

PROCESS EDUCATION AND CONTINUAL PROCESS IMPROVEMENT AT WESTERN MICHIGAN UNIVERSITY (WMU)

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Abstract $\frac{3}{4}$ The College of Engineering and Applied Sciences (CEAS) at Western Michigan University has initiated several strategic studies and programs to shape and direct the next five to ten years. With new leadership in the college and the University, the college began a major self-study and planning activity in Fall 1999 to re-assess mission, vision, goals, and objectives. One significant outcome of this activity was specific goals and objectives related to curriculum development and faculty professional development. Education of faculty in improved methods of teaching/learning was initiated in February 2000 when a group of six faculty, including several engineering department chairs, participated in a Teaching Institute (TI) led by Pacific Crest at Rose-Hulman Institute of Technology. This activity was followed by WMU's sponsorship of a TI for CEAS and other colleges within WMU at which the initial group served as mentors. An Advanced TI for Curriculum Design was conducted for the college, followed by another introductory TI in cooperation with a local community college and WMU's Center for Teaching and Learning. Finally, a Program Design and Assessment Institute was conducted in January 2001 to integrate the curriculum assessment systems within the college. Over two thirds of the faculty within the College of Engineering and Applied Sciences, along with other faculty from the College of Education, College of Arts and Sciences, Kalamazoo Valley Community College, and several universities from across the country have now participated in workshops at WMU. These activities have seeded an ongoing plan of faculty development, program review, and continuous improvement of college programs and processes. The details and results are presented.

Index Terms $\frac{3}{4}$ Assessment, Continuous Improvement, Process Education

INTRODUCTION

In Fall 1999, with new leadership in the college and the University, the College of Engineering and Applied Sciences at Western Michigan University began a major self-study and planning activity to re-assess its mission, vision, goals, and objectives. Involved in this effort were faculty, students, staff, alumni, advisory board members, and

employers. Areas of strength and areas for improvement were identified. These were reclassified, refined, and finally condensed into areas for further study and development of recommendations. The areas identified were Computing; Curriculum; Personnel; External Relations; Physical and Financial Resources; Process and Assessment; and Scholarship, Research, and Graduate Programs. Within these areas were specific goals and objectives related to curriculum and faculty professional development. Concurrently, the new EC2000 criteria for accreditation of engineering programs has inspired the re-examination of academic programs, instructional methods, and implementation of a system of continuous assessment and quality improvement. [1]

A program to acquaint faculty with improved methods of teaching/learning was initiated in February 2000 when a group of six faculty members, including several department chairs, participated in a Teaching Institute led by Pacific Crest, Inc. at Rose-Hulman Institute of Technology. This first step was followed by several other institutes and workshops in course and curriculum design and assessment. As of May 2001, fifteen months after the beginning of this effort, over two thirds of the college faculty have participated in one or more workshops and are implementing new tools for instruction, assessment, and evaluation.

PROCESS EDUCATION™

The basis for these improvements in educational methods is Process Education™ [2], an educational philosophy focusing on improving students' learning skills and creating "self-growers." Self-growers are people who take ownership of and responsibility for their own educational growth. The goal of Process Education is for students to develop their levels of learning, preparing them to continue their education long after they leave an educational institution and throughout their careers. This mandate to create life-long learning is clearly articulated in the EC2000 criteria. Consequently, engineering education is being transformed from delivery of traditional content-based educational programs to outcomes-based learning. The result is the production of professionals for our technological workforce who are able to continue their self-education throughout their careers.

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This shift in perspective has been impending for nearly a decade. "A paradigm shift is taking hold in American higher education. In its briefest form, the paradigm that has governed our colleges is this: A college is an institution that exists to provide instruction. Subtly but profoundly we are shifting to a new paradigm: A college is an institution that exists to produce learning. This shift changes everything. It is both needed and wanted." [3]

Traditionally, the acquisition of skills essential to life and work has been considered a by-product of study, not something requiring explicit attention on campus. We know of only a handful of the nation's colleges and universities that have developed curricular approaches similar to, for example, the list of critical skills by the U.S. Secretary of Labor's Commission on Achieving Necessary Skills (SCANS). [4] However, such skills -- written and oral communication, critical analysis, interpersonal competence, the ability to obtain and use data, the capacity to make informed judgments, and the skills required in community life -- are essential attributes of a liberal education when they are accompanied by discipline-based knowledge. These skills can be learned along with course content. However, if they are to be learned and fully assimilated, they must be taught and practiced, not merely absorbed as a result of unplanned academic experience. [5]

