AC 2009-13: BENCHMARKING TWO URBAN MET BACHELOR PROGRAMS

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Benchmarking Two Urban MET BS Programs

Abstract

Since the change to outcomes based accreditation in 2000, most engineering technology programs have adapted to the change and have implemented program outcomes and the accompanying assessment and evaluation techniques. TC2K created significant change in the engineering technology world, change that still has lasting effects eight years later. While the change to outcomes based assessment has not always been welcome, adapting to the change has caused many programs to become increasingly aware of what similar programs are doing in other parts of the country or even other parts of the world. A part of all strategic planning includes comparing oneself to one's competitors. In the educational world, we are not necessarily so concerned with competition but with improving and serving students. Hence, institutions frequently collaborate, so the term benchmarking is used for the initial comparison between programs. This paper benchmarks two urban Mechanical Engineering Technology programs and compares their background, objectives and outcomes, curriculum, and laboratories. It is hoped that this benchmark will encourage other programs to perform similar comparisons in an effort to improve and serve students.

I. Introduction

The Mechanical Engineering Technology programs at Youngstown State University[1], Youngstown, Ohio (YSU) and Purdue University Calumet[2] in Hammond, IN (PUC) share many similarities. Both institutions primarily serve regional, urban populations. Both programs have a long history of ABET accreditation dating back to the 1960s. Both programs have undergone recent ABET evaluations based on TC2K Criterion[3].

There are differences as well. PUC has four full time, tenured faculty all at the full professor level while YSU has two assistant professors. PUC has approximately 130 MET majors while YSU has approximately 80. Also, while both programs serve urban areas, their focus has been different. YSU has long served the automotive and steel industries as its primary constituency while PUC has served the steel industry. Both automotive and steel industries have experienced difficulties, and both MET programs are placing graduates in more diverse areas with success.

II. MET Program Objectives

As part of the outcomes based assessment process, both programs developed program objectives independently. We define program objective to be the skills students possess after graduation as they enter the workforce. Table 1 below compares both programs.

Table 1 – Program Objectives

YSU	PUC
Graduates of the MET program at YSU will, in their first several years of employment, have the ability to: 1. Work competently in technical and professional careers related to the field of Mechanical Engineering Technology 2. Communicate effectively in a professional environment 3. Continue growth in professional knowledge 4. Achieve recognition and/or compensation consistent with their educational achievements. In addition, for two year graduates, 'they immediately become productive in careers involving design, drafting, testing, and production of industrial machines and consumer products.' for Bachelor Degree graduates, 'they are prepared for more responsibility and more rapid advancement. Application-oriented courses… prepare them for more advanced design work, while courses dealing with manufacturing systems analysis, quality control, and industrial management prepare them for supervisory positions.	The Mechanical Engineering Technology Associate of Science program will produce graduates that: 1. Are prepared for successful careers in the areas associated with the fabrication, testing, documentation, operation, sales, and maintenance of basic mechanical systems. 2. Advance in their careers and continue their professional development. 3. Understand the overall human context in which engineering technology activities take place. In addition to the three objectives listed above for the Associate of Science degree, the Mechanical Engineering Technology Bachelor of Science program will produce graduates that: 4. Are prepared for successful careers in the areas associated with the analysis, applied design, development, implementation, and oversight of more advanced mechanical systems and processes.

While YSU lists one set of objectives, PUC separates out specific technical objectives between the AS and BS programs. Taken as a whole, the two sets of objectives are reasonably consistent. YSU specifically calls out communication objectives while PUC emphasizes human context. Both sets of objectives emphasize the importance of successful careers and future growth.

III. Program Outcomes

Again, both programs developed MET Program Outcomes independently. Here, we define a program outcome as a skill the students possess at the conclusion of program. Table 2 compares the outcomes from each program.

