2006-952: CURRICULUM DESIGN FOR THE ENGINEER OF 2020: A UNIVERSITY COMMUNITY CREATES A PUBLIC AFFAIRS CURRICULUM FOR ENGINEERING UNDERGRADUATES

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Curriculum Design for the Engineer of 2020: A University Community Creates a Public Affairs Curriculum for Engineering Undergraduates

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Abstract

This paper describes the process by which the curriculum of the award-winning Guy T. McBride Honors Program in Public Affairs of the Colorado School of Mines (CSM) is being redesigned. Best practices in curriculum development have been followed (e.g., developing a clear mission statement with measurable outcomes; aligning course-level learning objectives with Program outcomes and expected attributes of CSM graduates; establishing an implementation matrix to organize topics and content into a logical course sequence; embedding assessment processes throughout; and engaging the broad participation of Program faculty) to design a new Program for review by its faculty governance committee and by the institution. The paper incorporates the results of assessing the curriculum process via interviews with faculty who have been engaged in the redesign effort.

Introduction and Background

The McBride Honors Program in Public Affairs at The Colorado School of Mines (CSM)\(^1\), instituted in 1978, is an award-winning exemplar in the liberal arts which “…provides a select number of CSM engineering students an opportunity to cross the boundaries of their technical expertise in engineering and applied science, and to gain the understanding and appreciation of the contexts in which engineering and applied science and all human systems reside, and specifically to explore and integrate the social, cultural, ethical and environmental implications of their future professional judgments and their roles as citizens in varied and complex settings.” [1]. The 27 semester-hour program of seminars, courses, and off-campus activities features small seminars; a cross-disciplinary approach (faculty from engineering and science disciplines and faculty from the humanities and social sciences are regularly co-moderators of the seminars); and, opportunities for one-on-one faculty tutorials, instruction and practice in oral and written communication, a Washington, D.C. public policy seminar, a practicum experience (internship or foreign study), as well as participation in the McBride “community within a community” approach [2-5].

Circumstances external to the McBride Program itself, which include the on-campus enhancements of the Division of Liberal Arts and International Studies and the Division of

\[^{1}\text{The Colorado School of Mines (CSM) has successfully evolved from its mining history roots to a modern public technological institution which offers eight undergraduate ABET accredited engineering degrees, four science degrees, as well as a degree in economics and business, 27 graduate degrees at the masters and doctoral levels several of which are inherently cross-departmental and interdisciplinary in nature, and a highly active and growing research and sponsored programs portfolio in all areas of the institution’s expertise. The undergraduate body of approximately 4000 students ranks in the 90\textsuperscript{th} percentile in quantitative skills and 80\textsuperscript{th} percentile in verbal skills on SAT and ACT examinations. Entrance requirements are the highest among all Colorado institutions of higher education and among the highest for public institutions nationally.}\]
Economics and Business, the development and growth of the field of Public Affairs nationally, and the persistence of legacy courses which some faculty endorse while others criticize, all have created the need for and the opportunity to revitalize and refocus the historically cross-departmental McBride Honors Program. A goal of the curriculum reform effort reported here has been to achieve a more thoroughly interdisciplinary learning experience, to educate engineers and those in associated fields who, as called for in the National Academy of Engineering’s *The Engineering of 2020* “...will assume leadership positions from which they can serve as positive influences in the making of public policy and in the administration of government and industry” [6]. Views expressed in *The Engineer of 2020* capture the inherently public role of engineers who interact with conditions that are international and global in scope in technological, social, economic and biospheric contexts as they practice their profession. This view is mirrored in the American Society of Civil Engineers’ Committee on Sustainability’s report [7], which stresses an understanding of the concepts of sustainability as essential for the preparation of engineering practitioners, not only in terms of technical design skills but in terms of engineers as responsible professionals who practice within the socio-economic and environmental contexts in which they live and function as citizens. Based on these internal and external drivers, CSM’s McBride community is redesigning the current curriculum, providing a strong foundation in public affairs, removing outdated legacy courses that have been components of the Program for decades, and replacing these with rigorous technically-focused investigations of the inherently intertwined nature of modern engineering practice and public policy.

