

**Developing a Philosophy of Practice:  
A New Approach to Curricular Evolution in Engineering Education  
At the University of Wisconsin**

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### **Introduction**

ABET EC2000<sup>1</sup> is remarkable in the flexibility allowed engineering departments in determining the content of their curriculum and the methodologies used to teach the curriculum. This flexibility is in sharp contrast to the prescriptive curricula previously specified by ABET. The change to ABET EC2000 should provide opportunity for departments to produce improved and responsive curricula for their students. By setting goals and measuring outcomes, ABET EC2000 is a framework for assisting departments to engage in a process of continuous review of their curriculum. As remarkable as the flexibility is, equally remarkable is the distinct lack of structure for the method a department should use in their process of continuous review.

An additional issue arises because it is not obvious how to assist get a department to move from where it is now to a department that is actively engaged in continuous review of the curriculum. Our experience has been that it is a challenge to engage faculty in an engineering department to employ this process. Despite some effort in looking, we have not been able to find a suitable means that would guide our department in growing toward a process of continuous review.

This paper describes a number of different things we have done to attempt to assist an engineering department in embedding the ABET idea as part of activities regarding curriculum. First, we describe a 4-step process involving feedback that could be useful in the review. We include a description of the theory behind the proposed structure. Next is a description of ideas and practical realities of faculty roles that must be accounted for if there is any chance for success in moving a department towards embedding this process. Finally, we describe an example of implementation that details what we have done and what we have learned.

### **Faculty and Curriculum Evolution**

Faculty conversations about curricula are often difficult and include several factors that have a dominant effect on the conversation. First, conversation tends to focus on specific course details or course sequence content. This is in spite of the fact that very often it would be more appropriate to consider a particular issue in light of the entire curriculum.

Second, conversation about curricula is often volatile. We believe this occurs because faculty members have deeply held beliefs regarding the curriculum and content of specific courses. Further, they feel a responsibility to both the students they teach and the profession in which they engage. It is common to frame this belief with the comment “Every engineer must know ‘blank’,” where blank is any particular subject associated with the curriculum.

Third, it is also clear that faculty discussions about curricula are often constrained by a variety of real issues. For example, it is not trivial to make major changes to curricula and still ensure consistency with degree requirements. In many cases, changes are constrained by a variety of pedagogical issues, such as lack of suitable textbooks or lack of suitable models for instruction. It is also true that it requires effort and courage to make a change. And, it is not always apparent that there is adequate support to make changes, even in the best of circumstances.

Finally, our experience suggests that something important is missing for this process to be successful. There needs to be an overriding method or system that will assist faculty in making decisions about the curriculum. This mechanism may include a guiding educational philosophy that can be applied in the consideration of decisions regarding curricula. It may also include other forms of feedback to the process, for example, feedback from students or employers.

### **Theoretical Framework**

What we describe here reflects a belief that what is often missing from efforts at motivating curricular evolution is what Parker Palmer<sup>2,3</sup> called, “the work behind the work.” The work behind the work entails a focused and potentially harsh look at current practice. It involves critical reflection about the ways in which you have and have not achieved what you hoped to achieve. It involves noticing the shortcomings and wrestling with large questions such as “What is education for?”

### **Organizational Change**

Theory in educational change, including the work of Horton and Freire<sup>4</sup> and organizational change, as described by Senge,<sup>5</sup> has suggested that building a shared vision and learning within the organization will yield effective and long lasting change. We agree with these educational and organizational reformers who have suggested that efforts to foster change in higher education must be holistic in approach. In this context, holistic means that the process must consider all aspects of the educational experience, not just the objectives and outcomes, but the pedagogy itself as well as the history of the discipline. Most importantly, they reinforce our ideas that for positive, reflective, and continual curricular change to occur a department must engage in building a philosophy of practice to support their work.

