An Industrial Engineering Technology Curriculum for the Millennium

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Abstract

The Industrial Engineering Technology program at the University of Dayton has completed a major effort to study our existing curriculum and courses as the means to improve the coordination and dissemination of knowledge. While courses within our program have been and will continue to be updated each time a course is taught, this improvement effort was more far-reaching. We sought insight into future curriculum structure as well as future course configuration. The driving force behind this coordinated large-scale effort is our graduates and the companies who hire them.

The effort carefully reviewed our curriculum, the courses offered, their sequence and contents. Decisions to modify the existing curriculum and corresponding courses were based on information obtained through carefully constructed surveys. These surveys captured the needs and expectations of our graduates and the industries that hire them. The information gathered by these surveys enabled us to evaluate our curricula, establish course direction, select and update appropriate coursework, implement changes in course sequencing, and link courses into related series.

The leadership at the University of Dayton is focusing on the idea of being a mission driven and market responsive university, creating and providing value for our customers. The difficulty with encouraging academic programs to become more market-responsive, is the lack of clear cut plans and examples on how to do so. This effort provides an example of how a process approach can be utilized to redesign a curriculum to enhance its value.

The improvement methodology used in this large-scale effort is based on Dr. W. Edwards Deming's Plan-Do-Study-Act cycle. This paper describes the assessment measures we are using to ensure the integrity and continuity of our improvement activities. The paper also discusses how the surveys were used in order to gain insight into the changes necessary to create an Industrial Engineering Technology curriculum for the new millennium.

The Method: A Process Orientation

To revitalize our program, the Industrial Engineering Technology (IET) division decided to focus our efforts on creating alignment between student learning, curriculum design, and career paths following graduation. This placed the emphasis on education as a process. We felt this approach would enable us to improve our customers' perception of value, thereby increasing both enrollment and employment opportunities upon graduation.

When education is viewed as a process, the curriculum reflects an understanding of the links of material within a course, links between courses within a discipline and the link between the discipline and the students' activities upon graduation. This process orientation allowed us to take a more organized, customer-focused approach. We utilized a ten-step process fashioned after the Plan-Do-Study-Act cycle made famous by W. Edwards Deming. Following an established methodology enabled us to ensure the integrity and continuity of our improvement efforts.

Step 1: Identify Customers

Identifying the customers of the IET program was the foundation of the entire improvement effort. Our customers include: students, graduates, those who hire our graduates, our industrial advisory committee, professors, and administration.

Step 2: Define the Issue

Improving the material offered within a program's curriculum is, by necessity, an on-going process. Total curriculum revitalization is a project of a larger scale. To meet the needs of a market-driven university, a comprehensive, coordinated approach to curriculum revision was needed. A process-oriented review of the IET curriculum (Figure 1) would enhance the program, preserving the crucial capabilities required for success upon graduation and recruitment while maintaining a strong TAC of ABET accredited program and increasing overall operational effectiveness.

Step 3: Study the Current Situation

During this step, we explored who we are, what we are currently doing and what we are currently capable of doing. Having identified our customers in Step 1, randomly selected individuals from each category were contacted using surveys designed to investigate our customers' needs, wants, requirements, and expectations. Three individual surveys were created, one for each of the three key customers groups: current students, graduates, and the industries who hire them. See Figure 2 for an example of the survey structure.

The focus of the survey to the industries hiring our graduates was twofold: What are they hiring our graduates to do and what IET skills do they see as valuable in the workplace? From the graduates, we hoped to learn what they were doing, as well as, what IET skills they see as valuable in the workplace. By surveying our undergraduates, we hoped to learn what courses enabled them to be successful as co-op students and what they considered valuable in the workplace. By contrasting the results of these three surveys, we were interested in determining if there was a correlation between what graduates, students, and industry considered valuable and what we were teaching. We also wanted to learn if we were preparing graduates with skills matching employer needs.

One hundred surveys were sent to randomly selected graduates of the past 15 years. A review of the list showed that the chosen graduates were representative of our student population. Forty surveys were sent to representatives of the companies who hire our graduates. Fifty surveys

were given to our current students. Return rates were approximately 35% for each group. Most importantly, it was obvious from the responses to the surveys that respondents took great care in answering their surveys.