This paper documents the process of curricular reform at a mid-way point in our activities: through a series of faculty workshops and committee meetings CSM faculty and staff have created a new curricular framework which will be reviewed by a panel of leading experts from public affairs programs nationally. Pending the outcome of this review we plan to initiate the development of individual course offerings, and organize faculty development workshops focused on Socratic pedagogies and mentoring techniques for McBride seminar moderators. Workshops will be designed and offered to help Program faculty develop measurable learning outcomes and reliable, valid assessment measures for courses and modules. We anticipate that participation in these workshops will be a requirement for teaching in the revised McBride Program.

We believe that our experiences in the curriculum redesign process are relevant to all faculty communities considering the recommendations presented in *Engineer of 2020* [6]. Because we are building upon an existing Program which already contains threads of a public affairs curriculum, as opposed to starting anew without such a history, we share our documented successes in Program modification.

**The Curriculum Development Process**

To ensure that we develop a coherent curriculum which meet the needs of McBride students and address the issues raised in *The Engineer of 2020*, we have followed best curriculum design practices as described by the following principles set forth by the National Academy for Academic Leadership [8]:

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1. **A philosophy.** A curriculum should be founded on a carefully thought-out and articulated philosophy of education, and should be directly connected to an institution's mission statement.

2. **Clear purposes and goals.** A curricular mission statement and written curricular goals (intended student development outcomes or intended results) should be promulgated which articulates curricular purpose – what graduates should know and be able to do in demonstrable and measurable ways.

3. **A theoretically sound process.** Student activities should be chosen that are capable of developing the desired outcomes, as indicated by empirical research. Curriculum has its desired effect primarily through instruction. Therefore, the choice of course experiences and the specific quality and efficacy of these experiences in producing the stated, intended outcomes for all students are fundamental to the quality of any curriculum. Current empirically-based education theory is essential to effective instruction and thus to the improvement of curricular quality.

4. **A rational sequence.** Educational activities should be carefully ordered in a developmental sequence to form a coherent curriculum based on the stated, intended outcomes of both the curriculum and its constituent courses.

With these principles in mind, we describe the process by which a curricular framework for the McBride Public Affairs minor for engineering students has been developed. As shown in Table 1, this framework is the outcome of more than a year of activities involving all relevant constituencies within the McBride community, including current Program students, Program alumni, emeritus and current faculty, and academic administrators. We have subdivided this process into three phases: the discovery phase and the development phase, which we describe in this paper, and an implementation phase, to be initiated in 2006.

### TABLE 1 – Timeline for Curriculum Development Activities

<table>
<thead>
<tr>
<th>Semester</th>
<th>Project Phase</th>
<th>Activities</th>
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| Fall 2004 | Discovery Phase | • Institutional appointment of an Ad Hoc Committee to develop a White paper on the Program’s Public Affairs focus  
• Programmatic SWOT analysis |
| Spring 2005 | Discovery Phase | • On-campus discovery of expertise  
• Definition of critical characteristics of a Public Affairs program for engineers  
• Mission and Goals review  
• Alumni survey |
| Summer 2005 | Development Phase | • Course development activities through faculty mini-grants funded by CSM  
• Conduct Workshop on student outcomes  
• Conduct Workshop on making assessment-oriented learning objectives  
• Prepare Outline of curricular and co-curricular framework  
• Develop matrix of graduate profiles |
| Fall 2005 | Development Phase | • Arrive at consensus on Program mission and goals  
• Create two teams to develop independent curricula  
• Reformulate teams to combine best elements of both  
• Develop modular outline for seven-semester sequence  
• Prepare for external review |
The Discovery Phase. Multiple stresses which developed over time within the Program led to an active decision, documented in an internal White Paper, to critically evaluate the past and present Program mission and goals, the desired profile of our graduates, and the ability of a highly focused applied science and engineering university to deliver a rigorous, specialized honors program in the humanities and social sciences. We initiated the Discovery Phase with a reaffirmation of the Program’s mission and goals [1], an in-depth SWOT analysis (Strengths, Weaknesses, Opportunities, Threats), and an alumni survey of Program graduates from which we determined that life-long learning skills, improved abilities in written and oral communication, and the opportunity to travel internationally were frequently valued more highly than the actual academic content of the program. Using a format of informal seminars and workshops we engaged in a discovery period for the field of Public Affairs [9-13] leading us to identify critical characteristics for an undergraduate minor in public affairs which have the potential for recognition by both ABET and the Higher Learning Commission of the North Central Association, and the National Association of Schools of Public Affairs and Administration [9]. We determined that critical characteristics of such a Program should include:

