THE UPS, THE DOWNS AND THE UPS OF RESPONDING TO *EC2000*

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Abstract

Michigan State University began to prepare for *ABET's Engineering Criteria 2000* (*EC2000*) in 1996 by evaluating both this new accreditation criteria's opportunities and its challenges. In 1997 a decision was made to transition all academic programs in the College of Engineering from ABET's "Conventional Criteria" to *EC2000*. Six existing undergraduate programs and three new undergraduate programs were evaluated during the 1998-99 accreditation cycle. This paper provides an overview of the process used to prepare for this accreditation cycle, with special focus on the Computer Engineering Program. It then identifies the challenges associated with sustaining—over the long term—the initial momentum generated for assessing program outcomes and using this information to bring about curricular improvements. Sustainability of these processes requires more than the continued efforts of a few individuals. Perhaps ABET needs to pay close attention to this issue during the second full accreditation cycle for institutions operating under *EC2000*.

I. Preparing for *EC2000* and ABET's 1998-99 Accreditation Cycle

The Computer Engineering Program: A Historical Perspective

A CpE Task Force was formed at MSU in 1978 to determine the feasibility of developing an undergraduate CpE program. By the early 1980s, both the undergraduate computer-science and electrical-engineering programs identified CpE as a "minor" or "option" within the respective programs. In the middle 1980s, plans were underway to develop an undergraduate computer-engineering degree-granting program to be offered cooperatively by the (then) EE and CpS Departments. Since 1988, both departments have participated in the CpE Program, which formally resides in the ECE Department. MSU awarded its first B.S. degree in CpE in 1990. In 1994, a CpE Task Force was again formed to provide leadership and oversight of the CpE Program.

Preliminary CpE Program Assessment and Outcomes

In the 1995-1996 academic year, MSU began the process of seeking first-time accreditation of its undergraduate CpE program during the 1998-99 ABET accreditation cycle. The task force reviewed the *EC2000* accreditation criteria and then did a preliminary self-assessment of the undergraduate academic program. The following deficiencies were identified:

1. There was only a very loosely defined CpE faculty; moreover, the computer-science and electrical engineering faculty members resided in different buildings, hindering interactions and cooperation.
2. The CpE program was patched together using existing CpS- and EE-coded courses and had no distinctive qualities.
3. Through the internal self study, the following areas were identified as having deficiencies warranting academic-program revisions:
    a. Use of high-level languages in the curriculum;
    b. Formal integration of hardware-software issues;
    c. Use of contemporary engineering design tools; and
    d. Major engineering design experience.
4. The two electrical-engineering laboratories that serviced the CpE program were outdated.
5. Only weak interactions existed between the employers of CpE graduates and the CpE faculty.
6. Only weak mechanisms were in place to receive feedback from students in the program, from graduates and from alumni of the program.
7. There were no long-term plans in place to improve the program.

Process Used to Prepare for the 1998-99 ABET Accreditation Cycle

Beginning in the fall of 1996, concerned faculty began to meet on almost a weekly basis to develop strategies and plans to overcome the deficiencies identified during the 1995-96 period. Significant progress was made, as evidenced by the following achievements.

1. Thirteen CpE faculty members were identified—six from CSE and seven from ECE.
2. With the completion of the new addition of the Engineering Building in 1996, all of the faculty members who previously had been located outside the Engineering Building were relocated within the building.
3. The faculty began to develop greater interactions with the employers of CpE graduates. An Employer Stakeholder Focus Group was formed. Formal methods were developed to solicit feedback from employers.
4. This feedback led to revising the CpE curriculum. Academic program objectives were developed, and the program took on a very distinctive nature. It focused on embedded systems for control applications—i.e., both automatic control and process control. Because of the importance of communications, the program was identified as having three thrusts: computers (hardware and software), communications, and control.
5. Each of the principal courses in the academic program was reviewed: prerequisites, course content, course learning objectives, and the relationship of the course to the overall CpE academic-program objectives. This coordinated activity led to the revision of several courses, including EE 482, Capstone: Computer System Design.
6. A revised academic program was developed and approved by the faculty. This revised curriculum went into effect at the beginning of the 1997-98 academic year.
7. During 1997 and early 1998, two CpE student meetings were held to inform students about the program and obtain feedback. These meetings were well attended and resulted in useful input.
8. As a direct result of feedback from the employers of EE and CpE graduates and from EE and CpE alumni, the capstone design course was modified. This modified course placed added

emphasis on cross-functional teaming, oral presentations, written reports, hardware-software co-design, hardware and software standards, contemporary tools, open-ended design projects, life-long-learning skills and contemporary societal issues facing practicing computer engineers.