Step 4: Refine the Improvement Statement

What did the survey tell us? Here we examined the gap between what we currently do and what we will need to do in order to meet the needs, wants, requirements, and expectations discovered in Step 3. From the surveys, we were able to conclude that overall, our program is doing an excellent job of preparing our students for both their co-operative education and full-time work experiences. There was a definite correlation between what employers valued from our graduates and the type of work performed by our graduates. By evaluating the information from all three surveys, we were able to identify specific areas to focus our improvement efforts and resources.

Step 5: Analyze Potential Causes

During this step, we ensure that the conflicting needs of our customers are analyzed and prioritized in relation to existing constraints. Basically, we determined what changes we need to make and what prevents us from making those changes.

In the short term, due to certain constraints (TAC of ABET requirements, credit hour requirements, etc.), some changes were not possible. Other changes required us to examine why we did things the way we did them. For instance, it was clear that some courses needed to be offered earlier in the curriculum. We could have said that existing pre-requisites prevented us from making these changes and stopped our efforts right there. Instead we reviewed those pre-requisites to determine if they were valid and appropriate. In several instances, we were able to make changes without significant revisions to the courses.

The student survey communicated a need to change the order in which certain courses were offered. After investigating, we realized that the order of courses had evolved over time as we created new courses and added them to the curriculum. Now we had reliable information telling us where those courses should appear in the curriculum. Other stumbling blocks to making changes in the order of the courses included pre-requisites, general education requirements and the need to offer courses in conjunction with the timing needs of other majors. A careful reconstruction of the curriculum based on all of this information yielded a curriculum that better fulfilled the needs of all customers.

One very important piece of information revealed by the surveys is the need to maintain our wide variety of course offerings. Our graduates and the industries hiring them have come to rely on a broad base of IET skills. Preparing a graduate for a wide variety of jobs upon graduation is one of the unique aspects of our program.

Strong skills in effective speaking and technical writing were another specific requirement overwhelmingly demanded by students, graduates, and those who hire them. Given that our separate and well-constructed course in technical writing was recently removed from our

curriculum as a cost saving and credit hour reduction method, we will need to ensure that the development of these skills within our program is not lost.

Step 6: Develop a Measurement System

During this process, we designed measures of performance which will enable us to track our improvement progress. These measures are comprehensive enough to ensure that we are able to determine how well we meet the needs of our customers. The measures are designed so they can be used to answer the question: Have we provided value to our customers while producing a favorable return on the University's investment? The measures of performance include:

- Financial Measures:
  - Results measures:
    - Changes in market share
      - Full-time and part-time students
      - Transfer students
    - Enhanced asset utilization
  - Process measures:
    - Ability to "sell" course sequences to industry or part-time non-matriculated students

- Customer Measures:
  - Results measures:
    - Students perceive we are teaching valuable material
    - Industry perceives we are providing valuable graduates
    - Graduates perceive we are providing valuable knowledge
  - Process measures:
    - Improved student preparation in courses that serve as pre-requisites for either undergraduate or graduate courses
    - Improved preparation for co-operative work experiences

- Internal Measures
  - Results measures:
    - Improved ratings of part-time instructors
    - Improved ratings of full-time instructors
  - Process measures:
    - Removal of non-value added material
    - Insertion of up-to-date material, information and methods

- Learning and Growth Measures
  - Process measures:
    - Cross training of professors
    - Clearer links between subjects taught

Step 7: Develop a Plan of Action

At this point, we combined the knowledge gained from the previous six steps and decide what we were going to do. Our written plan of action stated the conclusions we reached from the survey, the actions we plan to take, the results we hope these actions generate, and how we will measure how we are doing.

Though it would be inappropriate to present our detailed plan of action here, our proposed plan of action includes:

-up-dating several courses
-changing the order in which come courses are offered
-creating a new course which combines two existing courses
-returning a course to the curriculum.

Step 8: Implement a Solution

This is the step where we do what we planned to do. We currently in the process of making many of the changes which resulted from this investigation, (Figure 3).