Table 2 – Program Outcomes

YSU	PUC
1. be able to apply principles of mathematics and applied science, to perform technical calculations and solve technical problems of the types commonly encountered in mechanical engineering technology careers. (consistent with TAC/ABET Criterion 2 Outcomes a, b, f);	1.1. Students will demonstrate proficiency in mechanical design, materials, manufacturing processes, mechanics, and fluid power. (a, b, c, d, f)*
	1.2. Students will demonstrate proficiency in applied mathematics and science. (b, c, f)*
	1.3. Students will demonstrate proficiency in computer applications. (a, d, g)*
2. demonstrate the ability to identify, formulate, and present creative solutions to technical problems in a variety of specialty areas within the broad field of mechanical engineering technology. (consistent with TAC/ABET Criterion 2 Outcome d);	1.4. Students will demonstrate proficiency in solving open-ended problems requiring multiple areas of knowledge. (a, b, c, d, f)*
	2.1. Students will demonstrate a level of effectiveness expected by employers when they produce written documents, deliver oral presentations, and develop, prepare and interpret visual information. (a, g, i)
3. be able to function competently in a laboratory setting, making measurements, operating technical equipment, critically examining experimental results, and properly reporting on experimental results, including their potential for process improvement. (consistent with TAC/ABET Criterion 2 Outcomes a, b, c, f, g);	2.2. Students will be exposed to the value of professional societies in their careers. (h)
	2.3. Students will demonstrate proficiency in managing projects. (e, f, g, i, j)
	2.4. Students will understand the advantages of self-learning. (h, k)
4. be able to use modern computational tools for technical problem solving, including scientific calculators, computers and appropriate software. (consistent with TAC/ABET Criterion 2 Outcomes a, b, f);	3.1. Students will have exposure to situations that develop a sense of personal responsibility and accountability for one's individual actions and performance. (i, k)
5. demonstrate a broad education and knowledge of contemporary issues in a global and societal context, as necessary to develop professional and ethical responsibility, including responsibility to employers and to society at large. (consistent with TAC/ABET Criterion 2 Outcomes i, j);	3.2. Students will have exposure to situations that develop their philosophy and appreciation for human differences. (i, j)
	3.3. Students will be able to demonstrate the ability to communicate in individual and team settings. (e, g)
	3.4. Students will demonstrate proficiency in assisting others in a group. (e, g)
6. recognize the need for life-long learning, especially concerning maintenance and improvement of technical skills (consistent with TAC/ABET Criterion 2 Outcome h); &	4.1. Students will demonstrate proficiency in mechanical design, materials, manufacturing processes, mechanics, fluid dynamics, and heat and power.(a,

7. demonstrate an ability to communicate effectively and function effectively with members of multi-disciplinary teams and with other workers in an industrial setting, including those from a variety of backgrounds. (consistent with TAC/ABET Criterion 2 Outcomes e, g, j). Program outcomes for the Associate's and Bachelor's Degrees differ only in that the Bachelor's Degree has expectations of greater extent of achievement	b, c, d, f)* 4.2. Students will demonstrate proficiency in applied mathematics and science.(b, c, f)* 4.3. Students will demonstrate proficiency in computer applications.(a, d, g)* 4.4. Students will demonstrate proficiency in solving open-ended problems requiring multiple areas of knowledge.(a, b, c, d, f)* * Level 1 outcomes for AS program, Level 4 for BS program.

Since both sets of outcomes are based on the TAC of ABET a-k criterion, one would expect the similarities obvious from Table 2. The only noticeable difference is the PUC outcome 3.4, students will demonstrate proficiency in assisting others in a group. In addition, PUC details out the outcomes in somewhat more detail.

IV. Curriculum

The following Tables 3 and 4 list the YSU curriculum in semester by semester format, and the courses are placed in the appropriate category as described by ABET Criterion 4. Tables 5 and 6 list the same for PUC.