9. A laboratory upgrade proposal was submitted to the university in January 1997 to modernize the two CpE laboratories that were being maintained by the ECE Department. This proposal was funded for $350,000, and both labs were renovated during the summer of 1997. New computers, computer peripherals, application software, and test equipment were installed in the labs consistent with the CpE academic-program objectives and the course learning objectives.
10. A $25,000 proposal was submitted to the Office of the Vice-Provost for Libraries, Computing and Technology to upgrade the computer-engineering library collection. This proposal was funded and carried out with Engineering Library staff.
11. A curriculum-development proposal—"VESL: Visions for Embedded Systems Laboratories"—was submitted to the National Science Foundation Combined Research-Curriculum Development Program [1]. This $530,000 project was funded in 1997 for three years, with $400,000 coming from NSF and $130,000 coming from MSU matching funds. Results of this project have impacted the CpE curriculum in the areas of rapid prototyping and embedded-system analysis, software engineering, real-time operating systems, and wireless networking. One goal, in partnership with Saginaw Valley State University and Lake Superior State University, was to support accessing and sharing of laboratory and instructional resources via the Internet and Web.

The ABET 1998-99 Accreditation Cycle

At the time of the ABET site visit to MSU in the fall of 1998, the overall status of the undergraduate CpE program was internally evaluated as being very good. Morale among CpE faculty and students was very high. Employer and alumni feedback suggested that the quality of the graduates of the program was rising steadily and that these graduates could compete favorably in the job market and in graduate school with CpE graduates at peer institutions. However, since it was a relatively new academic program it was recognized that long-term trends needed to be monitored and documented to validate fully the sustained quality of this academic program.

With this internal self-study complete, the faculty and administration felt quite comfortable seeking first-time accreditation of its undergraduate computer engineering program from ABET and under *EC2000*. The site visit, exit statement and final report on the program to Michigan State University confirmed that MSU had done a very good job in developing, delivering, and assessing this academic program. One observation noted in the exit statement that required attention related to the stated Educational Program Objectives. The CpE Program Evaluator noted that there were some inconsistencies in how these objectives were described in different media. During the thirty-day due-process period, MSU adequately addressed this issue, and the revised program objectives are now published in a uniform manner in all MSU publications (see for example the CpE web site [2].

II. Assessment of the Current Level of Achievement

While preparing for *EC2000* during the 1996-98 time frame, we assessed our progress on a bimonthly basis by completing ABET's "Level of Implementation Form." This form, along with ABET's "Matrix for Implementation Assessment" are reproduced in Appendix I and Appendix II of this paper, respectively. This form and matrix still provide a useful guide as we assess progress made since the 1998-99 accreditation cycle, and the latest version of these forms can be downloaded from ABET web site [3]. What follows is a self-assessment of the current level of achievement measured against the six factors identified on the "Level of Implementation Form" and defined in the "Matrix for Implementation Assessment." This self-assessment will be the basis for the next section, which addresses systemic issues related to supporting *EC2000*.

Educational Objectives

The CpE program was a new program and seeking first-time accreditation during the 1998-99 accreditation cycle, and we assessed ourselves as having achieved a "Level 3" of implementation (see Appendix II). Because it was a new program, we could not claim "Level 4" because we could not demonstrate that these educational objectives were "systematically reviewed and updated." This then should be viewed as an important assessment objective for the program to achieve before the program's next general review. To date, little progress has been made in achieving "Level 4" implementation with respect to the "educational objectives factor."

