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Anatomy of Assessment of Manufacturing Design Engineering Academic Program – Do's and Don'ts

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Anatomy of Assessment of Manufacturing Design Engineering Academic Program – Do’s and Don’ts

ABSTRACT

The anatomy of assessment of manufacturing design engineering academic program was evaluated in this paper. This paper summarizes not only the annual assessments that were undertaken to assess this program but also provides a comprehensive review of the assessment process that was developed and adopted in our institution to evaluate the manufacturing design program. Details regarding how to develop a curriculum map, a multiyear assessment plan as well as direct and indirect measures for assessment are illustrated. A list of do’s and don’ts are provided based on the information that was obtained from the assessment.

INTRODUCTION

In today’s competitive environment, employers are placing a high value on graduates that have demonstrated relevant skills and knowledge in any discipline. To establish that the graduates have learned the required knowledge and acquired the required skills, instructors turn to annual and long-term assessment processes. These assessment requirements may vary with each institution. However, there are certain assessment processes that these institutions are required to adopt by accrediting bodies such as ABET.

In general, most institutions will follow standard assessment processes, but they may adopt some unique methodologies to assess the manufacturing design program so as to keep in step with the constant changes that take place to satisfy current and future needs. To be an effective professional, the curriculum should focus on institutional and program learning outcomes such as developing good critical and analytical thinking skills, excellent written, and oratorical skills, and those team skills that are necessary to interact effectively as a member of a team within organizations or communities. These skills should be evaluated throughout the length of the program through assignments, tests, and capstone projects. This paper provides a comprehensive review of the assessment process developed and adopted in our institution to evaluate the manufacturing design program. It provides details regarding how a curriculum map and a multiyear assessment plan should be developed and what direct and indirect measures should be adopted for assessment. A recently completed five-year assessment data will be used to illustrate the effectiveness of assessment. A list of do's and don'ts are provided based on the assessment outcome.

Description of National University and Its Student Body

Founded in 1971, National University (NU) is an independent, nonprofit institution of higher education[1]. Since its establishment, the university has dedicated itself to providing educational opportunities to a diverse population of working, adult learners. With more than 24,000 full-time students, National University is the second largest private, non-profit California institution of higher education, with a 44-year history of educating traditionally underserved populations. National University students earn their degrees in a unique one-month format and attend classes at night, so they can continue to move forward in the workplace. The programs are accelerated so that the studies are completed at a more intense and faster pace than they would be at a traditional university. Each course has 45 hours of class-room contact. Students are allowed to take only one course at a time.

Background of the Program

Manufacturing Design Engineering is a very broad program encompassing many disciplines including mechanical engineering, electrical engineering, production engineering, and industrial engineering. The development of an effective academic program in this unique field was difficult because of the need to include a wide range of knowledge that would span the profession and attract a wide audience nationwide. In other words, for the program to be relevant, it had to incorporate a wide array of courses in engineering, technology, and manufacturing. A well-developed curriculum for this program would not only have to identify the common fundamentals and practices that define the theory and effective practice of engineering, technology, and science, but also communicate these principles in an academic forum. With this in mind, a baccalaureate degree program in Design Engineering was proposed in 2004. Subsequent modifications to it were made in 2008, 2010, and 2012 based on assessment outcomes.

Since the proposal of this original program, there has been an increase in demand for qualified manufacturing design engineering professionals. This is because this program offers practical training in the area of manufacturing design engineering. Unlike a traditional Mechanical Engineering program, this program emphasizes those technical skills that would build on each student's specific technical background and experience. The custom-designed mix of courses helps prepare professionals in the increasingly complicated competitive global and technical environment. In this program, engineering technology principles are broadly based and are drawn from many different disciplines such as applied sciences, engineering, natural sciences, mathematics, economics, business, and social sciences.

Program Requirements

The Bachelor of Science in Manufacturing Design Engineering[2] requires students to complete at least 180 quarter units, 76.5 of which must be completed at the upper-division level, 45 of which must be taken in residence, including the research project classes, and a minimum of 70.5 units of the University General Education requirements.