Table 3 – YSU AS Curriculum

Year and Semester (typical offering)	Table 1A Curriculum Associate Degree Courses (Department, Number, Title)	Category (Credit Hours				
		Communications	Mathematics	Physical & Natural Sciences	Social Sciences & Humanities	Technical Content
1st, Fall	STECH 1505 Intro. to Engr. Tech.					3
1st, Fall	MATH 1513 Alg./Trans. Functions		5			
1st, Fall	DDT 1505 CAD Technology					4
1st, Fall	ENGL 1551 Writing 1	3				
1st, Fall	GER elective: Pers./Soc. Responsibility				3	
1st, Spring	MET 1515 Mechanics 1					3
1st, Spring	CCET 2604 Prop./Strength of Mat'ls					3
1st, Spring	CCET 2614 Materials Lab					1
1st, Spring	PHYS 1501 Fund's of Physics 1			4		
1st, Spring	PHYS 1501L Fund's of Phys 1 Lab			1		
1st, Spring	ENGL 1551 Writing 2	3				
2nd, Fall	MATH 1570 Applied Calculus 1		4			
2nd, Fall	PHYS 1502 Fund's of Physics 2			3		
2nd, Fall	PHYS 1502L Fund's of Physics 2 Lab			1		
2nd, Fall	MET 3714 Fluid Mechanics					2
2nd, Fall	MET 3714L Fluids Mechanics Lab					1
2nd, Fall	MET 2616 Mechanics 2					3
2nd, Fall	MET 3706 Machine Design 1					3
2nd, Spring	MET 3705 Thermodynamics					3
2nd, Spring	MET 2630 Manufacturing Techniques					2
2nd, Spring	MET 2630L Manufacturing Techniques Lab					1
2nd, Spring	MET 3707 Machine Design 2					3
2nd, Spring	DDT 2606 CAD Technology 2					4
2nd, Spring	COMST 1545 Communication Theory & Practice	3				
2nd, Spring	GER Elective: Societies & Institutions				3	
TOTALS for ASSOCIATE'S DEGREE		9	9	9	6	36
PERCENT OF TOTAL		13.0	13.0	13.0	8.7	52.2

Table 4 – YSU BS Curriculum

Year and Semester (typical offering)	Table 1B Curriculum Bachelor's Degree Courses (Department, Number, Title)	Category (Credit Hours				
		Communications	Mathematics	Physical & Natural Sciences	Social Sciences & Humanities	Technical Content
3rd, Fall	MATH 2670 Applied Calculus 2		5			
3rd, Fall	EET 3725 Electromechanical Systems					4
3rd, Fall	MET 3711 Heat & Power Cycles					3
3rd, Fall	ISEGR/MGT Elective					3
3rd, Fall	MET Elective					3
3rd, Spring	MET 3700 Physical Measurements					3
3rd, Spring	MET 3715 Fluid Power					3
3rd, Spring	MET 3720 Mechanisms					3
3rd, Spring	CCET 3705 Computing for Technologists					3
3rd, Spring	GER Elective: Personal & Social Responsibility				3	
4th, Fall	MET 4820 Machine Systems					3
4th, Fall	MET 4810 Manufacturing Systems Analysis					3
4th, Fall	MET Elective					3
4th, Fall	CHEM Elective			3		
4th, Fall	CHEM Elective, matching lab			1		
4th, Fall	GER Elective: Societies & Institutions				3	
4th, Spring	MET 4870 Applied Finite Element Method					3
4th, Spring	MET 4860 Robotics Technology					2
4th, Spring	MET 4860L Robotics Technology Lab					1
4th, Spring	GER Elective: Artistic & Literary Perspectives				3	
4th, Spring	GER Elective: Artistic & Literary Perspectives				3	
4th, Spring	GER Elective: Artistic & Literary Perspectives *or* Societies & Institutions				3	
TOTAL FOR BACHELOR'S DEGREE (includes AAS credits)		9	14	13	21	76
PERCENT OF TOTAL		6.8	10.5	9.8	15.8	57.1

