courses for which individual faculty members accept responsibility. Fisher, Fairweather, and Amey described this as “the tension between collective responsibility and the boundaries of academic freedom.” Understandably, faculty concern regarding curriculum tends to focus most strongly on courses related to their area of professional expertise that they teach. Secondly, faculty members focus on courses that are prerequisite to courses of interest (specifically the degree to which students emerging from these courses are prepared for the next course in the sequence). From the perspective of the individual faculty member, the “curriculum” may be
viewed as a bureaucratic, organizational entity for which administration has responsibility. However, systemic department curricular reform requires the unified perspective, which in turn requires the tension between the two perspectives be explored rather than ignored.

Faculty time is another impediment to successful curricular change initiatives. Senge et al identified the perception of the lack of discretionary time that might be invested in the project as the second major process that hinders initiation of change. Some curriculum change proponents assume that construction of a new plan of courses on paper will result in change. However, meaningful change requires spending time articulating what is needed and/or wanted, understanding the status quo, defining the difference between the two, and developing a plan for change that has faculty members across the department support. Developing all four initiatives requires time—a precious commodity. Conversations about the value of engaging in the departmental curricular reform initiatives are a necessary prelude to decisions by faculty members to invest the time required.

Additional challenges include credit hour caps determined by institutions and/or state governments, explosion of content across disciplinary areas, the apparent need to engage in the difficult work of determining what important content will have to be “left out” of courses to make room for new information, and pressure to make adjustments for accrediting agencies. If the challenges are insufficiently addressed, the result of the reform effort may be a curriculum that is less broad and deep than benefits either students or faculty. Reasonable assumptions about what is “covered” and how it is “covered” may be inaccurate and leave faculty members uncertain of the motivation for the statement from students that they “have not ever seen” a particular concept. The literature suggests that the best curricular reform efforts are the ones that result in changes in faculty thinking about the learning process. Efforts that fail to determine a starting point (prior knowledge) and work toward change typically resolve in a state known as “change without difference” or a plan that is implemented in such a way that it looks essentially the same as the status quo.

Based on these challenges, one key balance to be struck is broad, active participation and intellectual development of department faculty members while maintaining impetus and direction for curricular renewal. This is especially true of the present project, in which three diverse departments in the same engineering discipline collaborate to renew their individual curricula. Another key element is increasing the capacity of the department to engage in substantive, informed conversations regarding its curriculum. Approaches to address these key features will be discussed.

The sections below are organized around the steps that have been taken on the project to date. First, the project team has engaged departments in conversations about the intended outcomes of the renewal project. Without agreement on the broad outcomes of curricular renewal, substantive conversations about the revisions that must be made are impossible. Second, the project team has engaged departments in conversations about how the units will assess progress in attaining the outcomes it has developed. Assessment processes generate data that can inform future conversations about curricular renewal. Third, the project team has engaged department faculty members in developing course folders. With documentation on the intentions and methods used in each course, department faculty members have a firmer grasp of the current curriculum: What
does each course intend to accomplish? How are these intentions realized? With a clearer picture of present reality, the department can engage in more reasoned dialogue about how to obtain desired outcomes. Fourth, the faculty has begun to develop new materials, such as interlinked curriculum components (ICCs), to support specific areas of the renewed curriculum.

**Process Step No. 1: Developing Departmental Outcomes**

Instead of first asking which courses or which topics should be included in a revised chemical engineering curriculum, the project team began by asking what new capabilities were desired for graduates with a BS in chemical engineering. The project team initially framed these additional capabilities in terms of four outcomes that described what graduates would be able to do or how they would think:

a) Apply fundamental ideas in chemical engineering over a **greatly expanded range of time and length scales**. Lengths range from sub-molecular and nanoscale processes to super-macroscopic plant integration encompassing more traditional continuum and macroscopic scales. Time scales range from sub-nanosecond molecular motions to month-long time constants for plants.

b) Apply ChE fundamental ideas to emerging application areas such as biotechnology, nanotechnology, informatics, semiconductor fabrication, new materials, etc. In both traditional and emerging application areas, systems involved have become more complex and, in many cases, subsystems are more highly interacting. Although the fundamentals have not changed, future graduates must be able to extend their fundamental knowledge to new areas with the facility and new tools, e.g., systems thinking, molecular simulations, stochastic processes, and nanoscale engineering, that department faculty desire and employers expect.

