# AC 2009-176: MULTIDISCIPLINARY ENGINEERING: FLEXIBILITY AND ABET ACCREDITATION

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# Multidisciplinary Engineering– Flexibility and ABET Accreditation


## Abstract

An extremely flexible Multidisciplinary Engineering (MDE) program was developed that extensively uses existing courses taught by other engineering programs. The program has nine structured concentrations and also allows student-developed concentrations. In the latter concentration 50 % of the course credits required for graduation are electives or selectives. Students receive extensive pro-active advising to ensure their plans meet both graduation requirements and their educational objectives. The most popular concentration is currently acoustical engineering. An intensive and extensive assessment program that individually tracks the progress of each of the sixty students on the twelve program outcomes was developed. The MDE program was ultimately successful in obtaining ABET accreditation. The assessment procedures developed here provide a model for proving that all students including transfer students have met program outcomes. Based on analysis with the Myers-Briggs Type Indicator, male students in MDE are more likely to be intuitive, feeling and perceptive than male students in other engineering majors. These differences are statistically significant. Thus, development of flexible curricula that are attractive to and retain students that are less likely to stay in other engineering programs may be low-hanging fruit in reforming engineering education. Other universities could use the MDE program as a model of a very low cost, flexible program that helps retain engineering students and can meet ABET accreditation requirements.


## Introduction: The Precursor to Multidisciplinary Engineering

The Multidisciplinary Engineering (MDE) program grew out of the Interdisciplinary Engineering Studies (IDES) program, which was founded in 1969 and has over 1600 alumni. IDES was established as a separate division in Engineering at a time when students were leaving engineering because of a general anti-technology and anti-government attitude in the USA. The goals of the IDES division were to help recruit and retain students who had the ability to do engineering but also had other compelling interests. To retain maximum flexibility the decision was made to not seek ABET accreditation and to require a minimum of 30 credits of engineering. Students were only allowed to follow plans of study that could not be done in one of the standard disciplines offered at the university.

By the early 21$^{st}$ century it was evident that IDES was serving two groups of students. One group of students wanted an engineering education but did not plan to pursue an engineering career. For example, these students were in preprofessional programs such as premedical engineering or prelaw engineering. The non-ABET accredited program was a good fit for these students. The other group of students was interested in pursuing an engineering career in programs such as acoustical engineering, biomedical engineering, and engineering management. Graduates who followed careers that did not require them to become registered professional engineers had few complaints about their educational preparation. On the other hand, graduates who wanted to become professional engineers often had considerable difficulty in being allowed to take the professional engineering examination because they had not graduated from an ABET accredited program. (Until 2006 IDES had a waiver from the Indiana State Board that allowed seniors in IDES to take the Fundamentals of Engineering exam.) It was clear that students who planned to practice engineering would be better served if an ABET accredited program were available.

Remaking a non-accredited program into an accredited program is a nontrivial undertaking. One major difficulty was that the Division of Interdisciplinary Engineering Studies consisted of ½ of one professor (the Head) plus an administrative assistant and did not teach any credit granting courses. All engineering courses were taken from the various Schools of Engineering. In effect, IDES was an advising shop. The way around the lack of faculty became clear in 2003 when the College of Engineering started to remake the Department of Freshman Engineering into the Department of Engineering Education (ENE). Original plans for ENE did not include an undergraduate program. The Heads of Freshman Engineering and IDES and the Dean of Engineering agreed that merging the two departments would provide ENE with an undergraduate program, clear the way to develop an ABET accredited program since a faculty would be available, and (almost a miracle) reduce the number of administrators. The new department was officially approved on April 9, 2004.

Since the non-accredited IDES program served the needs of one group of students, we decided to retain this program while developing a new Multidisciplinary Engineering program that met ABET's accreditation standards. Fortunately, the university already had approval from the state to offer both a Bachelor of Science in Engineering (BSE) degree and a Bachelor of Science (BS) degree – otherwise, significant time and effort would be required to achieve this approval. The BSE degree was reserved for MDE students. Both programs are restricted to areas that are not covered by traditional engineering programs at the university.

In developing the MDE curriculum the decision was made to retain the basic idea that students would take the majority of their engineering courses outside of the MDE program. This decision greatly increases program flexibility and decreases the costs of a new program, but it adds the difficulty of how to ensure that students are satisfying the program outcomes. A multi-faceted assessment program was developed based on extensive assessments in two courses, encouraging students to take the Fundamentals of Engineering exam, an oral examination conducted by the Industrial Advisory Council, and an extensive exit interview.

**Multidisciplinary Engineering Program**

Multidisciplinary Engineering develops concentrations that cannot be easily followed in one of the other ABET accredited engineering programs at the university. The current ten approved concentrations are shown in Table 1. Nine of the concentrations are structured while the tenth concentration, Student Developed, is extremely flexible and allows students to design their own concentration within specified constraints. The major constraints are that the plan of study cannot be close to one of the other ABET accredited engineering programs at the university, courses must be available, all ABET requirements must be met by the concentration, and a maximum of 24 credits can be from one engineering school. Currently, three concentrations (lighting engineering, nano-engineering and ocean engineering) have no students. This is not a difficulty because *a concentration is only a piece of paper.* Because the MDE program uses existing courses, there are no additional costs in having concentrations with no or few students.