Thus, Process Education is a philosophy that utilizes an approach of continuous quality improvement toward the key educational processes of teaching, learning, curriculum design, assessment, and administration. Implementation of Process Education involves the use of innovative concepts, processes, and tools to create environments that are instructive and enlightening and that assist students in improving their learning and self-assessment skills. [6]

The principles of Process Education are as follows:

- Each person's learning processes can always be improved.
- There is no measurable limit to one's potential for learning; one's potential is not constrained by current ability.
- At times, everyone requires help with learning, but the goal is to become a capable, self-sufficient learner.
- Methodologies serve to model processes and are extremely helpful for learning to use processes more effectively.
- Educators must assess their students regularly, not only for purposes of feedback, but also to demonstrate the assessment process and help students learn to assess themselves better.
- An empowered learner is able to use learning processes effectively and to self-assess to improve future learning and performance.
- A quality learning environment involves facilitators who focus on improving students' learning processes in specific defined areas through timely, appropriate, and constructive interventions. [7]

IMPLEMENTATION OF PROCESS EDUCATION

Clearly, implementation of the preceding principles requires that faculty understand teaching and learning processes, so that they can go beyond instruction limited to discipline specific content and basic analysis skills. In addition, faculty must manage their courses to increase their students' critical thinking skills and levels of learning, so that students are ultimately able to monitor their own learning processes. Integration of Process Education across a college requires the following elements:

- Developing students' learning skills using a systematic approach in all learning domains
- Improving students' self-assessment skills
- Improving the processes associated with education: teaching, learning, curriculum design, assessment, mentoring, retention, and administration
- Adhering to a set of principles which are based on unlimited learner potential

LEVELS OF LEARNING

In order for faculty to become effective teachers, they must not only be thoroughly familiar with their disciplines, but they must also understand the concepts of levels of learning. While this terminology is familiar among professional educators, it is little known among engineering faculty, whose education has been largely within the technical and scientific community. Once faculty in engineering and technology become familiar with these concepts, they can more effectively work to elevate the learning levels of their students. Levels of learner performance can be defined according to the following criteria:

- *Trained Individuals* have developed a specific knowledge base, with specific skills for a specific context.
- *Learned Individuals* have acquired a broad base of general knowledge and can apply it to related contexts.
- *Lifelong learners* have developed the skills and motivation to self-facilitate their ongoing learning and apply it to variety of contexts.
- *Enhanced learners* have developed a higher level of learning skills, and they actively seek new knowledge and contexts for application in a constantly changing environment.
- *Self-growers* continually grow by using strong self-assessment skills to improve future performance.

Table I, following, provides further amplification of these definitions.

Table I
Definitions of Levels of Learners

<p>Trained Individuals</p> <p>Must have new things explained to them. Need to be told what to do. Find that managing others is extremely difficult. Must have explicitly defined rules, procedures, and policies. Need constant supervision and monitoring of performance.</p>
<p>Learned Individuals</p> <p>Feel comfortable learning within their base of experience. Can perform low-level problem solving within their base of experience. Can train others in the areas of knowledge they know best. Are willing to accept challenges within their areas of expertise. Accept feedback based on “what they produce” better than feedback on “how they perform.”</p>
<p>Lifelong learners</p> <p>Can tackle a reasonable percentage of learning requirements in a changing environment. Are able to apply previous problem solutions to new situations. Are willing to manage people who have more expertise than they do. Seek out new challenges in related areas of knowledge. Accept and use feedback based on their performance.</p>
<p>Enhanced learners</p> <p>Accept all learning challenges and adapt readily to changing environments. Seek out greater challenges, responsibilities, and problems to solve. Are willing to manage a team effort and mentor members within the team. Seek to push the boundaries of their performance. Seek out mentors to help them improve their own performance.</p>
<p>Self-growers</p> <p>Seek to improve their own learning performance with every experience. Create their own challenges. Serve as a leader and mentor to others. Take control of their own destiny; there are no bounds. Self-assess and self-mentor to facilitate their own growth.</p>

Bloom’s Taxonomy, developed in the 1950’s is another commonly used scale to define levels of knowledge and of facility in the use of processes. [8] Table II compares the vocabulary used in parallel systems to categorize learning levels. These definitions of both learning and performance levels are important to the culture of engineering education. Traditionally, much science and engineering teaching and learning is at performance levels 1 and 2, *i.e.* restricted to definitions of terms and use of analytical methods in narrow contexts. These lowest levels of learning are those most easily tested by standardized examinations. However, for professional engineering practice, it is desirable that undergraduate engineering students’ performance be elevated to levels 3 and 4, allowing application of knowledge to new contexts, as they near completion of their academic programs. Graduate students and independent researchers should reach levels 5 and 6 in which they

contribute to the knowledge base with new information and processes. [9] Engineering design, should routinely be at level 4, and may even be at level 5, when it is applied to completely new contexts. Clearly, although traditional engineering education imparts content knowledge, it may fall considerably short of providing higher level learning performance.