Constituents

While preparing for first-time accreditation during the 1996-98 time frame, all constituent groups were engaged in the process of defining program objectives and desired outcomes. They were also actively involved in program assessment, at "Level 3" of implementation. However, since the site visit during the 1998-99 ABET accreditation cycle, these same constituent groups have been less active, especially the direct involvement of current students in the program, alumni, and the employers of the program's graduates. Based upon current activities in this area, the "Level of Implementation" for constituent involvement is tending to slip to a "Level 2" implementation, while the program's goal should be to achieve a "Level 4" by the time of the next general review. What currently is lacking in our achievement of "Level 4" is "evidence of many sustained strategic partnerships in all constituent groups." We will, however, slip to "Level 2" if we are unable to demonstrate at the time of the next general review that we have "some sustained strategic partnerships."

Processes

At the time of the 1998-99 ABET accreditation cycle, we assessed the implementation of our "Processes" to be at Level 3 because we concluded that processes were defined, documented and controlled for all major elements of the criteria. Moreover, these processes were clearly tied to the mission, program objectives, and constituent needs. At the time of the 1998-99 ABET accreditation cycle, we believed that we could in a short period of time achieve Level 5 because other institutions had already begun to benchmark MSU's processes. However, as mentioned in the discussion regarding the "constituents factor," the processes have been slow to progress and

have actually shown signs of weakening in the past couple of years. The current defined process is illustrated in Appendix III of this paper. It is based upon ABET's "two loops" for *EC2000*. The timing of the events in the two loops are tied to the natural rhythm of events that normally take place within the ECE Department at MSU. While this process has been discussed at curriculum committee meetings and faculty meetings, it has not yet been made fully operational. Clearly, this implementation factor needs immediate attention, or it might slip to Level 2 and, consequently, adversely affect other implementation factors.

Outcomes Assessment

Since the 1998-99 ABET accreditation cycle, little progress has been made to systematize outcomes assessment. At that time, we were at Level 3 since we could demonstrate that all major outcomes were defined, that a process for systematic evaluation and improvement was in place and anticipated problems were being addressed. We had also identified a few problems with support areas; so, there was some evidence that we might actually achieve Level 4 before the next general review. We advocate that the College of Engineering level and at the University level drive the outcomes assessment process and monitor the process diligently. Without leadership provided at these levels, it will be very difficult for the academic program to sustain even a Level 3 of outcomes assessment for the long term. Our viewpoint is that effective outcomes assessment needs to be driven at a level above those involved in the day-to-day operation and management of the academic program.

Results

Based upon the assessment processes that were in place during the 1998-99 ABET accreditation cycle, it was clear that the CpE program had good outcomes in several major areas and that these results had improved because of the systemic approach deployed during the 1996-98 time frame. Most notable were the results due to revising the major engineering design experience [2].Students began to work on multidisciplinary teams. They worked on open-ended design problems involving embedded computers. There was an increased emphasis on the need for standards, oral and written communications, and contemporary societal issues, including engineering ethics. In retrospect, the successes by the major engineering design experience were driven more by individual faculty and less by a "the system." This may compromise sustainability, as described next.

System

ABET requires that a system be in place to meet the *EC2000* accreditation requirements. Level 5 implementation requires a "a sound, highly integrated system; deployed throughout the program, college and institution; driven by the mission and objectives." We view the "system" as the key because it has a direct impact upon each of the other five implementation factors—i.e.; educational objectives, constituents, processes, outcomes assessment and results. Top-down administrative leadership is essential for the system to exist and function properly. At the time of the 1998-99 ABET accreditation cycle, the system was clearly sitting at Level 3—i.e.; a system was in place; deployed throughout the program and college; driven by the mission and objectives. Today, it may be difficult to claim anything higher than Level 2—i.e., a system that is

only partially deployed within the program and college. Hence, Michigan State University has one great challenge with respect to "the system." It must demonstrate during the next general review of its CpE program that it has in place a system that is at least as well developed and operational as at the time of the 1998-99 ABET accreditation cycle.