c) **Construct solutions for more complex, more open-ended synthesis tasks** with greater facility and with an expanded design toolkit: optimization, statistical analysis, etc. Greater synthesis and design capabilities are required by the expanded list of application areas and their more stringent demands on knowledge and synthesis skills.

d) **Transfer fundamentals and knowledge to novel challenges**. Graduates cannot acquire all of the data, information, ideas, etc. that they will require in careers that will span 40-50 years. Therefore, an increasing priority is attached to the ability of our graduates to learn and transfer their learning to innovative settings. Bruee²¹ describes learners who had quickly become competent in new areas as ‘intelligent novices.’

These four outcomes were additions to the list of outcomes that the departments had formulated for their ABET visits. The project team prepared a memo to department faculty with these outcomes and asked for their comments to improve the set of outcomes. Only two comments were received, but the project team suspected that more direct interaction would be necessary to engage department faculty members in thoughtful conversations about what additional outcomes were desired. Therefore, the project team asked for a department meeting in which the outcomes could be presented and comments solicited.

At the conclusion of the meeting, department faculty members had accepted the four outcomes above, but added three additional outcomes. The final set of seven outcomes is listed below.

a) Apply fundamental ideas in chemical engineering over a greatly expanded range of time and length scales
b) Apply ChE fundamental ideas to emerging application areas  
c) Construct solutions for more complex, more open-ended synthesis tasks  
d) Transfer fundamentals and knowledge to novel challenges.  
e) Prepare many different written forms of high quality communication  
f) Deliver many different oral presentations of high quality communication  
g) Demonstrate proficiency with different types of instrumentation, material characterization tools, and discipline-specific software tools

Process Step No. 2: Developing Department Curriculum Map

Another step that was taken in parallel with developing departmental outcomes was to develop a curriculum map. A curriculum map is similar to a concept map. In a concept map, there are two kinds of graphical entities. The first entity is a concept box that contains a concept relevant to the subject for which the concept map is being developed. The second entity is a link box that connects two concepts and describes how the two connected concepts are related. A curriculum map also contains two types of graphical entities. The first entity is the course box that contains a course and a short list of the topics covered in the course. The second entity is a prerequisite box that links two courses in which one is a prerequisite for the second. The prerequisite box contains expectations that the second course has for students who have completed the first course and are now entering the second course. The curriculum map for the chemical engineering curriculum at Texas A&M University is available for download.

Once an initial draft of the curriculum map was developed, copies were distributed to the department faculty members for their input. Many faculty members responded with improvements to the descriptions of individual courses and descriptions of the expectations of prerequisite courses. The process of developing the curriculum map encouraged department faculty members to view the curriculum as an entity with components. Viewing the entire curriculum is different from the more typical perspective in which faculty members focus on the course or courses that they teach regularly.

Process Step No. 3: Developing Course Folders

Course folders are a version of teaching/course portfolios tailored for this project. Like teaching/course portfolios, the course folders are a place to assemble artifacts of the teaching process that illustrate faculty statements regarding their philosophy and practice and can then be used as catalysts both for faculty reflection and faculty peer review. These documents provide a foundation for greater understanding of the department curriculum as a whole by providing a launching point for examination of both the content involved in each course (what students need to know) and the tasks in terms of both formative and summative assessment (what students need to be able to do) that are the focus of the curriculum. Documentation that facilitates faculty knowledge and interaction in these areas can have a powerful impact on student success. Imagine the potential benefits from use of key concept examples across courses rather than only in individual courses. This practice alone might substantially decrease the number of times faculty members confront the student response that they have not seen a concept before. It also would send a compelling message to students about the interconnectedness of the curriculum and perhaps motivate them to adopt more lifelong learning approaches.
The Department of Chemical Engineering hosted its ABET accreditation visit in fall 2004. Since, in preparation for the ABET visit, the department prepared course folders, the team decided that the course folders required for the project could be expansions of these documents to inform the curricular reform process. Working from the elements assembled for ABET accreditation (course syllabus in ABET format, a table that identifies outcomes that are addressed by the course, instructor notes, and examples of student work) the committee recommended an expansion to include instructor reflections at key points in the semester, evaluations, samples of student work including instructor feedback, and critical analysis of teaching and learning. This expansion is based on literature on both teaching and course portfolios. Several factors motivated this decision. First, the existing course folders provide a launching point for the effort—a more appealing start than creating something new. Second, the documents provide a strong foundation for the peer review process to be undertaken by the course string committees including determination of how courses are linked through course strings, what ICCs (see Process Step No. 5) are relevant, and how those ICCs need to be structured to best support student learning in those courses. Third, agreement on decreasing repetition and/or duplication in the curriculum to make room for expanded time and length scales while identifying topics for ICCs requires that the department as a unit have a detailed understanding of how the curriculum “fits” together across the department – a goal that is best pursued through individual documentation of teaching and the work of the course string committees before moving to department level conversations. Reasonable assumptions that certain content is “covered” in particular course need to be explored verified and coordination regarding repeatedly covered concepts established. Fourth, course folders provide the foundation for exploring questions of assessment since “data” from teaching such as assignment, exams, feedback to students, etc. will be available for review.