ASSESSMENT VERSUS EVALUATION

A critical aspect of the Process Education environment is the implementation of a program of assessment. Assessment -- as distinguished from evaluation -- provides feedback that the assessee can use to achieve better performance. On the other hand, evaluation provides a pass/fail decision relative to a fixed standard, but it does not provide information that can be used for future improvements. In an assessment program, an assessor provides a list of several strengths of the assessee’s performance (to ensure that these aspects are preserved), another list of several areas that could be improved, and finally a list of insights or observations garnered from the assessment exercise. While assessment does not provide a grade or score on a specific exercise, it does encourage improvement of the assessee. This is, after all, a goal of education -- to improve learner performance, not simply to filter out and abandon the low performers. Furthermore, because assessment is much less threatening than evaluation, faculty can use it effectively to improve their own teaching skills. Faculty who are accustomed to the use of assessment techniques frequently ask their students to provide assessments of class activities so that methods of teaching and learning can be more effectively focused upon student needs. [10]

TEACHING INSTITUTES

To implement these principles, each faculty member must develop a broad set of techniques and tools to suit his/her unique context and teaching/learning environment. Teaching Institutes (TI’s) develop faculty members’ skills so that, as individual instructors, they can implement the concepts of Process Education within their classes. These institutes provide faculty with the ability to manage learning in their classroom environment. Faculty members are presented a model of Process Education so that they learn from direct experience how to deal with issues pertaining to teaching and learning and to understand their role as mentor. During a TI, participants learn to set goals and measurable outcomes, and to use assessment as a tool for improvement.

The objectives of a TI are for faculty the following:

- Incorporate more process approaches in their teaching, learning, service, and research.
- Value their role as mentors, and better assess and measure the development of students’ learning skills.
- Integrate new and improved student learning techniques and tools.

Table II
Comparison of Terminology for Learning Levels

Level	Bloom's Taxonomy	Alternative Terms	Process Area
1	Knowledge/ Facts	Information base	Information processing
2	Comprehension	Knowledge	Critical Thinking
3	Application	Knowledge skill	Higher-order critical thinking
4	Analysis	Problem solution	Problem solving
5	Synthesis	New knowledge	Research
6	Evaluation	Peer reviewed knowledge	Assessment

- Implement new and improved teaching techniques and tools.
- Incorporate existing process curricula and learn to design process curricula for use in their own courses.
- Value the importance of self-assessment in the growth process and design strategies to make more use of specific assessment tools with students and themselves.
- All work within an academic program should build toward the overall program objectives.
- The design of curriculum should take into account a methodology for learning.
- Most activities should be created so that they can be self-directed by students.
- The reason for each activity is clearly established learning objectives and performance criteria.
- A formative assessment system measures short-term and long-term objectives, and it documents personal growth of the learners.

CURRICULUM AND PROGRAM DESIGN

Improvements to an educational program require more than improvements in teaching and learning by individual instructors. Not only must individual faculty members' teaching and classroom management skills be elevated, but the same principles must also be infused into courses and the entire curriculum. Thus, an educational program can be continually improved by elevating the quality of instruction, improving the management of the educational system with better performance criteria and measures, improving the quality of curricula, and by empowering learners to continually improve their performance. When these principles are implemented, a well-designed academic course should accomplish the following:

- Allow for shared ownership of the syllabus.
- Set an effective sequence and pace for activities.
- Set criteria for student performance.
- Identify important tools.
- Provide a "knowledge map" of the content.
- Establish a sufficient information base.
- Provide a means for application through projects and problem solving activities.
- Provide a system for assessment.
- Give structure for the processes used.
- Provide critical resources.
- Set out to achieve growth in specific learning skills.

These elements are presented in a Curriculum Design Institute, during which goals and objectives for a specific course are established. These are then used to develop a set of class activities to achieve the desired outcomes.

The methods used to design a course are equally applicable to entire academic programs. These methods form the basis for continued assessment and improvement of an academic program, according to the following criteria:

These methods are addressed in a Program Assessment Institute, in which faculty first establish goals and outcomes for their academic program. These are then followed by development of program outcomes, standards, and metrics.