Preparation for the Major (11 courses: 45.5 quarter units)

The candidates for the program must take the following courses as part of their preparation for the major:

- CHE 101 Introductory Chemistry
- CHE 101A Introductory Chemistry Lab
- MTH 210 Probability and Statistics

  OR
- CSC 220 Applied Probability & Stats.
- PHS 104 Introductory Physics
- PHS 104A Introductory Physics Lab
- CSC 208 Calculus for Comp. Science I
- EGR 220 Engineering Mathematics

- EGR 225 Statics & Strength of Material
- EGR 230 Electrical Circuits and Systems
- EGR 219 Intro to Graphics and Auto CAD
- MTH 215 College Algebra & Trigonometry

These courses are designed to provide the students with a strong foundation in math, engineering, and applied science. In addition, students are introduced to the theory and applications of probability and statistics, CAD/CAM, graphics, statics and strength of materials.

Requirements for the Major (18 courses: 81 quarter units)

The following are the required courses for the major. Each course may have a prerequisite, so the students are advised to take the class in a sequential manner. Each student has an advisor who helps enroll the student in classes. If an issue related to enrollment arises, then the lead faculty is contacted for advice.

- EGR 320 Scientific Problem Solving
- EGR 320L Scientific Problem Solving Lab
- EGR 310 Engineering Economics
- EGR 316 Legal Aspects of Engineering
- DEN 308 Computer Aided Engineering I
- DEN 411 Computer Aided Engineering II
- DEN 417 Computer Aided Engineering IV
- DEN 420 Computer Aided Engineering V

- DEN 422 Materials and Manufacturing
- DEN 423 Human Factors in Engineering
- DEN 426 Reliability Engineering
- DEN 429 Product Design Optimization
- DEN 432 Concurrent Design Engineering
- DEN 435 Design and Analysis of Experiments
- EGR 440 Project Management Fundamentals

Engineering Senior Project

- EGR 496A Engineering Senior Project I
- EGR 496B Engineering Senior Project II

Due to the changing requirements in the global manufacturing enterprise, we made several adjustments to our program by introducing new courses. The contents of the courses are kept up to date by periodic review by the instructing faculty and lead faculty. The problem-based learning introduced in this program makes the course contents relevant. The instructing faculty members are practitioners in the respective field, and they ensure that the program contents are relevant to the needs of the public and private sectors. Lectures by invited guests and field visits make the program directly applicable to the needs of the industry and prepare graduates with the skills and knowledge expected by their potential employers. In addition, this program is designed to prepare the candidates to successfully complete certifications such as the following:

- A Certified SolidWorks Professional (CSWP)
- Professional Engineer (P.E. License)

The Program Learning Outcomes (PLOs) for the program are listed below. At the end of the course students should be able to

1. Combine knowledge and practices needed for working on engineering projects that require innovative and interdisciplinary background, skills, and experience.

2. Utilize product reliability and design optimization concepts in engineering applications.

3. Apply state-of-the-art computer-aided engineering tools and engineering graphics techniques and methodologies

4. Integrate engineering project management standards for efficient and competitive design of engineering products and processes.

5. Apply the concepts of engineering experiment design and analysis

6. Analyze human factors, ergonomics, and safety issues as part of the requirements for design of engineering systems, products, and services

7. Analyze a production problem and design and/or develop a manufacturing system

8. Develop oral and written communication skills appropriate for engineering professionals

9. Demonstrate global awareness and team skills needed in manufacturing design engineering

The tasks that are to be accomplished along with the sample skill levels required to carry out the task are listed in Table 1. These skills are developed throughout our program. In addition, soft skills that include oral skills, speaking, and decision-making are also an integral part of our institutional learning outcomes.

Task	Skill Used in this Task
Plan and establish sequence of operations to fabricate and assemble parts or products and to promote efficient	Engineering and Technology

utilization.	
Review production schedules, engineering specifications, orders, and related information to obtain knowledge of manufacturing methods, procedures, and activities.	Production and Processing
Estimate production cost and effect of product design changes for management review, action, and control.	Judgment and Decision Making
Draft and design layout of equipment, materials, and workspace to illustrate maximum efficiency using drafting tools and computer.	Design
Communicate with management and user personnel to develop production and design standards.	Oral Expression
Recommend methods for improving utilization of personnel, material, and utilities.	Critical Thinking
Confer with vendors, staff, and management personnel regarding purchases, procedures, product specifications, manufacturing capabilities, and project status.	Speaking
Apply statistical methods and perform mathematical calculations to determine manufacturing processes, staff requirements, and production standards.	Mathematics
Study operations sequence, material flow, functional statements, organization charts, and project information to determine worker functions and responsibilities.	Deductive Reasoning