- A core curriculum, which incorporates and helps students integrate the following topics: Economics; Finance and Budgeting; Statistics and Modeling Techniques; Public Policy and Policy Analysis; Ethics.
- Focus Areas (or concentrations) that address public policy issues of relevance to engineering students. We have identified the following for further exploration: Environmental Policy; Resource Utilization Policy; Science and Technology Policy; and, International Development Policy.
- An independent project (honors thesis) related to an issue from one of the concentrations which will include an internship (domestic or foreign) or service-learning component.

At the end of this investigation phase, all Program faculty had a broader understanding of the field of public affairs, a deeper appreciation for the interface of public policy and engineering, and a clearer view of the current state of the Program. We completed this phase during the spring 2005 semester, and by near unanimous vote of the faculty (about 30), began the process of designing a curricular framework for a Program with a more clearly defined understanding of what a public affairs curriculum for engineers should contain.

The Development Phase. Moving forward with the foundation that defines a public affairs core, and with a reaffirmation that our educational goal has been largely successful from an alumni standpoint, we initiated the development of a new curriculum. We began by forming faculty study groups to investigate topical material, and subsequently recombined faculty

| Spring 2006 | Development Phase | Conduct campus-wide discussion of “honors programs” |
| Summer 2006 | Implementation Phase | Conduct external review by public affairs and honors program experts |
| Fall 2006 | Implementation Phase | Revise curricular framework following external review |
| Fall 2006 | Implementation Phase | Seek required academic and administrative approvals for the framework |
| Fall 2006 | Implementation Phase | Undertake course development |
members into two separate curriculum development teams, instructing them to defuse issues pertaining to legacy courses by focusing on student outcomes, learning objectives, and content in modular pieces. The development teams eventually merged into a single team by picking the best pieces each had to offer to produce an exciting and innovative approach to this requirement and identify “Overarching Questions” for each academic year. These are shown in Table 2. With the overarching questions defining the purpose of the Program, the curricular content was readily identified at the modular level.

**TABLE 2 – Proposed Curriculum Framework**

<table>
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<tr>
<th><strong>OVER-ARCHING QUESTIONS</strong></th>
<th><strong>CURRICULUM MODULES</strong></th>
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<tr>
<td><strong>Freshman Year Spring Semester</strong>*:**</td>
<td>• Introduction to Public Affairs</td>
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<tr>
<td>How is public affairs and how and why do we as engineers and scientists study it? What is honors?</td>
<td>• Methodology—communication (includes writing, speaking, researching, organizing and visually displaying information, formulating arguments, using logic); decision-making techniques; observation skills; analytical techniques</td>
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<tr>
<td></td>
<td>• Introduction to Ethics</td>
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<td></td>
<td>• Case study—incorporates basic knowledge of social structure, governmental organizations and public policy formulation</td>
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<tr>
<td>Sophomore Year**</td>
<td>• Cultural Systems—small and large scale; project</td>
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<td>How do societies and groups organize themselves? How do the resulting ‘systems’ influence each other in a globalized world? How does a society’s world view affect its perceptions of other societies in a globalized world?</td>
<td>• Economic Systems (from an historical perspective)—domestic; international; project continued</td>
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<tr>
<td></td>
<td>• Political Systems (from an historical perspective)—domestic; international; project continued</td>
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<tr>
<td></td>
<td>• Conjunctions &amp; Disjunctions of Systems in the Modern World—project finalized</td>
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<tr>
<td>Junior Year</td>
<td>Making Policy</td>
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<tr>
<td>How are policy decisions made? What are the implications of these decisions? How do scientists and engineers apply our understanding of ‘systems’ and decision-making in the real world?</td>
<td>• Leadership and Power</td>
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<td></td>
<td>• Risk Assessment &amp; Communication</td>
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<td></td>
<td>• Conflict Resolution (including group dynamics)</td>
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<td></td>
<td>• Case Study / Simulation</td>
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<td></td>
<td>Analyzing Policy</td>
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<td></td>
<td>• Methodologies of Analysis</td>
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<tr>
<td></td>
<td>• Introduction of Senior Project – domestic &amp; international (general topics such as: land use decisions, alternate energies, disaster responses)</td>
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<td></td>
<td>• Progress reports</td>
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<tr>
<td></td>
<td>Spring Break: Domestic project travel or Summer: International project travel</td>
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<tr>
<td>Senior Year</td>
<td>Semester 1 – Senior Thesis</td>
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<tr>
<td>How can we pull it all together? (Synthesis, application, and life-long learning)</td>
<td>• Globalization</td>
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<td></td>
<td>• Topical discussions related to project</td>
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<tr>
<td></td>
<td>• Periodic tutorials</td>
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<td>• Progress reports</td>
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Given the inherently interdisciplinary nature of a public affairs program for engineers, one involving teams engaging both science/engineering and humanities and social science faculty, we recognize the heightened need for explicit learning objectives and assessment measures. Experience reveals that many faculty members have an unsophisticated working knowledge of such measures which they often do not articulate within their work. We are using this curriculum development project as an opportunity to help McBride faculty develop assessable learning objectives. Drawing on resources available through the Center for Engineering Education (CEE) [14-16], we hosted workshops for faculty teams involved in the planning activities.