Consistent with the EC2000 objectives, one of the objectives for this project was and is to develop a methodology for use by an engineering department that would result in the following processes. First, the department would engage in regular and systematic determination of a guiding educational philosophy. Second, this educational philosophy would be followed with

regular and organized review of the actual content of the curriculum to see if the curriculum was actually meeting the educational philosophy established by the department. Third, there would be habitual review of methods possible for teaching the content. Finally, assessment of the program would be continuous and commonplace. This process would be iterative and embedded as part of the normal activities of an engineering department.

To provide a structure for the curricular change objectives stated above, we considered the “double-loop learning” model of Argyris and Schön<sup>6</sup> specifically designed for change within organizations. As shown in Figure 1, this model is adapted from their work using Governing Variables, Action Strategy and Consequences. As their model suggests, if one works only with single-loop learning, actual outcomes become fractured because the mechanism for changing the governing variables is missing. With double-loop learning, a path exists that allow for change to the governing variables. We propose to begin with their model, designed for organizational change, extending it for curricular evolution.

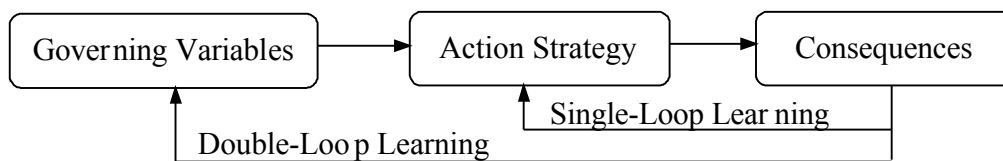


Figure 1. Single Looping/Double-Looping (Adapted from Argyris and Schön<sup>7</sup>)

## Curriculum Evolution

All departments are engaged in curriculum evolution. As an example, in Figure 2 we illustrate how some departments are carrying out this process. Referring to Figure 2, curriculum evolution using this approach tends to be centered on the individual faculty member. This necessarily results in focus on individual courses or course sequences.

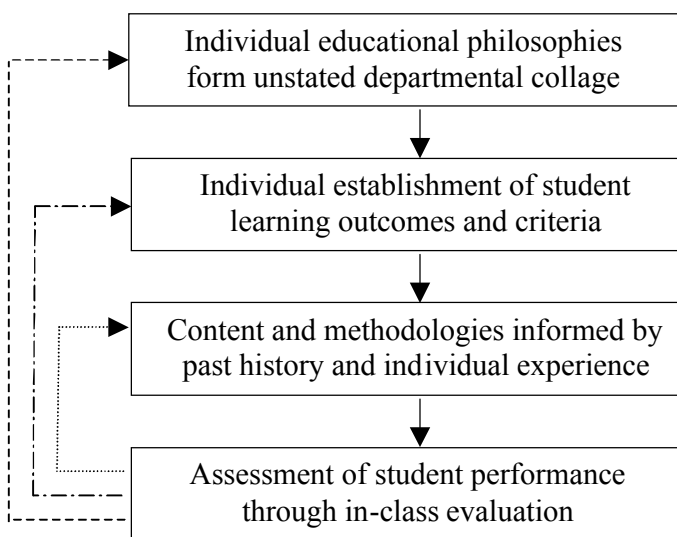


Figure 2. Example of Informal Structure used by Many Departments for Curriculum Evolution.

Extending the model of Argyris and Schön to provide a structure that involves the entire department in a more unified effort at curriculum evolution results in the structure illustrated in Figure 3. As shown, the normal path is active. It involves, first, the development of guiding or working departmental philosophy regarding undergraduate education and teaching. This follows the recommendation of Heywood,<sup>8</sup> who suggests that it not possible to determine appropriate outcomes and/or objectives for the curricula without an “operational or working philosophy.” Heywood defines operational philosophy as “the value system that drives a particular curriculum, course, or training session.” The guiding philosophy is followed by the determination of student learning outcomes and criteria for determining if the desired outcomes have been met. Next, is determination of the content of the curricula, coupled with the application of the optimum methodology in which to teach the subject or course. All of this is followed by assessment. The process does not end there, however. Expanding on Argyris and Schön, the assessment step is coupled to each of the other steps through feedback loops. For example, assessment of student performance for particular objectives might result in change in course content, but it could also indicate that the guiding educational philosophy needs further thought.