III. Discussion and Recommendations

Challenges facing the long-term success of *EC2000* initiatives at MSU

Our self-assessment bears out some of the challenges of sustaining *EC2000* processes. These are not unique to MSU, and our experiences are consistent with the findings of Van Duzer's study based on over 100 interviews of institutions that developed processes in preparation for accreditation under *EC2000* [4]. Several notable findings of ours that align well with his include the following:

1. Intellectual investment by individual faculty members determines commitment to the process. A faculty member may have been involved in numerous meetings during the initial *EC2000* accreditation cycle at MSU, but if there was little intellectual investment there was little real buy-in. We believe that the system of values and rewards needs to provide encouragement for faculty to participate in the continuous-quality improvement (CQI) process outlined in *EC2000* at both the course and curricular level.
2. The original leadership in developing continuous improvement methods and processes rested mainly with a few *EC2000* faculty coordinators in the ECE Department. The department chair and college dean played a minimal role. We believe that they need to play a much more active role in sustaining the CQI processes. They will need to provide oversight and encouragement to ensure that processes described in the *EC2000* self-study reports are in fact implemented and operational.
3. The assessment methods we used during our initial introduction to *EC2000*, were generally unsophisticated, lacking measures of inter-rater reliability, clear scoring rubrics and tests for validity. We recognize that we must develop better methods to make learning visible in ways that assist the faculty. This in turn will help demonstrate to the faculty (as well as others) the long-term benefits of sustainable CQI processes.
4. The faculty value their time, which is broadly viewed as a very precious commodity [5]. Given the optimization curve that faculty must negotiate, rewards, policies, and ongoing leadership will have to be shaped to support the process. We believe that the single most important factor in determining the level of success and sustainability of CQI efforts within an academic program relate to the faculty's perception of the cost/benefit ratio, as determined by each member of the faculty.

These four findings are not isolated, with each being strongly dependent upon the other three.

MSU's response to these challenges

There are some indications that MSU is beginning to pay attention to these factors so as to renew and improve on its CQI processes. For example:

- **At the Department level.** Feedback from the 1998-99 accreditation cycle has been used to develop revisions to the major engineering design experience for the Electrical Engineering Program in the ECE Department. With ECE faculty

leadership, engineering faculty have teamed with education faculty to examine curriculum reform in undergraduate engineering education, citing the importance of *collective responsibility* [5].

- **At the College level.** The Curriculum Committee has begun to review course and program change requests in the context of educational program objectives and constituent concerns. The Committee is re-opening its discussions of assessment, led by the Associate Dean for Undergraduate Studies. The College Administration (deans, chairs), both seeing the value and reinforcing the value, has recommended the inclusion of course assessment forms in faculty teaching portfolios (e.g., in annual and promotion and tenure reviews).
- **At the University level.** MSU recently established the position of University Director of Assessment. The University Committee on Curriculum has recommended including an outcomes assessment plan for student learning as part of information submitted with new or revised academic program requests. Appendix IV presents the form for submitting such a plan [6]. Alternatively, responses to assessment questions may be submitted on the standard, academic program request forms. MSU is benchmarking other institutions' assessment plans, e.g., University of Wisconsin at Madison [7] and University of Colorado at Boulder [8].

Sustaining educational reform efforts

Having a well-defined and functioning system in place to meet *EC2000* accreditation requirements appears to determine the sustained level of achievement for other *EC2000* implementation factors. A system to sustain *EC2000* initiatives depends upon the *collective responsibility* of the academic department and its faculty, which is a core concept in curricular reform [5] and organizational change [9, 10]. *Collective responsibility* refers to a program or unit's set of collective responsibilities involving other units, the university, and external constituent groups, in addition to individual faculty responsibilities and achievements. Faculty values and rewards at institutions such as MSU tend to focus upon the achievements of individual faculty members rather than the achievements of an academic program or of an academic unit. Hence, individuals tend to focus their energies on the content of specific courses that they teach, on specific research projects on which they are principal investigators, and on specific institutional service issues that relate directly to their individual goals. This then suggests the leadership role needed by department chairs, deans, and provosts. Faculty participation in the *system* to meet *EC2000* accreditation requirements is essential; however, faculty will not likely buy into this process unless they come to value the success of the system in bringing about continuous quality improvement of academic programs.