To facilitate development of the course folders, members of the Center for Teaching Excellence (CTE), who have been involved in the project since the preparation of the proposal for the implementation grant, offered a workshop for the department faculty in fall 2005. The goals of the workshop were to 1) provide an overview of how the committee came to recommend this process as part of the grant proposal and 2) describe the components of the expanded folders and planned activities.

**Process Step No. 4: Developing Learning Objectives and Assessment Processes Folders**

Like program educational outcomes in Criterion 3 of the Engineering Criteria, most learning outcomes do not describe observable behaviors. Since data can only be collected on observable behaviors, learning objectives need to be formulated for each outcome in order to describe desired observable student performance related to each outcome. To encourage development of learning objectives that describe observable student performance, assessment processes were to be constructed for each learning objective that was developed.

Moving from learning objectives to judgments regarding the degree to which the program is achieving its learning objectives requires relevant, appropriate, and informative data upon which judgments can be based. Prus and Johnson described 15 different assessment methodologies, together with strengths and weaknesses for each methodology. There is no perfect assessment methodology, and evaluators often select multiple assessment methodologies to balance their
strengths and weaknesses. Choice of the appropriate methodologies depends on many factors, including the goals and scope of the evaluation.

Outcome assessment is a method for determining whether students have learned, have retained, and can apply what they have been taught. Assessment plans have three components: a statement of educational goals, multiple measures of achievement of the goals, and use of the resulting information to improve the educational process. The results of outcomes assessment are part of a feedback loop in which faculty members are provided information that they can use to improve their teaching and student learning. For example, after industry provides feedback on the co-op student or intern, faculty members and administrators can determine if their program and courses within the program are effectively teaching teaming skills and appropriately providing opportunities for students to practice teaming skills in class and on course projects. Designing a program-level assessment, collecting assessment data on an outcome, and analyzing the results may be complex and less objective than technical research; however, the goal is clear: to determine as reliably as possible if the objectives have been met and, if not, what should be done to improve each student’s educational experience.

The project team decided to use the same process that was used for developing department learning outcomes to develop learning objectives and their associated assessment processes. First, the project team drafted a set of learning objectives and assessment processes. To begin, the project team focused on the first four learning outcomes. For these four learning outcomes, the draft of the learning objectives and assessment processes is shown in Table 1.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Assessment Processes</th>
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<tbody>
<tr>
<td>Desired Outcome a) Apply fundamental ideas in chemical engineering over a greatly expanded range of time and length scales</td>
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</tbody>
</table>
| a.1 Demonstrate comprehension (Bloom’s Taxonomy, Level 2) of the transfer mechanisms associated with each conserved quantity | - Self-assessment instruments for critical concepts
- Use existing concept inventory assessment instruments in thermodynamics, heat transfer, fluid mechanics, materials, etc.
- Assigned homework and test problems |
| a.2 Demonstrate application (Bloom’s Taxonomy, Level 3) of extended conceptual framework in diverse physical settings, including different length and time scales. | - Self-assessment instruments for critical concepts.
- Assigned homework and lab test problems |
| a.3 Demonstrate connections across extended conceptual framework | - Concept maps |
| a.4 Demonstrate modeling using stochastic processes | - Assigned problems in statistical mechanics and molecular modeling |