Before we leave this discussion of structure, it is perhaps illuminating to point out that the structure we are proposing is a direct application of the engineering design procedure to curriculum improvement. Extracting from Burghardt,<sup>9</sup> shown in Figure 4, is a simplified version of the design process. Each of the steps in the design process has a direct analog in curriculum evolution, implying that the curriculum improvement structure should be something both recognizable to and welcomed by engineering faculty.

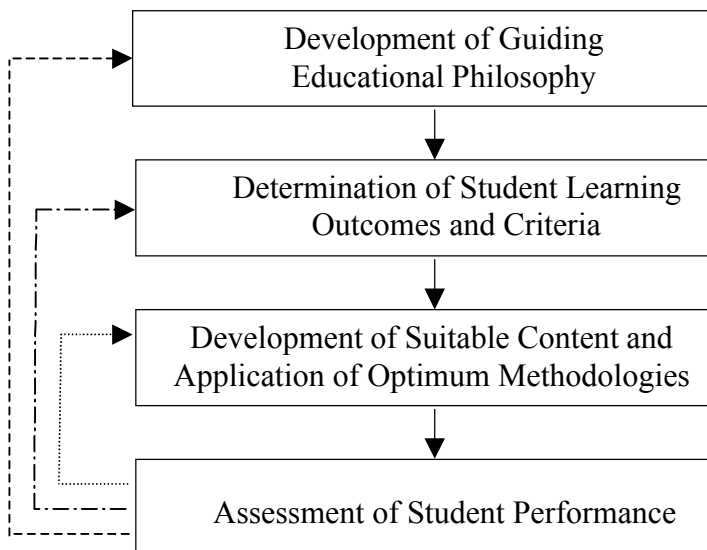


Figure 3. A Formal Structure for Curriculum Evolution

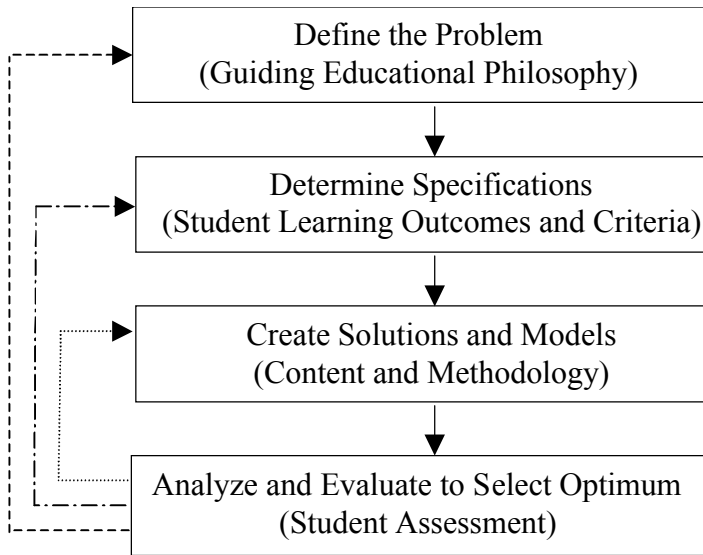


Figure 4. Application of the Engineering Design Process to Curriculum Improvement

### Major Challenge: Getting From Here to There

As we have indicated, our goal is to assist engineering departments in using a process that we have proposed. A significant challenge, however, arises for departments attempting to engage in this process. This challenge comes about because the current state of the department and departmental culture do not allow the department to complete the process. In other words, the department as an organization does not know how to get from where it is now to where it would like to be. Before we can expect a department to insert this process into ordinary department activities, it will be necessary to provide a bridge from the current state. From here we describe efforts at building this bridge. A little chronology is necessary to explain how we came to where we are.