Source: U.S. Department of Labor Occupational Information Network (O*NET)[3]

Table 1: Tasks and Associated Skill Levels Developed in the Manufacturing Design Engineering Program

The instructional materials needed for the various courses have been developed and made available in our eCollege learning platform. It provides weekly contents, presentation materials, case studies, relevant videos, quizzes, and exams. In addition, the instructional materials are updated on a regular basis. The instructors are encouraged to modify these materials to suit their teaching strategies. In fact, several instructors have adopted several teaching strategies, some of which include the following:

- Problem based learning techniques

- Case study analysis
- Expert lecture to review the applicability of theories
- Tablet PCs as an interactive tool when students wish to visually pose those questions that are difficult to verbalize

All of these techniques have been adopted to teach concepts in this program. Final program projects provide students with an opportunity to apply the concepts they have learned to solve multi-faceted problems. In addition, skills such as critical thinking, writing, oral, team work, and others are taught during the course of the project class. A capstone course provides an invigorating experience to students in this program of study since it integrates concepts and skills learned throughout the academic tenure. Typically, projects focus on the application of materials learned throughout the program to solve multi-faceted problems such as those they would encounter in the students' post-academic future employment. In these projects, students select project topics under the guidance of a faculty advisor, analyze the problem, formulate a detailed plan to reach a solution, perform necessary evaluations and/or experimentations, identify and/or propose meaningful results and solutions, test the proposal to the extent possible, prepare a detailed report, and make a presentation. The 'front end' project plan and the 'back end' documentation and presentation are both important elements. Since the entrance into the capstone projects follows the completion of other courses, faculty project advisors can assign problems that are not only relevant to the students' interests but are also helpful in reinforcing the concepts taught. Each class runs for two instructional months. Although the capstone course is done at the end, students are encouraged to identify and select a project prior to about six months before graduation. Typically, projects are proposed by corporate sponsors, who are frequently employers of the students or corporations looking for answers to a problem. This problem is often communicated to the students through the lead faculty. As a result, students get the opportunity to deal with real problems of significant issue to the sponsor, and they, typically, involve engineering, technology, science, and design related issues. Interdisciplinary teams of two to three students are assigned to each project. These teams work with faculty members and representatives of the sponsors to develop detailed, implementable solutions. At the end of the course, student teams make presentations of their project to the sponsoring company. Student teams, typically, travel to the sponsor's location to learn about the problem and meet the company representatives with whom they work.

Typical learning outcomes for a culminating project experience include students demonstrating the capability to accomplish the following:

- Evaluate critically a given project's feasibility and define a specific problem or study,
- Present a comprehensive review of relevant literature,
- Identify sources of relevant data, generate and/or gather data as appropriate, and provide in-depth analyses,
- Identify, describe, and apply appropriate models for drawing conclusions,
- Create a comprehensive project report based on the findings that relate to all essential elements of the project, and
- Defend the project's findings during oral presentation to faculty, class, and, if applicable, to external project sponsors/clients.

The instructional and lead faculty members often participate in the evaluation of the students during the phase of the project to ensure the currency of the courses. The infrastructure and associated assistance are built in so that students and faculty members can avail them when required. Instructors conduct the project class and are often in charge of the capstone process including student progress. Project supervisors, who are also faculty members, advise students on their projects. However, in some instances, the capstone instructors and project supervisors could be the same.

Program Assessment Review (PAR)

Each year, this program was assessed using an established program assessment review (PAR) process. The process included review of student learning using a variety of evaluation methods including assignments, tests, and projects. The process started with an establishment of a curriculum map, which integrated the program's learning outcomes to each course as shown in Figure 1. Then the assignments, tests, projects, and other tasks were created to augment the introduction, development, and mastery of the program learning outcomes. At the end of each academic year, the lead faculty, with the help of instructional faculty members, assessed 20% of each program's learning outcomes. These included a review of course syllabus, student submittals, instructor review, and other testimonials. The results of the assessment process were uploaded into NU's Academic Management System (AMS). This was made available to all reviewing body within the university. The results of the PAR review were critically analyzed by the school's assessment committee, chair, dean, graduate council, and the university's assessment committee for accuracy and independent verification. The assessment recommendations were implemented during the following academic term. Resources such as funds requested through budgeting process were given priority over others.