The Environmental and Ecological Engineering concentration continues one of the traditional functions of IDES, which was serving as a way for students to earn a degree in a new area until a new engineering program could be established on a permanent basis. For example, the most popular IDES program for many years, Biomedical Engineering, was phased out when the new School of Biomedical Engineering started its undergraduate program. The Environmental and Ecological Engineering concentration allows students to earn an accredited degree while the new Division of Environmental and Ecological Engineering develops an undergraduate curriculum and obtains permission from the state for a new degree. New concentrations will be developed when a need becomes apparent. Currently, a Systems Engineering concentration is being developed in collaboration with the School of Industrial Engineering.

The combination of flexibility while meeting ABET standards is achieved by first *specifying a structure that ensures all students meet ABET course requirements*, second by proactive academic advising, and third by an extensive and intensive individual (not sampling) assessment process. The basic structure of the MDE program is shown in Table 2. Students in the MDE program take the same common first year as other engineering students, the same second year mathematics, and the same general education program. The sophomore science selective is broader than for other engineering students although students in some concentrations must take physics. All students must take a course in probability and statistics – if they select an engineering course on this topic it counts as part of their 47 credits of engineering. The engineering core typically consists of 19-22 credits. Except for the professional seminar IDE 301 and the major design experience, either EPICS (Engineering Projects in Community Service[1,2]) or IDE 485, *the engineering core specifies topics not courses*. These topics were chosen to match the topics in the Fundamentals of Engineering exam to facilitate graduates becoming professional engineers. Specifying topics instead of courses provides maximum flexibility for students transferring into the program either from other universities or from other programs at the university. The specified professional seminar and major design experience must be taken because extensive assessments are done and each student is tracked individually. The engineering selectives ensure that students have a sufficient amount of design, laboratory, and coverage of materials.

Tailoring of the individual concentrations is mainly done in the engineering area and the area, and to a lesser extent in the general education program. The flexibility of the MDE program is illustrated in Table 2. For the student developed concentration up to 43.5% of the course credits can be elective (although they must be chosen in the appropriate categories) and up to 50% of the course credits are either elective or selective. This flexibility allows the program to offer students the opportunity to study almost any engineering topic as long as the courses are available at the university. If not all necessary courses are available, as in the case of Ocean Engineering, then students must plan on taking part of their program at another university. Concentrations requiring study elsewhere are not popular. As noted earlier there is no cost of having some unpopular concentrations, and they do provide students more choices.

Table 3 shows the specific plan of study for Acoustical Engineering. This plan is more specific than Table 2 since students must take sophomore physics (electricity and magnetism), the design selective must be ME 413, there are specified engineering selectives and specified selectives in the Theatre Department (these are practical sound studio courses). In addition, there are strong suggestions on which general education courses and engineering electives to select. Most students in Acoustical Engineering do a minor in Theatre Design and Technology, and many also do a minor in either Electrical & Computer Engineering or Mechanical Engineering.

With a large number of concentrations including the possibility of students designing their own concentration, strong proactive academic advising is a necessity. Students are required to do preliminary plans of study when they enter the MDE program. These plans include all the student's electives and selectives. For the standard concentrations a final plan of study is typically filed and approved by the academic advisor during the first semester of the student's junior year. Modest changes such as substitution of electives are allowed, but they are supposed to be approved in advance. Student developed plans of study require students to discuss their proposed plan with the academic advisor, the MDE program director, and often a faculty advisor from another department before the plan is filed. Individual approval of student developed plans of study by the ENE Undergraduate Committee is a graduation requirement. The academic advisor also ensures that each student meets both ABET and university graduation requirements. Students must see the academic advisor at least once per semester (most see her much more often than this) to check that they are on track for graduation. The MDE program spends more effort and money per student on advising (and as will be seen later, assessment) than standard programs, but this effort and money are available because the program teaches only two courses.

The MDE program is unique because the vast majority of engineering courses are not taught by the degree granting department ENE. Only four credits of the engineering core, the one credit professional seminar, IDE 301, and the 3 credit major design experience course, IDE 485, are taught by ENE professors. The other major design experience course, EPICS, is taught by the independent EPICS program, but since the director of EPICS is also a professor in ENE, the MDE program has essentially the same control over this course as for courses taught by ENE professors. With the current exception of one engineering elective (ENE 595 – Cognitive Engineering which is required in the Integrated Engineering concentration), all other core, selective, and elective engineering courses are taught by other engineering schools within the university.

It is important to note that the IDES and MDE programs are extremely cost effective methods for providing students with many more choices of engineering majors. Adding choices increases the retention of students, particularly students who do not feel they fit into standard programs. The freedom to make their own program attracts students who have not felt at home in one of the standard programs. Since opportunities for student choice in courses increased motivation[3], it is probable that choice in curriculum will also increase motivation. In spring 2009, 2/3 of the students in IDE 301 had transferred into IDES/MDE from another program at the university. Some of these students, particularly those who developed broad interests[3], would probably not have stayed in engineering. Because adding a few students to an existing lecture course has almost no additional cost, the major costs are for the two core courses required for the MDE program, for the academic advisor, and for the program director – who also teaches in the program. By retaining students, these two programs earn much more in tuition than they cost.