### A Pathway to Curriculum Evolution

The College of Engineering of the University of Wisconsin-Madison was reviewed by ABET in the spring of 2001. As a result of the process leading up to the review, we saw a need for a more comprehensive look at curricular issues in the Mechanical Engineering Department. This is not to imply that the Mechanical Engineering Department was picked because of any particular deficiency. Instead, the Mechanical Engineering Department was chosen because of the real interest the faculty have in engineering education. In addition, one of us (Martin) is a professor in the department. Finally, there was a desire to build on the activities of the Foundation Coalition in developing novel undergraduate curricula. Consequently, the Department Chair was approached and asked if he would endorse a plan similar to what we describe here. The Department Chair supported the idea of working on curriculum evolution. He took the idea to the Dean of the College for his approval. With the approval of the department chair and the support of the Dean, the process was on its way.

Our efforts started with the faculty at a “beginning of the academic year” department gathering.

At this gathering, groups of faculty were asked to consider issues with specific courses or course sequences in the mechanical engineering curriculum. Four separate courses or course sequences were considered. At this meeting, instead of asking faculty what to do to fix the problem, we asked them to step back from immediately seeking a solution and answer the following questions:

Question 1: To ensure that you make the best informed response to your issue, what information do you need?

Question 2: What information do you have?

Question 3: What information do you trust and why?

Question 4: How can we/you get the information you need?

Question 5: What outside sources would assist us?

Question 6: Who is responsible? Who should be responsible?

We asked Question 1 because it seems to be common that discussions about courses are often constrained by needed information that is not at hand or not easily attainable. It is often true, however, that the information is readily available, hence, Question 2. In some cases, we observe that people might not trust information from particular sources, so it is important that this is known (Question 3). We wanted to get feedback from the faculty about how this information be collected since the faculty would likely be a good resource (Question 4). Similarly, faculty would also be a good source of outside sources (Question 5). And finally, we wanted the faculty to determine who should be responsible for these issues (Question 6). Faculty may feel that they are responsible, or that there is not any determination of who should be responsible, again limiting any action.

There were a number of interesting outcomes of this activity. First, one group was not able to complete any part of the assignment, primarily because the faculty member who had most recently taught the course was defensive about this focused look at “his” course, and this group spent the session learning the details of the course as recently structured. Three of four of the groups indicated that they needed information from the ABET requirements, in spite of the reality that the department had been reviewed by ABET within the past year. Three of four of the groups felt that additional information was needed from students and employers of the students. All groups asked questions related to how the course or course sequence fitted into the curriculum as a whole. Finally, the general consensus was that faculty members were responsible for resolving these issues.

Simultaneous with the first efforts at a department curriculum gathering, a number of department members were interviewed for their ideas about courses, their views of teaching and their wishes for the department. For example, one department member suggested that in some cases the basics are being short-changed. Another interview revealed a major concern that research was becoming even more greatly valued over teaching. A number of the department members asked, “Do we

have a customer?” And if so, “Who is that customer?” One long-time faculty member lamented the lack of collegiality and community, which in his opinion had been lost over the years as the department grew. Faculty were concerned about a standardized grading philosophy, the importance of a capstone design course and information about other departments across the country and how other departments dealt with curricular decisions. And finally, in general, the interviews revealed that the instructional staff in the department was very interested in teaching and learning.

At a departmental meeting following the interviews and gathering, curricular issues were the primary focus. In between the first gathering and the departmental meeting, we had gathered most of the information that was requested by the groups. In addition, we had developed a plan for each of the groups for how they might work toward resolution of the issue on which they were working.

In short, this meeting did not go as we expected. Several faculty members were openly unhappy about this activity, and indicated during the meeting that they did not think this was a good use of time in a department meeting.

### **Thinking More Expansively**

From these sessions, two things were obvious. First, it became clear that it was necessary for the faculty to step back from actual course content, teaching techniques and sequencing. It seemed necessary that the department begin to look for and find common ground on which to build a set of values- a guiding philosophy- that could assist it in making continual curricular evolution possible. Second, it was also evident that we would need to change the actual process we were using if we expected that faculty would continue to participate.