National University AHS • School of Engineering, Technology, and Media (SETM) • Department of Applied Engineering
Bachelors of Science Manufacturing Design Engineering

2013 BS in Manufacturing Design Engineering Curriculum Map
Courses and Activities Mapped to Required Courses

	Required Courses															
	EGR 320	EGR 320L	EGR 310	EGR 316	DEN 303	DEN 411	DEN 417	DEN 420	DEN 422	DEN 423	DEN 426	DEN 429	DEN 432	DEN 435	EGR 486A	EGR 486B
Courses and Learning Activities																
Outcome 1 Combine knowledge and practices needed to work on engineering projects that require innovative...			I					D		D		M	M		M	M
Outcome 2 Utilize product reliability and design optimization concepts in engineering applications.					I	D	D	I		D		M			M	M
Outcome 3 Apply state-of-the-art computer-aided engineering tools and engineering graphics techniques and...					I	D	M	M							M	M
Outcome 4 Integrate engineering project management standards for efficient and competitive design of...							I	D		D	D				M	M
Outcome 5 Apply the concepts of engineering experimental design and analysis	I	I							D	D			D	M	M	M
Outcome 6 Analyze human factors, ergonomics, and safety issues as part of the requirements for design of...				I	I	I	D	D	D	M	M				M	M
Outcome 7 Analyze a production problem and design and/or develop a manufacturing system				I					I		D		D	D	M	M
Outcome 8 Develop oral and written communication skills appropriate for engineering professionals				I						D		D	D	D	M	M
Outcome 9 Demonstrate global awareness and team skills needed in manufacturing design engineering									I		D	D			M	M

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created with taskstream

Figure 1: Curriculum Map for BSDEN Program

Legend: I – Introduced; D – Developed; M - Mastered

Two direct and one indirect measure are used to assess each PLO. The direct measure includes assignments, projects, exams, and papers. The indirect measure, typically, includes student surveys. Each PLO can be assessed in multiple courses as shown in the multi-year assessment plan in Table 2. In this case, not only on-ground classes, but also online classes were used for the assessment. A number of insights are gained through this assessment. These include information regarding students' achievement of learning outcomes, effectiveness of instructional methods, quality of instructing faculty, and deficiencies in areas such as text -books, laboratory equipment, and other facilities. The assessments done during each year is used to propose recommendations that are acted on during the following year.

Table 3 summarizes the PAR assessment conducted during the academic year 2012. As illustrated, each PLO was assessed using two direct methods and one indirect method.

		Means		Evidence Collection		
Fiscal Year	PLO No.	Direct Means	Indirect Means	Items	Process	Location
2011-2012						
	4	Student Assessments of Learning in EGR 440	Student Survey	Projects Assignments Quizzes	End of Course Survey, Good and Bad assignments review	San Diego, Off site
	1	Student Assessments of Learning in EGR 496 A and B		Assignments, Quizzes	Good and Bad assignments review	San Diego. Off site
	8	EGR 496 A & B, External evaluation of selected Projects by a panel of experts		Capstone Project Assessments, written reports	Review by Panel of Experts	San Diego, Off site
2012-2013						
	2	Student Assessments of Learning in DEN 426	Student Survey	Assignments Quizzes	End of Course Survey, Good and Bad assignments review	San Diego, Off site

	3	Student Assessments of Learning in EGR 219, DEN 308, DEN 417, DEN 420		Projects Assignments Quizzes	Good and Bad assignments review	San Diego, Off site
	8	EGR 496 A & B, External evaluation of selected Projects by a panel of experts		Capstone Project Assessments, written reports	Review by Panel of Experts	San Diego, Off site
2013-2014						
	5	Student Assessments of Learning in DEN 429, DEN 432	Student Survey	Assignments, Projects, Quizzes	End of Course Survey, Good and Bad assignments review	San Diego and Off site
	6	Student Assessments of Learning in DEN 423		Assignments, Quizzes	Good and Bad assignments review	San Diego and Off site
	8	EGR 496 A & B, External evaluation of selected Projects by a panel of experts		Capstone Project Assessment, written reports	Review by Panel of Experts	San Diego, Off site
2014-2015						
	7	Student Assessments of Learning in DEN 422	Student Survey	Projects, Assignment, Quizzes	End of Course Survey, Good and Bad assignments review	San Diego and Off site
	9	Student Assessments of Learning in EGR 496 A and B		Project Review	External panel of experts	San Diego and Off site
	8	EGR 496 A & B, External evaluation of selected Projects by a panel of experts		Capstone Project Assessment, written reports	Review by Panel of Experts	San Diego, Off site
2015-2016						
	3	Student Assessments of Learning in EGR 219, DEN 308, DEN 417, DEN 420	Student Survey	Projects Assignments Quizzes	End of Course survey. Good and Bad assignments review	San Diego, Off site