The structure of these programs could easily be adopted by other universities with large engineering programs.

**Objectives, Outcomes, and Assessment**

Without controlling courses, how does the MDE program ensure that all students meet the MDE program outcomes, that graduates meet the MDE program objectives, and how do we convince ABET that we have accomplished this? We have developed an assessment program that ensures all students satisfy the 12 outcomes of the MDE program. The outcomes were selected to ensure that graduates would meet the objectives of the MDE program (Table 4) and meet ABET criteria. Objective I is an attitudinal objective. Our performance target is that 90% of graduates will agree or strongly agree with this statement. Because of the large number of concentrations within MDE, it is difficult and perhaps impossible to write a single performance objective for the MDE program. Thus, objective II is phrased as meeting "one or more of the following milestones." For objectives II.2 and II.5 we will count degrees, certificates, and so forth. For objectives II.1, II.3 and II.4 we have carefully defined terms and will use them to determine if the objectives have been satisfied. The performance target is that 75% of graduates will satisfy Objective II. A plan was developed to determine if graduates are meeting the program objectives listed in Table 4. Because MDE had only one graduate at the time of the ABET visit and will not have a large number of graduates before the next visit, structured telephone interviews (Table 5), which are expected to have a relatively high response rate, will be used to interview graduates and employers. The plan calls for conducting the interviews every three years. The interviewing procedure was piloted before the ABET visit by calling a graduate and an employer.

The first 11 outcomes (Table 4) closely follow ABET outcomes 3 a to k while outcome 12 is leadership. The engineering core and concentrations shown earlier were designed to meet these objectives and outcomes. In addition to the assessments done in the engineering courses not taught by ENE faculty (all of these courses are taught by faculty in ABET-accredited programs), very extensive assessments are done in the professional preparation seminar and in the major design experience courses. Additional assessments are done with the Fundamentals of Engineering exam, an oral examination conducted by the members of the Industrial Advisory Council, and an extensive written and oral exit survey.

Although their learning outcomes vary, all of the engineering programs at the university assess students for ABET criteria 3 a to k. However, there is no uniform time during students' study for assessing students for the professional outcomes (MDE outcomes 4, 6 to 10 and 12). For example, some programs assess students for ethics in regular courses throughout the curriculum, some use sophomore professional seminars, others do this assessment with juniors in professional seminars, some programs wait until the senior major design experience course, and many programs use a combination of these methods. Because students in the MDE program take several different core courses and typically do not take the professional seminar and major design experience courses offered by the other disciplines, they may or may not be assessed for the professional criteria in these courses. Because all students including transfer students must take IDE 301 and either IDE 485 or EPICS, we rely on these courses for direct assessment of the professional criteria.

IDE 301 is a course on professional aspects that was specifically designed to provide the assessment data needed. The course schedule for IDE 301 for the Spring 2008 offering (Table 6) demonstrates the course coverage and assignments. There were 17 juniors and 3 seniors in the course. All the topics and assessments are repeated later at a higher level in IDE 485 and EPICS. These courses use written papers, oral presentations, projects, and peer assessments for the direct assessment of learning outcomes. All direct assessments are done employing rubrics. As an example, the rubric for outcome 8, Globalization, is shown in Table 7. This rubric is used to score each student's globalization worksheet (class 13 in Table 6) and the overall performance rating is recorded on a spreadsheet listing all of the assessments done in the course.

In addition to the large number of direct assessments, two different indirect assessments were done in IDE 301. At the beginning and end of the semester students anonymously took a survey asking them to rate their ability to satisfy the 12 MDE outcomes. Generally, student self-ratings were higher at the end of the semester. Because one theme of the entire MDE program is students taking responsibility for their education and because self-assessment is part of learning how-to-learn, a second assignment was a detailed self-assessment of all twelve outcomes using rubrics. A class period was dedicated to explaining a method of self-assessment using rubrics including a group self-assessment exercise of outcome 4, teamwork. For the assignment students were provided with rubrics for each of the twelve outcomes. They were instructed to provide evidence of their ratings based on activities, projects and assignments done in other courses, extracurricular activities or work. Although this was the least popular assignment, we feel it is a worthwhile exercise for the students. In addition, we believe that self-assessments have value in assessing engineering programs. Although students tend to rate themselves higher than instructors, the pattern of ratings correlated well with the instructors ratings. For example, if the instructor rated oral presentations as marginal and writing as acceptable, the student was likely to rate these as acceptable and superior, respectively.