| Desired Outcome b) Apply ChE fundamental ideas to emerging application areas |
| b.1 Demonstrate application of conceptual framework to nanoscale applications | - Assigned problems that demonstrate limits of traditional models
- Assigned problems that incorporate nanoscale, traditional, and macroscale models and approaches, scaling laws, and quantum phenomena |
| b.2 Demonstrate application of conceptual framework to biotechnology applications | - Assigned problems that apply thermodynamics concepts to aqueous solutions and polar solutes
- Assigned problems that apply transport mechanisms to cells as systems |
### Desired Outcome c) Construct solutions for more complex, more open-ended synthesis tasks

<table>
<thead>
<tr>
<th>b.3 Demonstrate application of conceptual framework to semiconductor fabrication</th>
<th>- Assigned problems that apply conceptual framework to situations in semiconductor fabrication</th>
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<tbody>
<tr>
<td>b.4 Analyze and evaluate chemical engineering systems using an entire systems approach</td>
<td>- Written and oral applications of conceptual framework - Opportunities to write and receive peer review on critical elements to be integrated (for example - use of Calibrated Peer Review™ software)</td>
</tr>
<tr>
<td>b.5 Use framework and systems approach to encompass length and time scales with consistent approach</td>
<td>- Assign problems over a range of scales in which students demonstrate application of the conceptual framework. Use peer critique and correction - Assign complex and highly varied systems “cases” and grade comparative analyses.</td>
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#### Desired Outcome d) Transfer fundamentals and knowledge to novel challenges

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<tr>
<th>d.1 Use framework to provide orientation in novel situations, identify relevant information, recognize and address uncertainty, integrate multiple perspectives, interpret and organize information, use criteria to evaluate options.</th>
<th>- Prepare written document on approaches to using conceptual framework or preparing a design. Then, use rubric provided in (Wolcott, 2003) to assign reports to one of the five categories: Learner proceeds as if goal is to o find the single, &quot;correct&quot; answer o stack up evidence and information to support own conclusion o establish an unbiased, balanced view of evidence o reach a conclusion based on evaluation of alternative wrt priorities o strategically construct knowledge, improve conclusions over time</th>
</tr>
</thead>
<tbody>
<tr>
<td>c.1 Decompose complex tasks into tractable decisions</td>
<td>- Solutions of written problems including numeric and verbal (approach, rationale) problems</td>
</tr>
<tr>
<td>c.2 Combine individual decisions to develop integrated solutions</td>
<td>- Design project reports or portions of reports. Opportunities to write and receive peer review on synthesis approaches (for example - use of Calibrated Peer Review™ (CPR)). Reports assessed with prepared rubrics.</td>
</tr>
<tr>
<td>c.3 Prepare design solutions for both traditional and emerging chemical engineering systems</td>
<td>- Design project reports with written self-critical reflection and peer critiques. Opportunities to write and receive peer review on synthesis approaches with CPR™. Reports assessed with prepared rubrics.</td>
</tr>
<tr>
<td>c.4 Given a design situation, formulate and solve an optimization problem to yield design solution.</td>
<td>- Design project reports or portions of reports with written self-critical reflection and peer critiques. Opportunities to write and receive peer review on synthesis approaches with CPR™. Use prepared rubrics to guide scoring process and products</td>
</tr>
<tr>
<td>c.5 Quantify uncertainty in a design setting</td>
<td>- Assign multiple synthesis problems involving uncertainty. Use peer and instructor feedback.</td>
</tr>
</tbody>
</table>

Some of the terminology in Table 1 may be unfamiliar to some readers; therefore, the following brief descriptions of some terms are provided below.

### Self-assessment Instruments for Critical Concepts

Self-assessment instruments for critical concepts are survey instruments in which students would be asked to self-evaluate their own competence with respect to a set of concepts or applications of the extended conceptual framework. Such survey instruments would need to be developed for the specific objectives on which the department agrees. Also, this approach might be applicable for objectives other than the first two.