John W. Meredith, current Chairperson of the IEEE Committee on Engineering Accreditation Activities published an article describing an industry view comparing TQM (total-quality management) industrial processes with *EC2000*. He makes a strong argument that TQM in industry and *EC2000* in academe have much in common [11]. Moreover, he suggests that universities might gain significantly by learning how best TQM industrial practices might be applied to build a successful system to meeting *EC2000* accreditation requirements.

The purpose of the *EC2000* requirements are quite simple—its goal is to provide a framework for institutions to continuously improve the effectiveness of their engineering educational programs. Meredith stresses this in his article. To this end, we suggest that an institution, such as Michigan State University, can develop a system that will lead to systematic improvements of its educational results. In the past MSU has partnered with key employers of its graduates to understand their successful TQM practices. It needs to continue to use and build upon these key partnerships in the future. In addition, MSU needs to benchmark the best practices of other *EC2000* institutions, and it needs to apply lessons learned from these benchmarking exercises.

At the heart of institutionalizing necessary reforms will be improving the overall academic environment in which the reforms will take place. Here, administrative leadership at the department, college, and institutional level will be essential. Improving academic program results through systemic reform practices must be both valued and rewarded.

VI. Acknowledgements

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Biography

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David Fisher is a Professor of Electrical and Computer Engineering at Michigan State University. He serves at Project Director and Principal Investigator for the GE Fund-sponsored project: “Reforming the Early Undergraduate Learning Experience.” Dr. Fisher is a registered Professional Engineer in the State of Michigan and is an ABET-IEEE Program Evaluator for *EC2000* computer engineering and electrical engineering programs.

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Appendix I—ABET's Level of Implementation Form [3]

Each evaluator completes this form at the conclusion of the visit. Each program has completed this form before the visit and the data for all visits during the current cycle will be accumulated for analysis after the current accreditation cycle is completed. The data gathered from the institutions will not be available to any part of the accreditation decision making process.

Institution: _____

Unit or Program (specify): _____Evaluator _____

Date Prepared[1]: _____

	Implementation Factor	Score (1-5)[2]
a.	Educational Objectives	
b.	Constituents	
c.	Processes	
d.	Outcomes Assessment	
e.	Results	
f.	System	

Instructions:

Report implementation factors for the engineering unit as a whole and for each program being evaluated. Data on this table should reflect the current level of Criteria 2000 implementation. Refer to Figure A-1, ***Matrix for Implementation Assessment*** for descriptions of implementation levels. Enter a numerical value that most accurately describes the extent to which:

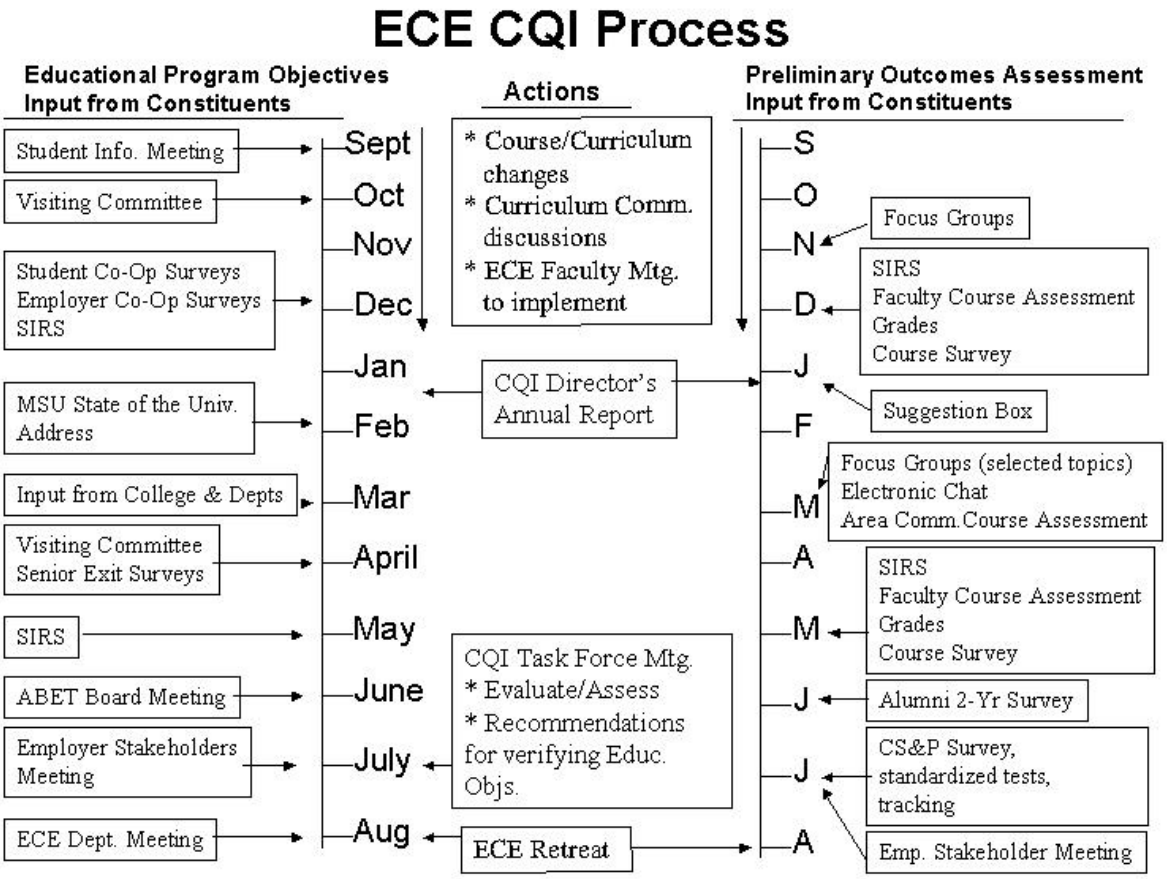
a. Program **Educational Objectives** have been established and maintained
b. **Constituents** are involved in helping set program objectives and in evaluating the level to which they are being achieved
c. The required **Processes** are operational
d. **Outcomes Assessment** is being practiced
e. **Results** of outcomes and the various processes are being used to improve programs and assure objectives are being achieved
f. An overall **System** is in place to meet the accreditation requirements

Institutions should provide this information to ABET Headquarters prior to the campus visit. Team members provide this information to Team Chair at conclusion of campus visit, and Team Chair forwards to ABET Headquarters immediately thereafter.

Appendix II—ABET's Matrix for Implementation Assessment [3]

	Educational Objectives	Constituents	Processes	Outcomes Assessment	Results	System
1	Not well defined	Informal contact	Few, if any processes defined and documented	Limited to ad hoc efforts	Anecdotal	None evident
2	Broadly defined and documented; clearly tied to mission; evidence of constituent input	Somewhat involved in defining objectives and desired outcomes, and assessment	Some major processes defined and documented; clearly tied to mission and program objectives	Some outcomes defined and improved in systematic manner; problems recognized and corrected	Satisfactory outcomes; some evidence of positive trends in areas deployed	Early stages; partial deployment within the program and college
3	Comprehensive; defined, documented' and measurable; clearly tied to mission and constituent needs	Clearly involved in defining objectives and desired outcomes, and assessment; evidence of some sustained strategic partnerships	Processes for all major elements of criteria defined, documented, and controlled; clearly tied to mission, program objectives, and constituent needs	All major outcomes defined; systematic evaluation and process improvement in place; problems anticipated and prevented	Good outcomes; positive trends in several major areas; some evidence that results caused by systematic approach	In place; deployed throughout the program and college; driven by mission and objectives
4	Comprehensive; defined, documented and measurable; clearly tied to mission; responsive to constituent needs; systematically reviewed and updated	High degree of involvement in defining objectives and desired outcomes; evidence of many sustained strategic partnerships in all constituent groups	Processes for all elements of criteria are quantitatively understood and controlled; clearly tied to mission, program objectives, and constituent needs	All outcomes defined; systematic evaluation and process improvement in place; many support areas involved; sources of problems understood and eliminated	Excellent outcomes; positive trends in most areas; evidence that results caused by systematic approach	Integrated; deployed throughout the program, college, and support areas; driven by mission and objectives
5	Comprehensive; defined documented, measurable and flexible; clearly tied to mission; readily adaptable to meet constituent needs; systematically reviewed and updated	High degree of involvement in defining objectives and desired outcomes, assessment; and improvement cycles; sustained evidence of strategic partnership with all key constituents	Processes for all elements of criteria are quantitatively understood and controlled; clearly tied to mission, program objectives, and constituent needs; seen as benchmarks by other institutions	All outcomes defined; systematic evaluation and process improvement in place; all support areas involved; common sources of problems understood and eliminated	World-class outcomes; sustained results; results clearly caused by systematic approach	Sound, highly integrated system; deployed throughout the program, college, and institution; driven by mission and objectives