The EPICS program received the National Academy of Engineering Bernard M. Gordon Prize for Innovation in Engineering and Technology Education in 2005 and has been described in detail elsewhere[1,2]. The other major design experience course, IDE 485, is a brand new course first taught in Spring 2008 with eight students. This course is designed to provide design experience and to assess all twelve outcomes. IDE 485 was scheduled for two hour design labs on Monday and Wednesday and for a one hour interactive lecture on Friday. The design part of the course consisted of two team projects. In the short first project both teams designed a multi-purpose, all-weather shopping cart – the Eco-Cart. Each team had to define exactly what an eco-cart was. Two major team projects were offered, and reconstituted teams were organized based on the interests of each student. One project involved developing a test bed for a local company printing Braille books while the other involved working with Engineers Without Borders on a project to provide pure drinking water in Cambodian villages. Because laboratory/shop facilities were under construction, the designs for the first course offering were paper designs. Assessments of the project included assessment of MDE outcomes 1-5, 7 and 11 based on written and oral presentations and peer evaluations. The Friday sessions were a follow-up on IDE 301 and included assignments and assessments on MDE outcomes 4, and 6-12.

Several additional assessments were done. The Industrial Advisory Council subjected a sample of graduating seniors to an intense ½ hour oral examination on the 12 outcomes. In this direct assessment the council members used the rubrics supplied by MDE to rate the seniors on their answers for each outcome. Because the difficulty alumni had in becoming PEs was the major driving force for development of the MDE program and because passing the Fundamentals of Engineering exam is the first step in becoming a PE (a program objective), the FE exam was selected as another direct assessment. FE exam data was used for outcomes 1 and 5 (3 a and e) and to a lesser extent outcome 6 (3f). The MDE program encouraged all graduates to take the FE exam and offered to pay ½ the cost when they took the exam and the other ½ of the cost if they passed. However, since the FE exam is not required, this assessment is a sample of volunteers. All graduating seniors were orally interviewed by the program director who used a structured format. This oral interview provided a useful indirect assessment and overview of the entire program. Although the main purpose of structured telephone interviews with graduates and employers is to assess satisfaction of program objectives, these interviews also provide indirect assessment data on outcomes.

With the exception of the Industrial Advisory Council oral exam and the FE exam, we do not use sampling for assessments. Every student is assessed and the assessment for each student is recorded individually and each student is tracked individually to show that he or she satisfies all of the outcomes. Students who do not satisfy one or more of the outcomes in the junior course IDE 301 are flagged for special attention in the senior major design experience courses. If necessary, remedial actions are identified and required. Individual tracking in a few absolutely required courses is probably the only method that can be used to ensure students who transfer in a large number of credits meet all of the program outcomes. However, ensuring that transfer students meet program outcomes is an ABET requirement that is apparently not enforced. Larger programs (MDE currently has 60 students) may believe individually tracking would require too much effort, but all courses already track each student individually to assign grades. Extending this bookkeeping to assessments is not difficult, but does require extra effort. However, the cost per student of individually tracking every student is not large. The total cost per student in the MDE program is considerably less than for traditional programs where the major expense is the teaching budget.

**ABET Results**

The Multidisciplinary Engineering Program had one graduate in May 2007 and was visited by ABET in fall 2007 at the same time the rest of the engineering college was visited. There were no difficulties with criteria 1 (students), 4 (professional component), 5 (faculty), 6 (facilities), and 7 (institutional support and financial resources); and there are no additional program criteria. As a new program with a single graduate we were able to demonstrate a plan for assessing objectives (criterion 2), but did not yet have data to prove graduates were meeting objectives. Thus, the program received a Concern for criterion 2. At the next ABET visit we will prove that graduates are meeting the program objectives.

For criterion 3 we used the assessments discussed earlier except for IDE 485 which had not been taught yet. The direct assessments were the FE exam, the oral examination conducted by the ENE Industrial Advisory Council, and assessments from some of the core and selective engineering courses taught by other programs. If the program teaching the course included assessment of that course in their assessment plan, we used their data. This assessment data was available for electrical circuits, materials selective, and laboratories in circuits and in fluids. The data provided statistical information for all students in these courses without breaking out the MDE students separately. For core courses in four topics (engineering economics, fluids, statics & dynamics, and thermodynamics) the offering department's assessment plan did not include assessment of that course and student assessment data was not available.

Based on the information on the ABET web site, and in ABET assessment workshops, the faculty in the MDE program believed before the ABET visit that our assessment plan would be adequate. We were wrong. The ABET PEV believed that the assessments of technical outcomes 1, 2, 3, 5, and 11 (3 a, b, c, e and k) were insufficient. The major difficulty was the absence of data for the four core courses that had not collected data. In addition, since one of the two options (IDE 485) for a major design experience course had not been taught yet, there was no data for this course.

For the due process response the instructors collected direct assessment data on outcomes 1, 5 and 11 for the MDE students in the four core courses. For the fluids core course that had an associated lab, the instructor provided individually tracked direct assessment data on outcome 2. We also collected individually tracked data for IDE 485, which included significant direct assessment information on outcome 3. This additional assessment data plus the previously presented data were considered sufficient proof that MDE students were satisfying the technical outcomes, and the MDE program was accredited.