### Concept Maps
Consider the example where a student would be asked to draw a concept map for a course in fluid mechanics. For the concept map, a student draws a set of boxes that are the relevant concepts for the fluid mechanics course. Then, the student links two concept boxes together with a box of a different type. The second type of box describes the relationship between the two linked concepts (see \textsuperscript{5} for examples and tools for constructing concept maps). Concept maps can be evaluated in several different ways\textsuperscript{32}. First, what percentage of the expected concepts appeared in the concept map? Second, to what extent is each link that is drawn correct? Third, what is the number of links that were drawn? Fourth, what is the number of links that were made to each concept? There are other criteria that can and have been used to evaluate concept maps.

\textit{Calibrated Peer Review (CPR) TM}

Calibrated peer review (CPR) is a process, supported by software, for assessment of writing\textsuperscript{33,34}. An instructor prepares a writing assignment, specific questions about the writing assignment, three examples of responses to the assignment (high/medium/low quality), and responses to the specific questions for the three assignments. Students prepare and upload assignments. Then, they calibrate their assessment capabilities by reading and evaluating the three example responses prepared by the instructor. Finally, they anonymously peer review three other assignments. Their peer assessments are weighted by the quality of their evaluations of the three instructor-prepared assignments.

\textit{Rubrics}

Rubrics\textsuperscript{35} are an explicit scoring scheme in which the criteria for evaluation of a specific assignment are listed as rows in a table. The columns of the table are the different levels of qualities of responses, e.g., high, medium, low. Then, each entry in the table is a list of the attributes of a response for each criterion. For example, what for the first criterion is required for a high quality response?

\textit{Concept Inventory}

A concept inventory is an instrument that is developed to assess conceptual understanding of a specific subject\textsuperscript{36,37}. Questions usually do not require the learner to perform computations in order to arrive at an answer. Many concept inventories have already been developed.

\textit{Bloom’s Taxonomy}

Bloom’s taxonomy is a system for classifying objectives according to types of knowledge and levels of learning\textsuperscript{38,39}.

\textit{Process Step No. 5: Developing Interlinked Curriculum Components}

5a. Role and structure of Interlinked Curriculum Components
Interlinked curriculum components, or ICCs, are a major part of the proposed curriculum renewal process. The project team developed the concept and format of ICCs to increase unity, coherence, and efficiency and maintain effectiveness of the new curriculum.

An ICC is envisioned as a Web-based resource for teaching and learning as well as a ‘chunk’ of material that is significantly smaller than a typical semester course. In some ways ICCs resemble modular curriculum components\textsuperscript{40,41}, i.e., they will have a ‘narrow and deep’ focus on a specific application area or skill. However, the scope of many of our ICCs will be much broader to demonstrate common concepts (e.g. conservation laws) that \textit{span courses and application areas}. A list of 10 ICCs to be developed is shown in Table 2. Specifically, ICCs will support our project goals by:

- Providing a vehicle for pervasive and consistent reinforcement of the extended conceptual framework. For example, ICC #1b on “Conservation of Mass” as shown in Table 2 will be employed at several key places in the curriculum. First this ICC will be used to introduce the accounting principles framework in the introductory sophomore chemical engineering course, and then it will be re-visited in later courses to help the students incorporate complexities such as time-dependent flow rates and chemical reactions, into that framework. A version of ICC#1b has been developed and is currently being tested by selected students to improve its usability and to learn how students might make use of the material (see section 5c).

- Promoting lifelong learning among the students. Application-focused ICCs, plugged into a course in a modular fashion, will be a powerful means to promote and evaluate students’ ability to transfer their knowledge to new problems. For example, ICC #5 on “Microchemical Systems” as shown in Table 2 will provide an opportunity for the students to transfer their knowledge to a realm of much smaller length and time scales than is probed in the traditional curriculum. The ICC format will promote student self-directed learning strategies.

- Contributing to a diverse learning environment. ICCs will be an ideal platform for team design projects\textsuperscript{42,43} and project-based learning (PBL) exercises. Examples of successful incorporation of PBL have recently been cited by Felder\textsuperscript{44}.

- Employing state-of-the-art technology to enhance learning, e.g. through the use of interactive exercises and multiple visual representations\textsuperscript{45}. Furthermore, the ICCs will be continuously evolving collaborative documents that provide a mechanism for more efficient and uniform assessment of learning.