Step 9: Utilize the Measurement System to Monitor the Solution and Determine if the Solution is Working

As this process unfolds, we are using our measures to determine: did we do what we set out to do? How do we know? The actions we planned in Step 7 and are taking in Step 8 must support the measures of performance, which in turn, must support the purpose and goals of the IET program and the university. If the actions we took have not improved our ability to provide value for our customers, then we must revisit the previous steps and determine a more workable solution.

For instance: the efforts taken to re-sequence several courses were designed to support the performance measure: improved preparation for co-operative work experiences. The efforts involving a strenuous review of all course materials were designed to support the performance measures: removal of non-value added material and insertion of up-to-date material, information and methods. The action of creating a new syllabus format was designed to support the performance measure: clearer links between subjects taught, improved ratings of part-time instructors and improved ratings of full-time instructors.

Once the changes have been fully implemented, we will be contacting our customers again to measure their satisfaction with the changes. The surveys completed in 1999 will be used as a baseline against which to judge the value of our changes.

Step 10: Standardize the Improvement and Establish Future Plans

The insights we were seeking at the beginning of this curriculum review were two-fold: future curriculum structure and future course configuration, specifically: the courses offered, their sequence and contents. This effort was very important for the health of our program. The

survey provided us with valuable information concerning the material we are teaching, the order in which it is being taught and the emphasis the material receives in each course. This knowledge will enable us to continue to provide value to all our customers.

Having analyzed the surveys results, we have valid data telling us that we are doing an excellent job of preparing our graduates for their careers. The courses we have within our program have value for our students, co-ops, graduates and the industries that hire them. These courses make us unique and viable in the marketplace. We learned that alignment already exists between our students' learning, curriculum design, and the career paths of our graduates. This survey gave us insight into how to enhance that alignment. Information gained from the survey will be used to improve the order in which we offer courses. This effort also gave us insight into how we can rearrange the material covered within our courses to update them. We know we will need to emphasize effective speaking and technical writing. We feel that by making the changes our customers have helped us determine are necessary, we will improve our overall operational effectiveness and preserve our programs essential and distinctive nature.

This was a very worthwhile activity! We encourage you to contact their customers in an organized fashion and listen to what they tell you. This effort provided the knowledge and insight we needed in order to evaluate our curricula, establish course direction, select and update appropriate coursework, implement changes in course sequencing, and link courses into related series of courses.

Figure 1: Existing Industrial Engineering Technology Curriculum.

BACHELOR OF SCIENCE WITH A MAJOR IN INDUSTRIAL ENGINEERING TECHNOLOGY (IET)

Dept.	No.	Course		1st Term	2nd Term
		First Year			
SET	100	Engineering Technology First-Year Seminar	1-0-1		
MTH	106	Mathematics for Engineering Technology	3-0-3		
MFG	108L	Manufacturing Processes Laboratory		0-3-1	
MCT	110L	Technical Drawing and CAD		0-6-2	
CHM	123	General Chemistry		3-3-4	
REL	103	Introduction to Religion		3-0-3	
SET	101	Enrichment Workshop		1-0-0	1-0-0
ENG	101-2	College Composition I, II		3-0-3	3-0-3
	Or 114 or 198				
MTH	207	Introduction to Statistics			3-0-3
SET	153L	Technical Computation			0-3-1
IET	230	Work Measurement			3-3-4
HST	101-2	History of Western Civilization			3-0-3
PHL	103	Introduction to Philosophy			3-0-3
				---	---
				17	17
		Sophomore Year			
MFG	206L	Dimensional Metrology		0-3-1	
IET	316	Quantitative Methods in IET		3-0-3	
PHY	201	General Physics		3-2-4	
MFG	204	Industrial Materials and Processes		3-3-4	
MTH	137-8	Calculus I with Review		4-0-4	4-0-4
MCT	220	Statics and Dynamics			3-0-3
IET	225	Elements of Cost Control			3-0-3
CMM	101	Fundamentals of Oral Communication			3-0-3
IET	318	Statistical Process Control			3-0-3
				---	---
				16	16
		Junior Year			
IET	308	Production Management Methods		3-0-3	
IET	317	Industrial Economic Analysis		3-0-3	
MCT	313	Industrial Mechanisms		3-0-3	
---	---	General Education Requirements		3-0-3	3-0-3
---	---	Technical Electives		3-0-3	3-0-3
IET	422	Human Factors			3-0-3
IET	315	Management of Projects and Technical Organizations			3-0-3
ECT	110	Electrical Circuits			3-0-3
SET	499	Seminar			1-0-1
				---	---
				15	16
		Senior Year			
ECT	361	Programming Structures		3-0-3	
IET	432	Facilities Layout		3-0-3	
		General Education Requirements		3-0-3	6-0-6
		Technical Electives		6-0-6	3-0-3
IET	418	Cost Estimating			3-0-3
IET	405	Labor Administration			3-0-3
IET	490	Senior Project			2-0-2
				---	---
				15	17