Building faculty consensus has been one of the most difficult but most critical components of this project. Faculty views of the mission of the Program have diverged over time, and the committee-of-the-whole governance of the Program (often confused unhelpfully with daily program management) has not been able to respond effectively to dissention nor generate consensus to create a productive pathway forward. The workshops that were implemented successfully reduced acrimony and helped to develop consensus regarding the new curricular direction. Additionally, the existing CSM academic structure does not include academic honors programs in the science, engineering or specific non-technical disciplines such as economics. Thus, as the McBride Program strives to redefine “honors” for its purposes, so too will this effort help define “honors” for the entire community. It is clear that at this point in CSM history and institutional strategic planning, the redirection of the McBride Program must include input from the CSM faculty at large as well as input from an external review committee of experts in public affairs and the organization and management of honors programs, both underway as of the spring semester 2006.

Currently, we are in the process of soliciting the external review of the proposed curricular framework: for a university with a science and engineering focus, the implementation of a high quality public affairs program engenders resource questions related to hiring permanent CSM faculty versus developing a mutually beneficial relationship with a nearby institution to provide the expertise we currently lack.

**Evaluation of the Process**

As outlined in the acknowledgment section of this paper, a group of about 25 faculty members from a variety of fields participated in the curriculum design process. A subset of nine people...
was responsible for the curriculum design that is presented in this paper. The curriculum redesign process was evaluated through interviews with three key members of this 9-person curriculum design team. Interviewees were self-selected, remained anonymous, and were each interviewed once, for 90 minutes. Human Subjects approval was obtained for the interview process.

Interviewees were asked to answer the five open-ended questions listed below. Answers to each question will be discussed in turn.

- What was your role in the curriculum design team?
- What or who helped the team move toward its goal?
- What or who was an obstacle for the team?
- What was the most important part of the process?
- What was the most confusing part of the process?

**Role on the curriculum design team**
The specific roles of interviewees will not be discussed here, to protect anonymity. It can be said that the responses to this question did confirm that each interviewee was a key member of the team.

**What helped the team move toward its goal?**
Some structural components of the process, such as specific deadlines and deliverables, were mentioned as helping the process move along. However, we posit that the attributes of the team members themselves may have more significantly contributed to the “flow” of the design process. Although all interviewees saw the team as being collegial and egalitarian, individuals were willing to step forward and take the role as leaders, note-takers, and “devil’s advocates”. The team also created supporting documentation such as detailed sets of meeting notes, “straw person” curricula, a statement of philosophical and pedagogical foundations for the Program, and the set of over-arching questions listed in Table 2. The existence of the over-arching questions was mentioned by one interviewee as something that kept the team on task since these could be used as a benchmark to check the alignment of proposed components of the curriculum. The collegial nature of the team, which one interviewee called “one of the best teams I’ve ever been on”, seemed to arise from the team members’ universal, long-term commitment to the purpose and value of the Program and the desire to see the Program continue and improve.