Table 5 - PUC AS MET Curriculum

Year and Semester (or Quarter)	Course (Department, Number, Title)	Category (Credit Hours)				
		Communications	Mathematics	Physical & Natural Sciences	Social Sciences & Humanities	Technical Content
1, fall	MA-147 Algebra & Trig for Tech I		3			
1, fall	ENGL-104 English Composition	3				
1, fall	MET-161 Intro to Engineering Technology					3
1, fall	CGT-110 Technical Graphics Communication					3
1, fall	MET-242 Manufacturing Processes II					3
1, spring	MA148 Algebra & Trig for Tech II		3			
1, spring	MET-118 Statics					3
1, spring	MET-141 Manufacturing Materials I					3
1, spring	ENGL-220 Technical Report Writing	3				
1, spring	MET-162 Comp. Analysis Tools in MET					1
1, spring	COM-114 Fund/Speech Comm.	3				
2, fall	MA-221 Calculus for Technology I		4			
2, fall	MET-211 Applied Strength of Materials					3
2, fall	PHYS-220 General Physics I			4		
2, fall	MET-205 Production Design & CAD II					3
2, fall	MET-213 Dynamics					3
2, spring	PHYS-221 General Physics II			4		
2, spring	MET-230 Fluid Power					3
2, spring	POL-305 Technology & Society				3	
2, spring	MET-214 Machine Elements					3
2, spring	MET-266 Strength of Materials/Testing Laboratory					3
TOTALS REQUIRED FOR DEGREE		9	10	8	3	34
PERCENT OF TOTAL		14	15	13	5	53

Table 6 – PUC BS MET Curriculum

Year and Semester (or Quarter)	Course (Department, Number, Title)	Category (Credit Hours)				
		Communications	Mathematics	Physical & Natural Sciences	Social Sciences & Humanities	Technical Content
3, fall	MET Elective					3
3, fall	STAT-301 Elementary Statistical Methods		3			
3, fall	Free Elective					
3, fall	MET-325 Applied Thermodynamics I					3
3, fall	Technical Elective					3
3, fall	MA-222 Calculus for Technology II		3			
3, spring	ECET-214 Electricity Fundamentals					3
3, spring	MET-313 Applied Fluid Mechanics					3
3, spring	CHEM-111 General Chemistry			3		
3, spring	IET-22 Production Planning & Control					3
3, spring	MET-329 Applied Heat Transfer					3
4, fall	IET-308 Engineering Project Management and Economic Analysis					3
4, fall	MET-461 Computer Integrated Design & Manufacturing					3
4, fall	ENGL-420 Business Writing	3				
4, fall	OLS-331 Occupational Safety & Health					3
4, fall	MET-495 Senior Project Survey					1
4, fall	General Education Elective				3	
4, spring	Technical Elective					3
4, spring	OLS-474 Conference Leadership Training	3				
4, spring	MET Elective					3
4, spring	MET-497 Senior Project					3
4, spring	General Education Elective				3	
TOTALS REQUIRED FOR DEGREE		15	16	11	9	74
PERCENT OF TOTAL		12	12	9	7	58

At the AS level, the most noticeable difference is that YSU has 69 credit hours while PUC has only 64. YSU has one more 3 credit hour general education course and an additional machine design course that PUC does not include. Interestingly, YSU offers thermodynamics as a second semester sophomore course while PUC offers a separate materials course. The percentage break down in the communications, mathematics, science, general education, and technical areas are very similar except for YSU's additional general education percentage.

YSU is currently assessing the current its general education policy. There is concern that the current policy is not achieving the original objectives that were set out when the policy was implemented. As the assessment is on-going, it is too soon to report on what action will be taken. The Engineering Technology program is supporting a general education percentage more in line with PUC's. This position is based on input from the MET Industrial Advisory Board (IAB), surveys of alumni working in the discipline, comparisons to similar programs elsewhere and evaluations of required course material content required to meet program objectives and outcomes. The trend seems to indicate that graduates need to be more technically versed to keep their employers competitive. While communication skills are still considered very valuable, there is mounting evidence supporting a reduction in the quantity of general education and an increase in discipline related classes.