	8	EGR 496 A & B, External evaluation of selected Projects by a panel of experts		Capstone Project Assessment, written reports	Review by Panel of Experts	San Diego, Off site
	9	EGR 496 A & B, External evaluation of selected Projects by a panel of experts		Capstone Project Assessment, written reports	Review by Panel of Experts	San Diego, Off site

Table 2: Multi-year Assessment Plan for Manufacturing Design Engineering Program

2012 PAR (2012 Program Assessment Report)

Assessment Findings

Finding per Measure

Bachelor of Science Design Engineering Outcome Set

Program Learning Outcomes

Program Outcomes

After completion of this program, graduates will be able to:

Outcome 1

Combine knowledge and practices needed to work on engineering projects that require innovative and interdisciplinary skills

Measure: Indirect assessment
Program level; Indirect - Survey

Details/Description: This indirect assessment was measured using student course assessment. In this, both the course cumulative student GPA along with assessment of teaching is reviewed. In addition, the student comments are reviewed for consistency.

Acceptable Target: Student assessment: 4 out of 5 with good student comments
Course GPA – 2.75-3.00

Ideal Target: Student assessment: 4.5 out of 5 with good student comments
Course GPA – 2.75-2.90

Findings for Indirect assessment

Summary of Findings: DEN 309 course assessed was one of the most difficult classes in the program. This is heavily math and computer oriented course. Math is one of the weakest subjects for our students. We have tried many approaches including assigning the best teachers for math oriented classes. I am streamlining the instructor assignments from the past practices. Only qualified instructors are given the difficult classes. In addition, we are assembling instructors based on subject specific expertise.

The assessment of instruction is less than desired. The student comments ranged from "poor instruction"
to "too much work". The instructors for theses classes have been consulted and appropriate changes to the instruction along with text book are being made.

EGR 496 A and B courses capstone classes in BSDE major, these courses involve substantive projects that students demonstrate their learning in each major. These courses are in three month in duration.
Typically, three to five students worked in teams doing research leading to preliminary development of the final product. During these courses, students work in teams of three to five and doing research leading to preliminary development of the final product. Course A focuses on developing the team project concept and completing it to an approximate 50 percent level. The subsequent B course focuses on completion of the project including methodology and analysis.

Evaluation of the project materials clearly indicated that a high degree comprehension. The project course evaluated by several faculty members revealed well executed project with high degree of comprehension of course materials. The students were able to present and answer questions related to the topic.

Results: Acceptable Target Achievement: Met; Ideal Target Achievement : Moving Away

Measure: Innovative and interdisciplinary skills
Program level; Direct - Student Artifact

Details/Description: The program learning outcome, "Combine knowledge and practices needed to work on engineering projects that require innovative and interdisciplinary skills" is taught and measured in a number of courses in this program as listed below:

* Introduced – EGR 310
* Developed – DEN 420, DEN 423
* Mastered – EGR 496 A, EGR 496 B

There are several measures used including assignments, quizzes/exams, and projects to measure these skills. The quizzes and exams are marked based on right or wrong answers. For projects, the students are asked to integrate innovative and interdisciplinary skills by working as a team. This PLO is evaluated using the written and presentation part using a panel of experts. This process is same for the online as well as on site offerings of this program.

Acceptable Target: 80-88 %

Ideal Target: 89-100 %

Findings for Innovative and interdisciplinary skills

Summary of Findings: The program learning outcome was assessed in the following courses:

* DEN 308, in the developed category
* EGR 486 A, EGR 486 B, EGR 496 A and EGR 496B in the mastered category. (EGR 486 and 496 are conducted together)

DEN 308: Computer Aided Engineering I: Simulation Modeling and Analysis courses introduces simulation modeling and analysis, model development, intermediate and detailed modeling, modeling issues and techniques. This course uses Autocad software extensively.