To begin this process, we planned and held an off-campus community-building philosophy construction exercise for the department. With the approval and support of the Dean, faculty members cancelled Friday afternoon classes to drive to a quiet location about an hour from campus. Spouses, significant others, and families were invited and encourage to attend the day and a half event.

Figure 5 lists the components of the model that was used in designing this exercise, and how much time was devoted to each of the components. Each of the components will be discussed to show how and why each was used.

<b>Components of the Model</b>	<b>Approximate Time Allotted</b>
Appreciative Interviews	1.5 hours
Reading and Reflection	2 hours (2 selections)
Group Discussion and Reporting about Readings	1.5 hours (2 selections)
Reflection on Philosophy Statement Question	1.0 hour
Discussion: Where do we go from here?	0.5 hour

Figure 5. Components of the Model Used for Developing a Philosophy of Practice

## Appreciative Interviews

To assist in achieving affirmative collegiality, a stated goal in this process, Hammond's<sup>10</sup> techniques of Appreciative Inquiry were used. Hammond suggests that in every organization some things work well. Change can be managed through the identification of what works with an analysis of how to do more of it. Instead of looking for problems to solve, Hammond suggests that organizations look for solutions in those things the organization already does well. She further suggests that carrying positive memories of past group successes can aid a group in alleviating the anxiety that may come with the possible change.

To seek and affirm those things this department has done well, an appreciative interview process developed by Hammond<sup>11</sup> was an early step in the experience. Participants were paired to interview each other. The interview was structured with questions such as "Reflect on a time that demonstrated the positive aspects of working together as a department to get something done," and "What are some positive images in your mind of a graduate of the Mechanical Engineering Department?" Every faculty member was then "introduced" by his or her partner to the larger group on the basis of the interview questions. In this process, the listening to and reporting about his or her partner affirmed each individual's experience and enhanced the collegiality of the group.

As shown in Figure 6, the faculty generated a wide variety of responses to the inquiry exercise, and perhaps the entire faculty members were surprised at the positive feelings expressed by their colleagues.

<b>Describe a time you felt energized as a faculty member.</b>	<b>Reflect on a time that demonstrated the positive aspects of working together as a team.</b>	<b>What are your wishes for the future of the Mechanical Engineering major?</b>
When we finished tasks and projects.	Our departmental hiring efforts over the last few years.	Faculty will make a larger investment in time in undergraduate teaching.
Feeling the sense of "openness" of the department.	We needed to reorganize engines lab of the small engines consortium-and we did it!	Add ethics to curriculum.
When a student completed her degree though others had doubted she could.	Design faculty always went to lunch on Mondays and interacted as friends and colleagues.	Adapt to change.
Receiving a much-improved draft from a student.	Groups of people working together with common interests and goals, especially small groups-including faculty and staff.	Achieve a better balance between research and teaching.
Being around energetic young people.	When the General Engineering Building was new we put together the new computer labs-we did everything ourselves!	Faculty will improve what they teach and how they teach it.

Figure 6. Sample Responses to the Appreciative Inquiry Interviews



## **An Opportunity for Reading and Reflection**

Providing time to reflect on their practice has become a popular concept in teaching, learning, and curricular evolution. Brookfield<sup>12</sup> and others have suggested because the term “reflective practitioner” entered common parlance without a clear definition, it must have two distinct purposes. First, to establish a truly reflective practice, the instructor must critically examine considerations of power, and how power affects and distorts the educational processes. Second, instructors must question assumptions and current practice that seem to make teaching lives easier but actually work against long-term improvement, both in pedagogy and quality of profession.

Based on the work of Brookfield<sup>12</sup> and Schön,<sup>13</sup> ample time was provided for reading and reflection. Some faculty and staff members requested the readings in advance; however we made it clear that it was not our expectation that anyone would do the reading beforehand. The teaching, learning, and philosophy of education materials were chosen to be read without the distractions of the regular workday and the work setting. In addition, the faculty members were given the time and location in which they could enjoy learning and reflecting on the information provided in the readings. The list of readings used is shown in Figure 7. The readings included material specific to the philosophy of teaching, information specific to learning, and material related to engineering curricula.