### Table 2. Proposed Topics for Interlinked Curriculum Components

<table>
<thead>
<tr>
<th>ICC 1 - Conservation Principles</th>
<th>ICC 2 - Materials</th>
<th>ICC 3 - Continuum Principles</th>
<th>ICC 4: System Synthesis and Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a: Conservation Laws and Accounting</td>
<td>2a: Equations of State</td>
<td>3a: Coordinate systems</td>
<td>4a: Mass and Energy Metrics</td>
</tr>
<tr>
<td>1b: Conservation of Mass</td>
<td>2b: Other thermodynamic properties</td>
<td>3b: Equations of motion</td>
<td>4b: Thermal Management</td>
</tr>
<tr>
<td>1c: Conservation of Energy</td>
<td>2c: Transport properties</td>
<td>3c: Multicomponent systems</td>
<td>4c: Heat Exchange Network Pinch Analysis</td>
</tr>
<tr>
<td>1d: Conservation of Linear Momentum</td>
<td></td>
<td></td>
<td>4d: Mass Exchange Networks</td>
</tr>
<tr>
<td>1e: Conservation of Angular Momentum</td>
<td></td>
<td></td>
<td>4e: Chemical and Biochemical Rxn Network Pathways</td>
</tr>
</tbody>
</table>
5b. Development of ICCs

The project team identified two main concerns when considering the implementation of ICCs: effectiveness (does the ICC support learning?) and flexibility (will the ICC be used by faculty who did not develop the ICC?). These issues are being addressed in two ways. First, an ICC Portfolio will be developed after construction of a component to provide an accessible summary of intention, expectations, and content. ICC Portfolios are variations on Teaching Portfolios often used in promotion and tenure packages at different institutions. By developing the concept to a point where ICC Portfolios serve as specifications for components, with the expectation that any component that satisfies its specifications will be accepted by faculty members who participated in specification development, ICC Portfolios will address the “Not Invented Here” challenge of broader impact for curricular components. Second, ICCs will be developed through a process modeled on open source software development that will allow many users to participate in development of an ICC. Wiki-like software technology such as the Connexions project at Rice will promote collaborative development on the theory that faculty members are more likely to use material that they have developed. Multiple users also increase the likelihood of high quality material. Our vision is that some of the ICCs will evolve into the “new textbooks” for renewed curricula in departments across the country. Workshops will be held for promoting wider participation of the chemical engineering community.

5c. Prototype ICC

Within the project team we are developing a prototype ICC on the topic of Conservation of Mass (ICC #1b in Table 2). Our current progress can be seen. To date, we have engaged three faculty members and an undergraduate student to develop (1) learning objectives keyed to Bloom’s Taxonomy, (2) pre- and post-module short answer questions, (3) lecture-type textual material, (4) a seven-step problem-solving strategy, and (5) animations and an interactive tank-filling simulation. An undergraduate student, with assistance from technical resources on the TAMU campus, was primarily responsible for the advanced animation and simulation components.
We are preparing a small pilot study with five undergraduates to assess usability and effectiveness of the ICC in meeting the desired student objectives. Based on the results, we will re-work the module and develop an accompanying ICC Portfolio to prepare it for wider release and development, via the process described above.

While preparing for the Conservation of Mass ICC pilot study, we identified a particularly useful exercise for engaging faculty in conversations about ICC content. The focus of the exercise was to develop a one-page problem statement that would comprehensively test the ability of the students to meet the main learning objectives of the ICC. A preliminary draft by one faculty member and a graduate student yielded a problem where the students are asked to generate mass balance equations from a physical description of a simple tank with liquid inflows and outflows. This draft problem led to a detailed conversation about: (1) what faculty members expected students to do with mass conservation principles throughout the curriculum, (2) areas where the students are currently weak in meeting those expectations, and (3) suggestions for improvements/expansions of the draft problem statement. Two new one-page problem statements, plus an improved draft of the original, were generated within the next several days. We plan to incorporate this type of exercise as part of the ICC Portfolio development process described above.

Conclusions

Renewing an entire four-year engineering curriculum is an ambitious undertaking and the project team has tried to match the scope of its efforts to the scope of the project. Only preliminary results from the project are available to date, but it is hoped that the steps that have been taken to date and the results that have been achieved will be helpful to others who might undertake future curriculum renewal projects.

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