EGR 486A, B and 496 A and B courses are capstone classes in BSDE and BSCE majors, these courses involve substantive projects that students demonstrate their learning in each major. These courses are in three month in duration. Typically, three to five students worked in teams doing research leading to preliminary development of the final product. During these courses, students work in teams of three to five and doing research leading to preliminary development of the final product. Course A focuses on developing the team project concept and completing it to an approximate 50 percent level. The subsequent B course focuses on completion of the project including methodology and analysis. Final project submittal consists of all project deliverables including scope, design metthodology, drawings, product testing, and 100% project plans. Each team is required to make a presentation of their project and submission of a final report. The presentation is evaluated using the enclosed rubrics. Typically, the evaluation is done by faculty members. Students are asked to explain the work including rationale for their chosen work, methodology adopted and results.

The following sections of the courses were evaluated:

- DEN 308 – Sep 2011 (Off site)
- EGR 486/496A A and B – Nov, Dec, 2011 and Jan, 2012 (Online)
- EGR 486 A and B and EGR 496 A and B – March, April, and May 2012 (Onground)

These courses were taught by three experienced faculty members from industries.

The example work including assignments, quizzes, and project reports are enclosed. The score varied in each course as listed below:

- DEN 308 – Sep 2011 - Class GPA – 3.166; Grades: Low (C+); High – (B)
- EGR 486/496 A and B – Nov, Dec, 2011 and Jan, 2012 (Online) - Grades: Low (73%) High – (100%)
- EGR 486 A and B and EGR 496 A and B – March, April, and May 2012 - Grades: Low (92%) High – (95%) Evaluation of the assignment and quiz materials clearly indicated that a high degree comprehension of the topic covered. In addition, the class GPA indicated a high degree of rigor. The two project courses evaluated by several faculty members revealed well executed projects with high degree of comprehension of course materials. The

Table 3: Example PAR Assessment Performed During 2012 Academic year

Table 4 summarizes the teaching evaluation for the combined academic years from 2010 through 2013. This table also provides the cumulative mean GPA and total grades submitted. Full time faculty members taught 17% of the 131 courses that were offered during this period. Typically, the full time faculty members only teach the introductory and the more advanced classes. Efforts are now being made to hire full time faculty members to teach more of the classes in this program, but the effort has not seen much success. Nevertheless, the number of full time faculty members teaching in this program has improved during the last two years. Although the capstone projects are taught by adjunct faculty members, they are directed by the lead faculty member at all times. The average teaching evaluations for each academic year has been at or above 4.0 for the entire duration of 4 years (2010-2013). NU has an informal policy to maintain a GPA of 2.75 (on a 4.0 scale) for undergraduate courses to avoid any grade inflation. Of the 1020 total grades submitted during the entire period, the mean cumulative GPA was maintained at 2.95 on a 4.0 scale. This represents the rigor built within the curriculum. Although the goal is to maintain a GPA of 2.75, the higher GPA could be attributed to instructors who are easy graders as well as non-subject matter instructors. They are reminded constantly to increase rigor. In addition, most of the independent studies yield higher grades than that can be secured through a regular class. Independent studies are offered for small class sizes (usually less than 6) and to students who have missed regular classes. Independent studies are usually discouraged because the intent is to promote team-based learning.

The BSDEN curriculum deals with methodologies related to the areas of design engineering, analysis, manufacturing process evaluation, and project management. Each course is evaluated through discussion questions responses (face to face class discussions), class participation (on-ground), assignments, projects, quizzes, as well as the midterm and final exams. Typically, 60% of the grades are based on individual performance whereas 40% are based on team - based performance. The quizzes and exam scores offer a good measure of the effectiveness of individual learning, whereas projects help measure the students' application skills. Typical assignments require the application of the concepts learned. In addition, students are given short projects on which they are required to work with other class members as a team. These tasks generate a lot of discussions among students. They also help elevate students' critical thinking and analytical skills. These are also part of the institutional learning outcomes. Students work together on team projects in every course in the program except a few. As a result, the students develop team skills and gain experience in completing projects in a team-based environment.