PROCESS EDUCATION CHRONOLOGY AT WMU

These implementation tools – Teaching Institutes to develop individual faculty members' instructional skills, Curriculum Design Institutes to develop courses, and Program Assessment Institutes to examine academic curricula -- have all been part of Western Michigan University's program to implement Process Education.

In February 2000, six faculty members, including several engineering department chairs participated in a Teaching Institute at Rose-Hulman Institute of Technology in Terra Haute, IN. These six faculty members became mentors for a subsequent Teaching Institute in April 2000 hosted by the College of Engineering and Applied Sciences at Western Michigan University. This activity was attended by approximately 25 faculty from the College of Engineering and Applied Sciences, several faculty members from other colleges, including science and mathematics faculty from the College of Arts and Sciences, as well as representatives from the College of Education. One faculty member from a local community college, Kalamazoo Valley Community College, also participated.

In July 2000, the college hosted a Curriculum Design Institute attended by 18 engineering and engineering technology faculty and several faculty members from other institutions. This event focused on the development of a single course based on instructional outcomes. Faculty

learned to set course objectives and to develop a set of learning activities to accomplish these objectives.

In September 2000, another Teaching Institute was held with joint sponsorship of Kalamazoo Valley Community College and Western Michigan University's Center for Teaching and Learning, a center devoted to improvements in faculty instruction and student learning. This activity included approximately equal numbers of faculty from the two institutions, with 12 new participants from Western Michigan University's College of Engineering and Applied Sciences. Several engineering faculty members who had attended previous Teaching Institutes served as mentors.

Another recent event was a two-day Program Assessment Institute held on a Friday and Saturday in January 2001. In this event, nearly fifty engineering and applied sciences faculty, enough to provide three or four representatives for each of the college's 16 undergraduate programs, participated in a program to establish goals and performance objectives for their academic programs. An outcome from this activity was a document for each academic program, listing goals, measurable outcomes, instruments for measuring those outcomes, and performance standards.

The initial focus of these activities was on individual faculty to familiarize them with teaching and learning methods to improve classroom and course management. Faculty were exposed to the use of alternative methods of instruction, including activities beyond the traditional format of lectures, homework, and examinations. Faculty gained experience in developing students' skills in self-education and learned to engage them in the learning process, so that students could become monitors of their own learning.

This individual faculty focus was then extended to include design of a complete course, not just for coverage of content areas, but also to develop in students a set of skills, and to raise students' levels of learning. Finally, faculty participated in the development of an assessment plan for an academic program. The outcome from that workshop was a set of assessment plans consisting of program goals, metrics, and standards for each program. These documents, although still in draft form, are notable in the degree of agreement in student performance objectives among different academic disciplines. These will become the basis for college-wide assessment activities.

PROCESS EDUCATION EXAMPLES

Since the first Teaching Institutes were offered, many faculty have implemented new methods of instruction. One of us (Williams), a professor of mechanical engineering found that students were often ineffective in solving problems, even within the narrow context of course content. In relatively simple homework and quiz problems, new learners may make incorrect assumptions when they do not critically examine each step in their solution process. Students, desperately seeking any textbook formula that

might contain relevant parameters, do not understand when principles or equations are applicable to particular real situations. Consequently, they make incorrect assumptions, leading to incorrect results. In once specific case, students' confusion about whether stresses (rather than forces) were additive led to an incorrect calculation of the mechanical properties of a composite material. Problem Solving Methodology is a ten-step systematic process to address new problems, as shown in Table III. [1] A class period was devoted to instruction in how to use this methodology to solve problems systematically, making each step explicit, and challenging students at each step with the question, "How do you know that?" This approach developed students' skills in deciphering new problems and discovering for themselves where their logic may have gone astray. These skills are clearly transferable to other situations.

**Table III
Elements of Problem Solving:**

1.	Define the problem.
2.	Identify key issues.
3.	Collect and assess information.
4.	Identify assumptions.
5.	Break problem apart
6.	Model sub-problems.
7.	Integrate solutions.
8.	Test and validate.
9.	Generalize the solution.
10.	Communicate the solution.

Dr. Abdolazim Houshyar, professor of industrial engineering, has elevated the learning and performance levels of his students by expecting that students come to class having read introductory material. The class syllabus clearly states these expectations. Course notes and textbook assignments are available well in advance of the class meeting. Class sessions are begun with an opportunity for students to ask questions of the instructor. This allows students to learn background information independently and to determine for themselves which content and concepts are most challenging. Class time is then used most effectively to elucidate only those issues with which students have the most difficulty. Traditional lecture time is significantly reduced. Students become more independent, and they take more responsibility for their own learning process. Students have reported that they are learning more than they would with traditional lectures.