Why was the initial MDE assessment plan considered inadequate? A paper by Briedis[4] explains the probable causes. First, direct assessments are now expected in an assessment plan. Second, there are strong differences of opinion about the value of the FE exam for assessment of engineering programs. Third, the ABET gold standard for direct assessments appears to be repeated instructor assessments in multiple courses.

**Student Diversity Issues**

The attractiveness of the IDES and MDE programs to women and underrepresented minorities has depended on how attractive the individual concentrations are to these groups. When IDES offered a biomedical engineering concentration, that concentration had a high percentage of women. Although the engineering management concentration has always been relatively small, it has always been attractive to African Americans.

Another form of diversity is diversity in psychological type as measured by the Myers-Briggs Type Indicator (MBTI)[5,6]. All professions tend to attract students of particular types. The MBTI data for engineering (Table 7) shows that engineering is very attractive to Thinking types (make judgments based solely on facts) and Judging types (want to plan in advance and control time). On the other hand engineering is considerably underrepresented in the other sides of the MBTI dichotomies which are Feeling types (make judgments that include people and facts) and Perceptive types (tend to go with the flow and not control time). McCaulley[5] notes that feeling types are likely to have better people skills than thinking types. Male and female data is reported separately since there is a gender effect[5,6]. The IDES and MDE programs use the MBTI in IDE 301 as a method for students to better understand themselves and their interactions with others in teams and as leaders. The type data collected and the national results[5] are shown in Table 7 and Figure 1.

Comparing the IDES/MDE students to McCaulley's[5] all engineering data, it appears that the IDES/MDE students are less likely to be sensing, thinking and judging than students in other engineering majors. This means that they are more likely to be intuitive, feeling, and perceptive. A statistical test to test the hypothesis that two proportions are equal based on a normal approximation of the binomial distribution[7] was used to compare the all engineering % for males (McCaulley's[5] data) to the IDE 301 % for males for each of the four MBTI categories. For males the percentages for the sensing, thinking, and judging types was significantly less for the students in the IDES/MDE programs than McCaulley's[5] sample at the 95 %, 99 % and 99.9% levels, respectively. Conversely, the male students in IDES/MDE are more likely to be intuitive, feeling, and perceptive types than all male engineering students in McCaulley's[5] sample. The number of females who took IDE 301 was too small to conduct a statistically valid comparison. Although the numbers are relatively small, we conclude that the IDES and MDE programs increase the diversity of male and possibly of female engineering students based on psychological type.

Why does the IDES/MDE program attract students with different psychological types? Based on extensive exit interviews with graduating seniors and comments from alumni, the main reasons appear to be flexibility and choice. These students and alumni appreciated the opportunity to choose a high percentage of their courses and, equally important, the opportunity to avoid certain unpopular courses required in other engineering programs. In other words, the basic flexible program structure was attractive and considered beneficial by these students. In addition, the personal attention that they received was given high marks (this makes sense for students with a Feeling preference) and seemed important as a retention factor.

One of the reviewers raised the question of whether the program should adjust courses to play to the strengths of the students attracted to IDES/MDE. The two courses taught by the program, IDE 301 and 485, already do this by including discussions, personal attention and team projects. Changing how engineering professors teach courses, particularly if the courses are from other departments, is very difficult[8]. In addition, teaching more required courses in the program would increase costs and decrease flexibility. Thus, additional changes would either be very difficult or expensive. However, the MDE experience points to a very different, and much easier, approach to start changing engineering education than the standard approach of expecting professors to change their teaching[8]. By administratively forming a program with a very flexible curriculum we have shown that students who would often not be retained in engineering can be retained. Thus, development of flexible curricula may be low-hanging fruit in reforming engineering education.

**Summary and Conclusions**

An extremely flexible Multidisciplinary Engineering program was developed that extensively uses existing courses taught by other engineering programs. An intensive and extensive assessment program that individually tracks the progress of each student was developed. The MDE program was ultimately successful in obtaining ABET accreditation. Other universities could use the MDE program as a model of a relatively low cost, flexible program that helps retain students and can meet ABET accreditation requirements. The assessment procedures developed here also provide a model for proving that all students including transfer students have met program outcomes.

**Epilogue.**

On a personal basis we have spent five intense years of our lives developing a new department in the new discipline of Engineering Education and in the process developed and obtained accreditation for a new undergraduate Multidisciplinary Engineering program. We could have made the administration happy by writing research proposals and publishing research papers. Was developing the MDE program worth it? Hell yes! It's not often that one has the opportunity to develop and accredit a new undergraduate program that will retain students and make the lives of graduates more productive and satisfying.