Year Taught	Total Classes	Taught by Full-time	Mean Cumulative Course GPA	Total Grades Submitted	Mean Assessment of Learning	Mean Assessment of Teaching	Mean Overall Assessment
2010	34	2	2.96	229	4.17	4.32	4.28
2011	25	3	2.86	217	4.30	4.39	4.33
2012	37	8	3.07	237	4.14	4.12	4.12
2013	35	9	2.92	337	4.10	4.40	4.31
Average/ Total	**131**	**22**	**2.95±0.09**	**1020**	**4.18±0.09**	**4.31±0.13**	**4.26±0.10**

Note: 2009 was not considered due to lack of credible data

Table 4: Summary of Teaching Evaluations for the Academic Years 2010-2013

Table 5 lists all the recommendations resulting from the last five year PAR. This table also lists the PLOs assessed, year assessed, resulting recommendations, and results achieved. As shown, each specific assessment provides the root cause for the problem, potential solutions adapted, and the improvement achieved. Some weaknesses that were identified in the program include lack of writing and research skills, lack of industrial capstone projects, and the lack of adequate software tools for performing design analysis to enhance critical thinking. All these were resolved by the introduction of several new courses and the elimination of a few existing courses.

Year of Assessment	**PLOs Assessed**	**Resulting Recommendations**	**Results Achieved**
2009	1-9 (The lead faculty assessed all PLOs in each year through capstone projects)	• Improvement of writing skills • Standardize project requirements • Emphasize the use of the writing center	• Requirements of the project have been standardized • Specific rubrics for written projects were introduced.
2010	1-9 (The lead faculty assessed all PLOs in each year through capstone projects)	• Require implementation of some additional tutorials related to project management. • Require tutorials to implement writing skills improvement • Require funding allocation for non-industry sponsored capstone projects • Currency of text books • Need for better admissions advising • Need to combine some of the redundant PLOs	• Improved assessment through Student Exit Surveys over previous years • Requested funds for non-industry sponsored projects through annual budget • Text books for six courses were changed • Provost office was notified regarding the help needed for writing skills improvement. Appointed a school wide writing coordinator to implement writing assignments in many courses with the help of lead faculty • Provost has initiated a new process university wide to reorganize all PLOs

2011	Due to the sudden death of lead faculty, the assessment was not performed		
2012	1,4,8	• Develop subject specific expertise list and assign only those instructors to the classes • Revise math curriculum that will help students learn math. • Introduce centralized software system for applicable courses (cost shared with CEN/CM programs) • Introduce suitable laboratory courses	• Developed a list of instructors who are qualified to teach the classes/subject matter assigned • Introduced EGR 220, a new math course. This course is based on a NSF study. A new problem based curriculum is being introduced. • Plans were initiated to introduce the centralized software for applicable DEN and EGR courses. • Initiated a plan to revise one course by introducing both a lecture and laboratory course separately (EGR 320 and EGR 320L)
2013	2,3,8	• Streamline course Software download for the courses • Improve Project Writing Skills • Improve course level instruction for courses such as modeling software usage • Define a new design methodology project process • Develop a case study to be employed throughout the program (at least in five courses)	• New processes were introduced to download course software • Referred the writing skills improvement to the School Dean. Also, recommended students to hire external help in writing skill improvement • Identified instructional videos for instructing software such as SolidWorks • Developed a case study titled, “Computer Office Chair Design” and introduced assignments related to this in five courses

Table 4: Summary of Recommendations Resulting from the Last Five Year Program Learning Assessments

Other Innovations

A number of innovations were introduced during the review period, including the addition of small group projects, problem based learning concepts, industry expert guest lecturers, field visits, and technology to enhance and increase interaction in the classroom. Some select examples are provided below.

- In May 2007, National University's School of Engineering and Technology was awarded a Hewlett-Packard Technology for Teaching – Higher Education Grant, which included 21 Tablet Personal Computers, two wireless access points, and other ancillary equipment, and some cash. The cash was used to purchase licenses for use of advanced interactive software on every Tablet PC by every student in class. Approximately, ten students used the Tablet PCs in two engineering management classes with excellent results. The use of the Tablet PCs enabled introduction of real-time exercises on which all students worked simultaneously during class. Student submission of responses back to the instructor enabled the instructor to immediately identify areas where understanding was incomplete thus enhancing instruction.
- The problem-based learning concepts were introduced into several courses. In particular, EGR 220 Engineering Mathematics was developed based on the Write State University Model that was funded by the National Science Foundation. The unique methodology adopted in this course is currently used in 30 plus universities and colleges including National University. In addition, two other courses, namely scientific problem solving skills course and an associated laboratory course were developed to reinforce math applications.

- Developed a case study course titled, "Computer Chair Design." Several assignments related to this case study are being introduced in various courses within this program to illustrate how materials learned from various courses can be used to accomplish product design related to "Computer Chair."