The specific structure used to study the readings involved dividing the larger group into four smaller groups. Each group had a different set of readings. First, individual participants were free to leave the large meeting space to find a comfortable spot to read and reflect on assigned reading for an hour. Some participants chose to stay in the large meeting room while others were seen around the pool or sitting near the fireplace intent on their assignments.

After the reading and reflection time, individuals who had read the same articles formed groups to discuss and analyze the reading. Given a format and a worksheet for their discussion, each group appointed a recorder and a reporter. The reporter noted key features from the group’s readings in a process where each reporter shared with the large group key points from the group’s assessment of the reading. At each opportunity the facilitator asked the group for its assessment of the implications for a departmental philosophy. Ideas were recorded for the larger group to see.

This process was repeated twice with different group members and different reading. All readings were available to all members, even though an individual may not have been assigned that particular selection. As a result of this, participants sought out many of the more provocative readings.

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- Merrill, M. 1997. *First Principles of Instruction*. Unpublished paper.
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Figure 7. Reading List for Reading and Reflection

### Philosophy-Building Exercise

For the final item on the agenda of the gathering, the group facilitator led the faculty in a philosophy-building exercise. Each faculty and staff member responsible for teaching undergraduates was asked to take a few quiet moments to reflect on the question:

***What are our responsibilities as faculty members teaching undergraduates at a Research I university?***

After a time for individual reflection and writing, groups then began to discuss their ideas and consolidated them for reporting to the larger group. Then, one-by-one each response to the question was listed on chart paper, numbered and posted around the room. After all ideas had been exhausted, twenty-three statements had been generated. Next, each participant was asked to vote on the ideas that they felt were most important to the department responsibilities. As a result of this activity, the description of department responsibilities shown in Figure 8 was generated

from the statements with the highest number of votes. From our experience, the content and language are uncommon for a mechanical engineering faculty.

1. Provide
  - Motivating exposure to fundamental concepts in all areas of engineering,
  - Stressing WHY we teach what we teach,
  - For the purpose of extending student knowledge, while
  - Offering multiple opportunities for understanding.
2. Be passionate about what we do. Share our desire to learn with our students and enhance our students' excitement about engineering.
3. Enhance our students' ability to communicate.
4. Provide role models, with high achievement and ethical standards, while keeping ourselves in the forefront of technology without harming the environment.

Figure 8. Draft Philosophy Statement of Departmental Responsibilities

### **Community Building**

An attempt to bring faculty members together to build a common philosophy of teach requires a positive and collegial environment. The community-building events that were specific to this experience may be quite different in another setting. For the UW event, spouses and families had informal time to interact both while the faculty and staff were working and in other activities, formally and informally. Special events were planned for children, including a chance for children and families to “meet” Wisconsin reptiles and amphibians with the assistance of a naturalist. The entire ME community enjoyed a banquet and entertainment together. One department member remarked as the conference came to a close, “I don’t think I’ve ever left a meeting of this importance feeling refreshed rather than drained and exhausted.” We believe the community-building nature of the event, focusing on the positive things the department had done and the shared values of the group contributed to this general feeling.

### **Next Steps**

During the next phase of the process, faculty and staff reviewed the draft statement of departmental responsibilities developed at the curriculum gathering described previously. The draft statement was compared and consolidated with educational objectives determined previously by the department as part of the ABET review preparation at the next departmental gathering to consider curriculum. After this activity, the curriculum committee combined features of each set of statements and outcomes to create the document used to form a working or guiding philosophy. It is noted here as Figure 9.