**Acknowledgment**.

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**Table 1. Concentrations in Multidisciplinary Engineering**

| Title | # Students | Defining Characteristics |
|---|---|---|

| | | |
|---|---|---|
| Acoustical Engr. | 32 | Significant interaction with Theatre Dept. |
| Basic Engr. | 1 | General engineering program |
| Environmental & Ecological Engr. | 3 | Program for new engineering division |
| Engr. Management | 5 | Earn Management minor |
| Innovative Design Engr. | 6 | Significant interaction with Art & Design Dept. |
| Integrated Engr. | 4 | Integrates science & engineering |
| Lighting Engr. | 0 | Significant interaction with Theatre Dept. |
| Nano Engr. | 0 | Includes quantum chemistry or physics |
| Ocean Engr. | 0 | Requires semester at another university |
| Student Developed Engr. | 4 | Program unique for each student. |

**Table 2. Structure of Multidisciplinary Engineering Plans of Study**

| | Credits |
|---|---|
| **First year Engineering Program.** Calculus, chemistry, engineering design/computer tools, English, physics, speech, first year science selective | 29-32 |
| **Required sophomore mathematics**: Multivariate calculus, linear algebra, DEQ. | 8-10 |
| **General Education**: Humanities and social science | 18 |
| **Sophomore Science selective**. Physics, biology, chemistry | 3-4 |
| **Probability & Statistics Selective**: | (3 – counted elsewhere) |

**Engineering:**

***Required Engineering Core***:

| **Topic:** | **Example Courses:** | |
|---|---|---|
| Electrical circuits | ECE 201 or equivalent | 3 |
| Statics and Dynamics | ME 270, A&AE 203, MSE 250, (CE 297 + 298) or equivalent | 3 or 6 |
| Thermodynamics | ME 200, ABE 210, ChE 211 or equivalent | 3 |
| Engineering Economics | IE 343 or equivalent | 3 |
| Fluid mechanics | ME 309, CE 340, ChE 377, A&AE 333 or equivalent | 3 |
| Major design experience | EPICS (senior design option) or IDE 485 | 3 |
| Professional Preparation | IDE 301 | 1 |
| Typical Engineering Core total credits | | 19-21 |

***Engineering Selectives:*** Do parts a, b, and c.

| | |
|---|---|
| a. Three additional credits of engineering design. | 3 |
| b. Three credits of hands-on (not computer) laboratory. | 2 engr + 1 cr lab |
| c. Engineering course in materials or strength of materials. | 3 |
| Total credits engineering selectives: | 8 engr + 1 cr lab |

| | |
|---|---|
| ***Engineering area***: Courses to meet educational objectives of concentration. | 15-20 |
| Minimum Engineering credits @ 200+ level | 47 |
| **Area**: Courses in any major to meet concentration's educational objectives. | 9-19 |
| Minimum required for graduation | 124 |

**Table 3. Multidisciplinary Engineering: Acoustical Engineering Concentration**

| | Credits |
|---|---|
| **First year Engineering Program.** Calculus, chemistry, engineering design/computer tools, English, physics, speech. Students are *very strongly advised* to take a CAD course. | 29-32 |
| **Required sophomore mathematics**: Multivariate calculus, linear algebra, DEQ. | 8-10 |
| **General Education**: Humanities and social science. Strongly suggest MUS 250, Mus 361, Mus 362, & THTR 201. | 18 |
| **Sophomore Science selective**. Physics 241, 261 or equivalent. | 3-4 |
| **Probability & Statistics Selective**: An appropriate engineering course is strongly suggested to leave room for additional THTR courses. | (3 – counted elsewhere) |

**<u>Engineering:</u>**

***Required Engineering Core***:

| **Topic:** | **Example Courses:** | |
|---|---|---|
| Electrical circuits | ECE 201 or equivalent | 3 |
| Statics and Dynamics | ME 270, A&AE 203, MSE 250, (CE 297 + 298) or equivalent | 3 or 6 |
| Thermodynamics | ME 200, ABE 210, ChE 211 or equivalent | 3 |
| Engineering Economics | IE 343 or equivalent | 3 |
| Fluid mechanics | ME 309, CE 340, ChE 377, A&AE 333 or equivalent | 3 |
| Major design experience | EPICS (senior design option) or IDE 485 | 3 |
| Professional Preparation | IDE 301 | <u>1</u> |
| Typical Engineering Core total credits | | 19-21 |

***Engineering Selectives***: Do parts a, b, and c.

| | |
|---|---|
| a. Engineering design: ME 413, Noise Control | 3 |
| b. Three credits of hands-on (not computer) laboratory. | 1 cr lab + 2 engr lab |
| c. Engineering course in materials or strength of materials. | <u>3</u> |
| Total credits engineering selectives: | 8 engr + 1 cr lab |

***Engineering area***: ***Selective courses:*** Do one of the following

| | | |
|---|---|---|
| ECE 590D | Electrical Acoustics | 3 |
| ME 513 | Engineering Acoustics | 3 |

***Suggested Electives***: Strongly consider courses needed for a minor in either Electrical & Computer Engineering or in Mechanical Engineering — 13-14

Total Engineering Area Courses — <u>19-20</u>

Total required Engineering credits @ 200+ level — 47

| | | | |
|---|---|---|---|
| **<u>Area:</u>** | ***Selectives:*** | Select from THTR 163, 263, 353, 363, 553, and 563. Minimum | 7-9 |
| | ***Electives:*** | Consider a minor in Theatre Design and Technology | <u>0-9</u> |
| | | <u>Typical total in area</u> | <u>11-18</u> |
| | | Minimum required for graduation | 124 |

**Table 4. Objectives and Outcomes for MDE Program.**

Multidisciplinary Engineering *Program Educational Objectives*

I. Within 3 to 6 years of graduating from the Multidisciplinary Engineering program, graduates are expected to believe that their Multidisciplinary Engineering education was valuable preparation for their careers, regardless of the fields.