Dr. Johnson Asumadu, an assistant professor of electrical and computer engineering assigns teams of students to solve homework problems. Students must work together to maintain a portfolio of their group's work, and they must periodically present their results to other class members. Each presentation is followed by an assessment exercise in which students provide for each other the strengths, areas for improvement, and insights gained from the exercise. This strengthens students' skills in working

with others and in continuously improving their problem solving skills.

Mr. Thomas Swartz is a faculty member in the Department of Industrial and Manufacturing Engineering. In his technical writing class, Mr. Swartz developed an assignment to improve the critical thinking of his students as they evaluate the reliability of resources. In recent years, increasing numbers of students do their background research for technical papers using only the Internet, avoiding technical journals, professional periodicals, and other library resources. His concern is that students use reliable information that is of good quality. The solution was to make the students responsible for developing a workable set of criteria for evaluation of Internet resources. Then, if they wish to use the Internet or any other resource, they can apply the criteria. The process was to divide the class into groups of four students based on their intended academic major. Each group was provided the web address of the University Library's information on evaluating Internet resources, and they were assigned to read a similar section in the course textbook. The students then developed a checklist for such evaluations, selected examples of good, average, and poor websites, and presented the examples to the class using presentation software. The outcome is that students come away with a greater understanding of the issues related to research and use of information. In the future, these students will view information with a healthy skepticism.

NEXT STEPS

- Additional Teaching Institutes and workshops in curriculum and program assessment will be offered, with the ultimate goal of 100% participation by faculty within the college.
- Program goals and objectives developed for separate academic programs will be further examined to identify commonalities among programs and to achieve the effective and efficient delivery of all academic programs in the college.
- The assessment program developed over the past year will be further extended to courses and to entire academic programs.

CONCLUSION

The College of Engineering and Applied Sciences at Western Michigan University has embarked upon a multi-year program of self-study and assessment. Outcomes from this effort are the following:

- A strategic plan for the college has been developed and is being implemented.
- A program of assessment and continuous improvement of undergraduate education has been developed.
- Some courses have been revised to identify measurable outcomes and to develop a set of class activities to

achieve them. The principles used to develop this initial set of courses are being applied to other courses.

- A series of workshops to improve faculty teaching effectiveness has begun and will continue to include a wider circle of participants.
- Drafts of program assessment plans have been developed for each of our undergraduate programs.

Thus, Process Education has become an effective foundation for a program of assessment and continuous improvement of teaching and learning at Western Michigan University.

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REFERENCES

- [1] *Criteria for Accrediting Engineering Programs, 2001-2002*, Engineering Accreditation Commission, Accreditation Board for Engineering and Technology, p. 1, 2000.
- [2] Krumsieg, K. and Baehr, M., *Foundations of Learning, 2nd ed.*, Pacific Crest, Corvallis, OR, 1999.
- [3] Barr, R. B. and Tagg, J., "From Teaching to Learning – A New Paradigm for Undergraduate Education," *Change*, November/December 1995.
- [4] Kane, M., et al., *The Secretary's Commission on Achieving Necessary Skills -- Identifying and Describing the Skills Required by Work*, Pelavin Associates, Inc., Washington DC, 1990.
- [5] *An American Imperative – Higher Expectations for Higher Education*, Wingspread Group on Higher Education, The Johnson Foundation, Inc. Racine, WI, 1993.
- [6] Apple, D. K. and Hurley-Lawrence, B., "Education as a Process," presented at the Improving University Teaching Conference, July 1994.
- [7] Apple, D.K. and Krumsieg, K., *Process Education Teaching Institute Handbook*, Pacific Crest, Corvallis, OR, 1998.
- [8] Bloom, B., *Taxonomy of Educational Objectives*, McKay, NY, 1956.
- [9] Neff, G., et al., "Transforming Engineering Education from a Product to a Process," presented at the 1995 World Conference on Engineering Education, October, 1995.
- [10] Parker, P.E., et al., "Differentiating Assessment from Evaluation as a Continuous Improvement Tool," Submitted to 31st ASEE/IEEE Frontiers in Education Conference, 2001.
- [11] Myrvaagnes, E., et al., *Foundations of Problem Solving*, Pacific Crest, Corvallis, OR, 1999, pp. 28-33.