1 For example, 3-0-3 means 3 class hrs., and 3 sem. Hrs. of credit.
2 See General Education requirements, Chapter V. Some General Education courses are specified in the program (e.g., PHY 201); others are to be chosen from the listing of approved courses.

Figure 3: Proposed Industrial Engineering Technology Curriculum

BACHELOR OF SCIENCE WITH A MAJOR IN INDUSTRIAL ENGINEERING TECHNOLOGY (IET)

Dept.	No.	Course	1st Term	2nd Term
		First Year		
SET	100	Engineering Technology First-Year Seminar	1-0-1	
MTH	106	Mathematics for Engineering Technology	3-0-3	
MFG	108L	Manufacturing Processes Laboratory	0-3-1	
MCT	110L	Technical Drawing and CAD	0-6-2	
CHM	123	General Chemistry	3-3-4	
REL	103	Introduction to Religion	3-0-3	
SET	101	Enrichment Workshop	1-0-0	1-0-0
ENG	101-2	College Composition I, II	3-0-3	3-0-3
	Or 114 or 198			
MTH	207	Introduction to Statistics		3-0-3
SET	153L	Technical Computation		0-3-1
IET	230	Work Measurement		3-3-4
HST	101-2	History of Western Civilization		3-0-3
PHL	103	Introduction to Philosophy		3-0-3
			17	17
		Sophomore Year		
MFG	206L	Dimensional Metrology	0-3-1	
IET	318	Statistical Process Control	3-0-3	
PHY	201	General Physics	3-2-4	
MFG	204	Industrial Materials and Processes	3-3-4	
MTH	137-8	Calculus I with Review	4-0-4	4-0-4
MCT	220	Statics and Dynamics		3-0-3
IET	322	Human Factors		3-0-3
CMM	101	Fundamentals of Oral Communication		3-0-3
IET	323	Project Management		3-0-3
			16	16
		Junior Year		
IET	332	Facilities Layout	3-0-3	
IET	308	Production Management Methods	3-0-3	
IET	317	Industrial Economic Analysis	3-0-3	
MCT	313	Industrial Mechanisms	3-0-3	
---	---	General Education Requirements	3-0-3	3-0-3
---	---	Technical Elective		3-0-3
IET	418	Cost Estimating		3-0-3
IET	420	Industrial and Environmental Safety		3-0-3
ECT	361	Programming Structures		3-0-3
SET	499	Seminar		1-0-1
			15	16
		Senior Year		
IET	316	Quantitative Methods	3-0-3	
IET	415	Management of Technical Organizations	3-0-3	
		General Education Requirements	3-0-3	6-0-6
		Technical Electives	6-0-6	3-0-3
IET	425	Elements of Cost Control		3-0-3
ECT	110	Electrical Circuits		3-0-3
IET	490	Senior Project		2-0-2
			15	17

Figure 2: Sample Survey: Graduates in Industry

On the attached pages, you will find a list of the IET courses that we currently offer. Beneath each course title, the topics covered in each course are listed. **The goal of this survey is to determine which courses and topics are pertinent in today's and tomorrow's work world.** As you read the lists, please select the KEY topics and mark them using the following directions. *You do not have to mark each entry or course*.