II. Within 3 to 6 years of graduating from the Multidisciplinary Engineering program, graduates are expected to achieve *one or more* of the following milestones:
1. Advance professionally in positions that integrate engineering and other perspectives such as art, education, etc.
2. Earn an advanced degree or an advanced certification, or become a professional engineer.
3. Assume leadership roles in technical, community, artistic or other endeavors.
4. Become a successful manager, consultant or entrepreneur who is developing global expertise.
5. Written scholarly article(s), received patent(s), or have a patent pending.

*Program Outcomes* for the Multidisciplinary Engineering Program

Graduates will have:
1) An ability to apply knowledge of mathematics, science, and engineering;
2) an ability to design and conduct experiments as well as to analyze and interpret data;
3) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
4) an ability to function on multidisciplinary teams;
5) an ability to identify, formulate, and solve engineering problems;
6) an understanding of professional and ethical responsibility and actions that are congruent with this understanding;
7) an ability to communicate effectively by speaking and writing;
8) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
9) an understanding of how one learns and recognition of the need for lifelong learning;
10) a knowledge of how contemporary issues affect engineering and how engineering can impact these issues;
11) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice; and
12) an understanding of the principles, applications and importance of leadership.

Table 5. Checklist for Telephone Interviews with Recent Multidisciplinary Engineering Graduates

*Introduction for caller: Before the call,* ***check the graduate's file*** *so that you are familiar with the record.* ***Take notes during the call*** *and then complete the notes immediately after hanging up. The best way to determine if these objectives are met will depend upon the person called and the rapport you can develop with them. Direct questions will probably be productive for most of the objectives. Satisfaction of objective 3 is probably best determined by getting graduates to talk about their careers and their lives.*

__________________ ________________ _______ ___________ ________
Graduate's Name Phone # Grad date Caller's name date

**I.** *Ask to speak to the graduate by name.* Introduce yourself as _________ from the Multidisciplinary Engineering program at Purdue University. *If you know the person personally, briefly chat with them.*

***II.*** *Briefly explain that you are calling as part of the continuous improvement program. Although graduates were once familiar with the program objectives, read them to the graduate as a reminder.* In this interview we are trying to determine if the Multidisciplinary Engineering program objectives are met. These program objectives are: [Removed to save space. See list in Table 4.]

***III.*** *Start a discussion of the graduate's career.* Has the graduate earned an advanced degree, earned advanced technical certification, passed the Fundamentals of Engineering exam, or become a professional engineer?________________ *If yes, ask for details and record them.*

1. How is his/her career progressing?
2. If working, determine the name and location of the employer and the job title.
3. Ask the graduate to describe a typical day at work.
4. Does the graduate have command of fundamentals and skills necessary for the current position?
5. In general, does the graduate feel well prepared for the current position?
6. Are there other fundamentals and/or skills that are lacking for desirable future positions?

**IV.** *Explore what he/she does as an avocation (hobbies, volunteer activities, clubs) etc. Try to determine if the graduate is starting to assume leadership positions in technical, community, business, artistic or other endeavors. If this is not clear, ask.*

**V.** *What could the Multidisciplinary Engineering program do to improve?*

1. How does the graduate's skill set compare to those of other young engineers that he/she works with?
2. Are there any useful skills that other young engineers have that the graduate did not learn at Purdue?

**VI.** *If you haven't been able to determine if a program objective has been satisfied, ask specifically.* For example, have you written any articles, received any patents, or have any patents pending?

**VII.** *Ask if there is anything else the graduate wants to talk about or any additional comments.*

**VIII.** *Ask the graduate to rate how good a preparation his/her Multidisciplinary Engineering education was for his/her career using a scale from 1 = Poor, 2 = Marginal, 3 = Acceptable, and 4 = Superior.*

**IX.** *If the graduate is scheduled to have his/her employer interviewed (typically 2 or 3 years after graduation), ask for permission to contact the employer. If permission is granted, initial and date and ask for contact information for the graduate's immediate supervisor.*

**X.** *Thank the graduate for his/her time and encourage him/her to keep the department informed.*

Table 6. Course Outline for IDE 301 Professional Preparation Seminar (1 credit)