Summary and Recommendations

Based on multiple measures of effectiveness, the quality of the BSDEN program is good. This has been confirmed by reviews of the curriculum, by the quality of the faculty, and most importantly, by the graduates. The constant changes made to this program during the last five years have kept the program's materials current to the needs of the industrial community. There is no doubt that the program will continue to evolve with more improvements. The following recommendations came from the assessments done for the last five years.

Program Management Help

This program is a complex program requiring industrial experience, design experience, software experience and manufacturing experience. The lead faculty who is managing this program has over 20 years of industrial and manufacturing experience along with 15 years of academic experience. To manage this complex program, there is a need for adequate time for the lead faculty to develop case studies and capstone projects of real-world problems with industry sponsors, assign laboratory exercises, and design novel teaching methodologies. To manage this program, the lead faculty is given one course reduction (12.5% reduction in workload). This is far too low to manage an important and complex program such as this. The BSDEN program has experienced modest success during this period. Even with this limited addition, the lead faculty was able to develop an off-site program with an industry (only one such unique program within SETM). With an addition of one more course load reduction to lead faculty, a number of things can be accomplished including developing case studies, finding internships, actively seeking capstone project sponsorships, and engaging in publications. Hence, the need for this situation to be corrected.

Project Help for Capstone Projects

Ideally, capstone projects should be real-world problems with industry sponsors. The BSDEN program has experienced only modest success in finding and enlisting sponsors for capstone projects, despite our links to the industry during the review period. Efforts to identify and enlist BSDEN program project sponsors need to be continued and increased. In addition, we need adjunct faculty who are willing to supervise capstone projects. Part of the problem is the lack of pay to adjunct faculty members who are willing to supervise projects. This situation must be corrected.

Integration of External Certifications

Although this program is currently designed to meet to ABET accreditation requirements, efforts must be made to accredit the program. As a first step, SME (Society of Manufacturing Engineers) certification for manufacturing technologists must be evaluated. This may require review assistance by an external reviewer. In addition, SME certification may help in achieving ABET accreditation.

Continuous Program Evaluation

The curriculum must be continually evaluated and associated course learning outcomes need to be continuously revised and improved to ensure that they are measurable and that they are being measured properly and consistently. Continuing efforts are required as the technology continues to advance. New course learning outcomes will need to be added to some courses. New courses such as innovation should be introduced. Simulation and laboratory experiments also need to be tied to the course learning outcomes of the program.

Need for High Quality Faculty (Full Time and Adjunct)

High quality faculty members are an important measure of the quality of the program. Typically, full time faculty members manage/participate in many small programs. Most of the adjunct faculty members, although well qualified, simply teach but do not spend adequate time with the students. Most adjunct faculty members are retired from their services and do simple teaching. In this program, each adjunct faculty holds a full time job in the industry including the military. Examples of adjunct faculty members in this program include a deputy program manager in industry, an engineering project manager for a large military contractor, and an engineering manager for NAVY research center, SPAWAR. Effort must be made to recruit more adjunct faculty from industries. There is a need to have a full time faculty whose expertise is in the area of Solid Works, Optimization, and Concurrent design engineering.

Need for Simulation and Other Laboratory Tools

The program requires simulation and other laboratory tools. In addition, an engineering technician (experienced in engineering field) is needed to develop lab experiments using this simulation.

The School of Engineering's mission has served as a reminder for instructors and administrators to focus on improving student success. The most rewarding achievement in the assessment process is to be able to close the loop on program improvement and resource allocation based on analyses of student outcome assessment. The school's community, including faculty, university administration, and staff work in partnership to deliver academic programs and student services that support students to the fullest extent.

List of Do's and Don'ts

The following list of do's and don'ts were derived from the direct and indirect means of analysis conducted during the last five-year assessment.

List of Do's

1. Hire high quality subject matter experts who can teach complex subjects
2. Evaluate and implement applicable simulation tools and laboratory exercises
3. Evaluate and enlist project sponsors for securing capstone projects
4. Institute high level rigor in teaching with appropriate grades to overcome grade inflation
5. Continue to revise courses and implement applicable assessment processes

List of Don'ts

1. Fail to assign only subject matter experts to teach the relevant courses
2. Minimize independent study courses
3. Postpone ABET accreditation plans.
4. Postpone the implementation of recommendations from PAR.

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