1. On the list, **circle the title** if the IET courses or **the P** if the individual topics have enabled you to **perform** well at your job.
2. On the list, **circle the X** by the topics you **wish you had paid more attention to** when they were covered in class.
3. On the list, **circle the M** by the topics that were **missing** from your undergraduate curriculum that have prevented you from performing well in your career.
4. On the list, **place a V by the Course or circle the V by the IET topics** you perceived as **valuable while you were in school**.
5. Now that you are working, on the list, **place a W by the Course or circle the W** by the IET topics you **now perceive as valuable.**
6. If you feel the order in which the courses are offered should be changed, use **arrows** to show the changes.
7. **Draw a line** through the topics that are **obsolete**.
8. In the space provided at the end of each course topic list, please **add** any topics that you feel are missing from these lists.
9. List the software you use at work.
10. Which topics do you see as related in a work situation? For example: Cost estimating with economic analysis for project proposals.
11. Looking ahead in your career, what do you think you will need in order to remain successful in the IET field?

IET Courses

The attached pages contain lists of the contents of our IET courses. For each course, please read the lists and answer the questions in the space provided. While the courses are listed in the order in which they are offered during a students program, the lists of topics within a course are not in the order covered in class.

Elements of Cost Control; IET 225

Cost Analysis of labor, material, overhead	P	X	M	V	W
Bookkeeping	P	X	M	V	W
Transaction Analysis	P	X	M	V	W
Financial Statement Analysis	P	X	M	V	W
Managerial/Cost Accounting	P	X	M	V	W
Cost Classifications	P	X	M	V	W
Cost/Volume/Profit Analysis	P	X	M	V	W
Budgeting	P	X	M	V	W
Performance Reporting	P	X	M	V	W
Standard Costs	P	X	M	V	W
Variance Analysis	P	X	M	V	W
Capital Budgeting	P	X	M	V	W
Activity Based Costing	P	X	M	V	W
Financial Decision Making	P	X	M	V	W
Financial Statements (Balance Sheet/Income Statement)	P	X	M	V	W
Continuous Financial Improvement	P	X	M	V	W
Taxes	P	X	M	V	W

Work Measurements; IET 230

Principles of Motion Economy	P	X	M	V	W
Operation Analysis	P	X	M	V	W
Work Station Design	P	X	M	V	W
Time Standards For Mfg. Facilities	P	X	M	V	W
Time Standards For Government Facilities	P	X	M	V	W
Time Standards For Service Ind. Facilities	P	X	M	V	W
Developing Machine Requirements	P	X	M	V	W
Developing People Requirements	P	X	M	V	W
Workplace, Equipment, and Tool Design	P	X	M	V	W
Work Env. Design (lighting, heat, etc.)	P	X	M	V	W
Americans with Disabilities Act	P	X	M	V	W
Linking Machine/People Requirements to Product Costing	P	X	M	V	W
Pre-determined Time Standards Systems	P	X	M	V	W
Stop-watch Time Studies	P	X	M	V	W
Principles of Elemental Breakdown	P	X	M	V	W
Performance Rating, Leveling, Normalizing	P	X	M	V	W
Allowances	P	X	M	V	W
Standard Data	P	X	M	V	W
Work Sampling	P	X	M	V	W
Macro-motion Studies	P	X	M	V	W
Micro-motion Studies	P	X	M	V	W
Performance Control Systems	P	X	M	V	W
Direct versus Indirect Labor	P	X	M	V	W
Lean Manufacturing	P	X	M	V	W
Learning Curves	P	X	M	V	W
Problem-solving	P	X	M	V	W
Wage Payment	P	X	M	V	W
Training	P	X	M	V	W
Productivity Improvement	P	X	M	V	W
Motivation	P	X	M	V	W

Production Management Methods; IET 308

Just-in-Time	P	X	M	V	W
Inventory Control (EOQ, ROP, etc.)	P	X	M	V	W
Manufacturing Organizations	P	X	M	V	W
Manufacturing Planning and Control	P	X	M	V	W
Materials Requirements Planning	P	X	M	V	W
Kanban	P	X	M	V	W
Managing the Supply Chain	P	X	M	V	W
Push versus Pull Systems	P	X	M	V	W
Shop Floor Control	P	X	M	V	W
Capacity Planning/Management	P	X	M	V	W
Inventory Management	P	X	M	V	W
Safety Stocks	P	X	M	V	W
Lead Times	P	X	M	V	W
Lean Manufacturing	P	X	M	V	W
Processing Times	P	X	M	V	W
Activity Based Costing	P	X	M	V	W
Bottlenecks	P	X	M	V	W
Production Scheduling	P	X	M	V	W
Etc.					

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