Appendix III—ECE's Program Assessment Plan



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Appendix IV—MSU's Assessment Forms [6]

MICHIGAN STATE UNIVERSITY

Assessing Student Outcomes

College: _____

Department: _____

Program or Major: _____

Program Level: _____

Contact Person: _____

Inventory of Written Statements and Plans

1. Do you have a written mission statement or statement of purpose? **yes** **no**
   If yes, please attach a copy or reference where this can be found:

   _____

2. Do you have a written statement of intended educational outcomes describing what a student should know or be able to do when they have completed this program? **yes** **no**

3. Do you have a written method of assessment for measuring student outcomes? **yes** **no**

4. Does your program have a separate accreditation process? **yes** **no**
   If yes, please list all accrediting agencies below:

   _____

   _____

   _____

   _____

Assessment Methodologies

It is likely that some assessment measures are already in place in this program even if they are not identified as being part of a formal assessment plan. Listed below are some of the assessment methodologies you may be using. Indicate **"A"** if the method is currently being used; **"B"** if it is **not** being used but you are interested in using it; and **"C"** if the method of assessment does not apply to your program.

Direct Methods of Assessment

1. _____ Comprehensive Examinations
2. _____ Writing proficiency Examinations
3. _____ National Examinations assessing subject matter knowledge
4. _____ Graduate Record Exam General Test
5. _____ Graduate Record Exam Subject Test
6. _____ Certification Examinations
7. _____ Licensure Examinations
8. _____ Locally developed pre-test or post-test for subject matter knowledge
9. _____ Senior thesis or major project
10. _____ Portfolio evaluation of student work
11. _____ Capstone courses
12. _____ Audio or Video tape evaluations

Indirect Methods of Assessment

1. _____ Comparison or benchmarking with peer institutions
2. _____ Job placement of graduates
3. _____ Employer surveys
4. _____ Advisory groups from your profession
5. _____ Graduate school acceptance rates
6. _____ Student graduation/retention rates
7. _____ Exit interviews with students graduating or leaving the program
8. _____ Student satisfaction surveys
9. _____ Student course evaluations
10. _____ Focus group discussions
11. _____ Alumni surveys
12. _____ Alumni honors, awards, achievements
13. _____ Analysis of grade distributions
14. _____ Peer review of courses
15. _____ Peer review of program
16. _____ Curriculum/syllabus analysis
17. _____ Community service/volunteerism participation
18. _____ Other:_____

_____

_____

_____

Does your program have an experiential learning component? **yes** **no**
If yes, how do you assess the student learning outcomes from that experience?

1. _____ Participate in a class designed to complement the experience
2. _____ Student journals
3. _____ Formal evaluation procedures from field-based supervisor
4. _____ Formal meetings between supervisor, student, and faculty
5. _____ Formal test of practical skills
6. _____ Other:_____
   _____
   _____
   _____

Implementation Plans

1. How has your department used any of the indicators above to improve services and programs for students?

_____
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2. When you think about developing and implementing an assessment plan, what concerns do you have?

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