**What was an obstacle for the team?**
The compressed timeline of the curriculum development process was a hindrance as well as a motivation to keep the team moving along. All three interviewees identified as obstacles those activities which forced the design team to deconstruct the existing curriculum and think in terms of learning outcomes instead of defining specific courses. However, the deconstruction exercise was also viewed as an activity that helped faculty think beyond the constraints of past practice and, as a shared activity, also fostered collegiality. The fact that all team members were instructors for various courses within the existing seminar-based curriculum was also seen as a potential obstacle. Some team members had difficulty distancing themselves from their individual courses and their commitments to them; they found themselves thinking in terms of
how change would impact their course and their role in the Program, rather than dispassionately looking at the Program as a whole.

*What was the most important part of the process?*
Interviewees asserted that designing the curriculum collaboratively has been very important for the credibility of the new curriculum among the Program faculty. The collegiality and shared commitment to the Program was perceived as being vital to the success of the process. Being given the opportunity to look at the existing curriculum as a whole with “new eyes” was very much appreciated.

*What was the most confusing part of the process?*
Thinking of the curriculum in terms of learning outcomes instead of as a set of specific courses was the most frequently mentioned cause of confusion. Another limitation was that no one member of the team had detailed knowledge about every part of the curriculum. Consequently, often there were areas that various team members felt they did not have sufficient expertise to discuss.

**Conclusions, Lessons Learned, and Next Steps**

At this mid-way point in our project, we share some of the lessons learned from the process employed to date:

1. There is a clear need for a structured process with milestones and deliverables for the participants; however, from our interviews we discovered that this same structure resulted in the participants feeling “pressed for time.”

2. Encouraging the team to think about learning outcomes and modules of instructional materials rather than specific traditional courses made some team members uncomfortable but appears to have produced a more cohesive, coherent curricular structure with greater relevance to the underlying mission of the Program.

3. Commitment of the faculty team to an interdisciplinary vision is paramount to the success of the curriculum redesign; yet, such commitment is a double-edged sword, engendering demand for the persistence of legacy conceptions and courses that themselves had led to the need for and the decision to re-evaluate the Program.

4. The historic entrenchment and diverse views on the past successes and shortcomings and potential future directions of the Program required the faculty team to exercise great civility and respect during discussions: commitment to continuation and excellence of the Program, to the interaction with students, as well as the personal need to explore complexity beyond traditional disciplinary boundaries are the qualities that allowed a highly integrative curriculum to emerge.

5. Disciplinary and program “experts” versus “non-experts” are defined by those who are willing to be actively involved in the curriculum discussions; creating an effective
interdisciplinary team has a complexion that extends beyond selecting individuals to participate.

6. Our historic Program has its roots in a 30-year old vision not far removed from that more prominently stated in Engineer of 2020; self-reflection promoted by this project has reaffirmed our institutional commitment to the principles, values, and perspectives of our mission statement: …to provide a select community of CSM students the enhanced opportunity to explore the interfaces between their areas of technical expertise and the humanities and social sciences; to gain the sensitivity to project and test the moral and social implications of their future professional judgments and activities; and to foster their leadership abilities in preparation for managing change and promoting the general welfare in an evolving technological and global context.

At the time this paper was written, results for the curriculum development process are being used to inform a campus discussion to decide whether a new administrative structure is required for the McBride program and to assess future faculty staffing needs. The curriculum framework will also be reviewed by a distinguished external review committee knowledgeable about the interface between engineer and public policy. Feedback from this committee will be used to refine the framework and begin the task of creating individual courses and modules to be implemented, hopefully, starting in the 2007 academic year.

Acknowledgments

The curriculum framework presented in this paper is the collaborative work of a faculty team whose members and fields of expertise are: Profs. M. Boland (geology and public policy), G. Baughman (energy education), F.E. Cecil (physics), M. Cecil (geology and writing), K. Godel-Gengenbach (cultural anthropology), G. Greivel (mathematics and computer sciences), G. Holden (geology), W. Spaulding (public administration), and E. D. Sloan (chemical engineering). This team was a subset of the governing body of the McBride Program, a self-selected group of about 25 faculty from CSM, neighboring universities, private and public sector businesses, and government. The team members are all active seminar moderators leading a spectrum of course offerings from freshman to senior level.

The authors are grateful for the support provided by the office of the CSM Executive Vice President for Academic Affairs that enabled summer workshops to be conducted.

References Cited


Biographical Sketches

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