| Class | Date | Topic | Assignment |
|---|---|---|---|
| 1 | Jan.8 | Intro., ABET Survey. | *Sign up for Interview with professor.* |
| 2 | Jan 15 | Teams & team functioning. Teams assigned. | *Personal profile page due.* |
| 3 | Jan 22 | MBTI Continue team project (outside of class) | *Finish taking the Myers-Briggs Type Indicator (MBTI) by this period.* |
| 4 | Jan 29 | Team Competition Day. | |
| 5 | Feb 5 | Finish MBTI. | *Peer ratings of team due.* |
| 6 | Feb 12 | Leadership. | *Reports: MBTI analysis of personal interactions in team due.* |
| 7 | Feb 19 | Contemporary Issues. | *Read paper & start contemporary issues worksheet before class. Turn in worksheet at end of class.* |
| 8 | Feb 26 | Life-long learning, and learning styles. | *Learning Styles Inventory due. Leadership HW due. Do worksheet in class.* |
| 9 | Mar 4 | Jobs or Graduate (Professional) School | |
| | March 11 | No class, Spring Break | |
| 10 | Mar 18 | Ethics-1. | |
| 11 | Mar 25 | Ethics-2 | *Turn in check list and results of interview.* |
| 12 | April 1 | Self-assessment. | *Ethics assignment due.* |
| 13 | April 8 | Engineering in a Global Environment, Dr. Rick Zadoks, Caterpillar | *Read paper & start globalization worksheet before class. Turn in worksheet at end of class.* |
| 14 | April 15 | Communication. Oral. Students present elevator talks. | *Prepare "impromptu"2 minute talk before class.* |
| 15 | April 22 | Semester Wrap-up. Course evaluations. | *ABET self-assessments due.* |

Table 7. Rubric for MDE Outcome 8. Understand impact engineering solutions in societal/global/economic/environmental context. Note: the other rubrics used can be obtained from the first author, <wankat@purdue.edu>.

If a topic is not applicable, write NA in the topic box and do not rate the topic.

| Attribute | Unacceptable | Marginal | Acceptable | Superior |
|---|---|---|---|---|
| Explain impact engineering on environment & society that is globalizing | No reasons and examples, or incorrect reasons and examples | Mainly ineffective evaluation & explanation of impact. | Mostly effective evaluation & explanation of impact with 2 or 3 reasons & 2 or 3 examples | Effective assessment & explanation of engineering impact, multiple reasons and examples. |
| Broadens understanding of diverse & global cultures | No effort to broaden understanding | Participates in one activity to broaden understanding. | Participates in two or more activities, one of which is extensive. | Participates in study abroad & in multiple activities to broaden understanding. |
| Has a plan for personal success in a global society | No plan | Vague plan No contingency plan | Plan with some ideas and at least one contingency (alternate) plan | Well thought out plan including multiple contingency plans |
| Overall performance | Unacceptable | Marginal | Acceptable | Superior |

Table 8. MBTI data for engineering students[5] and for IDES/MDE students.

| | % E | % S | % T | % J |
|---|---|---|---|---|
| Engr data (McCaulley[4]) | | | | |
| Male (N = 3105) | 43.7 | 53.1 | 77.2 | 57.5 |
| Female (N = 679) | 55.1 | 51.5 | 61.6 | 65.3 |
| IDE 301 data | | | | |
| Male (N = 52) | 44.2 | 40.4* | 63.5† | 28.9! |
| Female (N = 12) | 50.0 | 41.7 | 41.7 | 50.0 |

* Statistically significantly less than engineering data at 95% level ($\alpha = 0.05$).
† Statistically significantly less than engineering data at 99% level ($\alpha = 0.01$).
! Statistically significantly less than engineering data at 99.9% level ($\alpha = 0.001$).

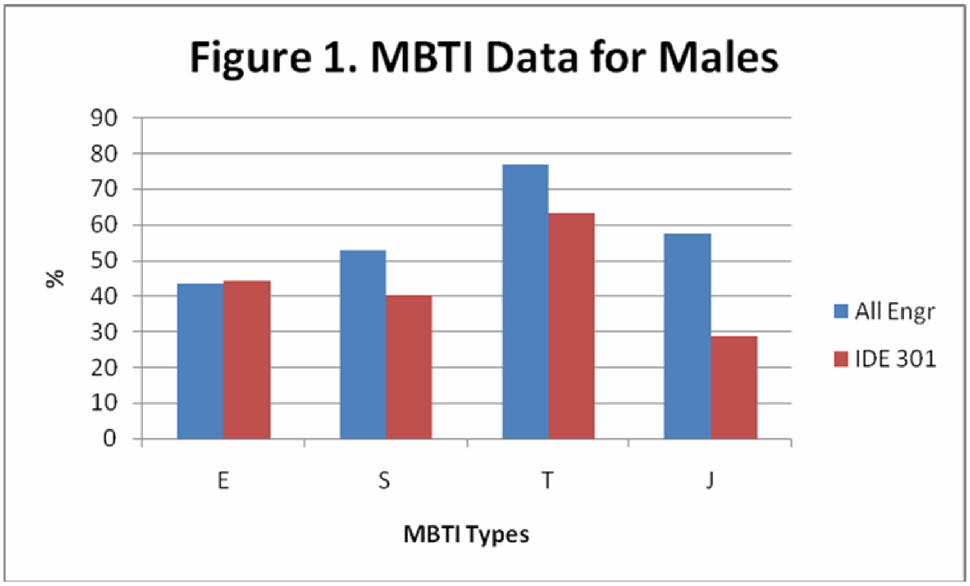
Figure 1. MBTI Data for Males
90
80
70
60
50
40
30
20
10
0
%
E
S
T
J
MBTI Types
All Engr
IDE 301