1. We believe that upon completion of the undergraduate program, a graduate should have a foundation in mathematics, science and design methodology applied to the disciplines of mechanical engineering in the areas of mechanical, fluid, thermal and manufacturing systems.
2. We believe that undergraduate learning should include:
  - a. Why we teach what we teach, and
  - b. Multiple opportunities for understanding.
3. We believe that the undergraduate curriculum should include contemporary and essential tools needed in the breadth and depth of mechanical engineering.
4. We believe that the curriculum should incorporate a variety of means to enhance students' ability to communicate.
5. We believe that our curriculum should enable student to recognize the need for and a desire to engage in life-long learning.
6. We recognize we have opportunities as role models for our students. As role models, we have a responsibility to present to our student multiple viewpoints of ethical, environmental and social matters.
7. We believe that engineering requires the ability to work both as individuals and in teams. Our curriculum should reflect this belief. In addition, it is our responsibility to provide experience in leadership, management, planning, organization, and real-world, hands-on engineering.
8. We believe student opportunities and experiences should lead to an appreciation of the business and entrepreneurial aspects of mechanical engineering.
9. We value creative thinking and believe that our curriculum should promote and develop creativity in the students and faculty.
10. We believe we should be passionate about what we do, and we should share our desire to learn with our students.

Figure 9. Educational Philosophy

Once the guiding philosophy was established, the faculty members have begun to work in small groups with individual objectives, comparing them with the stated objectives of the required course sequence for the undergraduate major. As all faculty members see most or all of the objectives of the course in the sequence of courses required for the major and compared those with the objectives derived from the philosophy statement exercises, we expect interesting discussions will begin about the fundamental structure of the major. These discussions will determine criteria useful in determining if the curriculum really is meeting the stated objectives. Faculty will be asked to establish criteria that will be useful for determining, for example, if students have gained sufficient skill in mathematics and basic physics necessary for mechanical engineering. This step will likely be difficult and will require additional thought to arrive at an efficient and workable process.

Finally, assuming that useful criteria can be developed, then the process described in Figure 3 will be implemented. Regular faculty gatherings will be facilitated to allow faculty a chance to work

together on the curriculum as a whole.

## Summary

We have been engaged in an effort to develop a philosophy of practice for curriculum evolution in the Mechanical Engineering Department at the University of Wisconsin-Madison. To accomplish this, we have developed two different pieces that are needed for a department to embed this practice in ordinary activities. First, we have developed a process that can be used by an engineering department that, if followed, will assist the department in curriculum evolution. Before a department can begin to use the process we propose, however, it is necessary to move the department from the way it currently works on the curriculum to a more organized and holistic process. It is our hope that the set of activities and general guidelines about work on curriculum will assist the both our department and others in making a transition toward continual renewal of curriculum based on a departmental shared philosophy.

## Acknowledgements

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<sup>7</sup>Arygris, C. & D. Schön. D. 1974. *Theory in Practice: Increasing Professional Effectiveness*. Jossey-Bass: San Francisco.

<sup>8</sup>Heywood, J. In press. *Curriculum, Instruction and Leadership in Engineering Education*. Trinity College Press: Dublin.

<sup>9</sup>Burghardt, M.D. 1999. *Introduction to Engineering Design and Problem Solving*. McGraw-Hill. Boston.

<sup>10</sup>Hammond, S. 1998. *The Thin Book of Appreciative Inquiry*. Thin Book Publishing: Plano, TX.

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<sup>12</sup>Brookfield, S. 1995. *Becoming a Critically Reflective Practitioner*. Jossey-Bass: San Francisco.

<sup>13</sup>Schön, D. 1987. *Educating the Reflective Practitioner*. Jossey-Bass: San Francisco.

DAYLE K. HAGLUND has been involved in the National Science Foundation-Foundation Coalition activities in curriculum evolution at the University of Wisconsin described in this paper. As a science educator, she has taught and developed science curriculum for school children and college students.

JENNIFER KUSHNER was the Associate Director for the Wisconsin Education Engineering Lab. She was involved in the development of the theoretical and organizational framework for this work.

JAY K. MARTIN has led the first-year introduction to engineering course for the past five years and is the principal investigator for the Foundation Coalition on the University of Wisconsin campus. As a mechanical engineering professor, he has recently changed the focus of his research from turbulent combustion in engines to biomechanical systems.