At the BS level, YSU requires 133 credit hours while PUC requires 125. PUC requires 15 credit hours of communications while YSU requires 9. Math, science, and technical areas agree within a few credit hours. Most of YSU's additional hours are in social sciences/humanities with 21 hours required while PUC requires 9. In the technical areas, YSU shows a greater concentration in the area of automation while PUC emphasizes project management, OSHA, and technical electives. Perhaps the largest area of difference is the capstone project. PUC uses a four credit hour two course sequence where the students propose and then complete an open ended project. YSU uses the MET 4860 course as the capstone with an open ended project as part of the course material.

PUC's capstone class is similar to a program that is being initiated at YSU. Both involve proposing then solving an open-ended problem. YSU differs in that a priority has been put on fostering innovation, creativity and collaboration with diverse groups earlier in the students' career. The plan is to team MET students with students from Fine and Performing Arts (FPA) in an environment where an open-ended problem can be worked using the strengths from both schools. MET students get exposure to loosely defined problems with many possible workable solutions, gaining experience in synthesis in addition to traditional analysis based work. Communication and diversity of perspective also play out naturally while giving FPA students a hands-on introduction to the engineering technology field. Pilot projects have shown a marked increase in MET students' performance with minimal cost to the department.

It is notable that both programs seem to value open-ended problems, communications and collaboration. While the approach is somewhat different, it seems that the goals are similar. YSU's proposed pedagogical method may be an incremental improvement over PUC's, but this still needs to be assessed with more data. These pedagogical methods seem to be consistent with other similar programs currently showing merit such as:

- AME Center – Arizona State University; Arts, Media and Engineering
    - Team-based research
    - Diverse expertise covering the full scope of the human experience
    - Interdisciplinary, multi-instructor courses
    - Emphasis on collective excellence
- The Keller Center – Princeton; Entrepreneurship, Leadership
    - Gain exposure to real-world engineering problems
    - Be able to solve problems from an interdisciplinary perspective

    - Understand technology in its societal context
- Converging Technologies – Union College; Engineering & Liberal Arts
    - focuses creative thought from engineering and the liberal arts on new ideas

IV. Textbooks

The textbooks used by both programs are comparable and at the same academic level. Select representative books are listed below for comparison.

Manufacturing Technology - Sophomore
PUC – Manufacturing Engineering and Technology 5th ed., Kalpakjian
Engineering Level
YSU – Materials & Processes in Manufacturing 10th ed., DeGarmo
Engineering Level

Machine Design/Analysis - Sophomore
PUC & YSU – Machine Elements in Mechanical Design 4th ed., Mott
Technologist Level – no calculus

Fluid Mechanics – Sophomore & Junior
PUC & YSU – Applied Fluid Mechanics 6th ed., Mott
Technologist Level – no calculus

The book selection shows no significant difference between the two programs. The books seem to be of similar level with equal levels of mathematical requirements. It should be noted that the math requirements of both programs are the same with equal classes in algebra and calculus even though these texts are outside the scope of this comparison.

V. Laboratory Development Efforts

As technology programs, both YSU and PUC have large dedicated laboratories so students get practical, hands on experience as part of their education. Tables 7 and 8 list the laboratories for the two programs.

Table 7 – YSU Laboratories

Laboratory	Building	Room	Area (Sq. Ft.)
Mechanical Lab	Moser Hall	4190	1120
Mechanical Lab	Moser Hall	4160	550
Fluids Lab	Moser Hall	0325	4900
ET Computer Lab	Moser Hall	4050	550
Civil Tech. Lab	Moser Hall	4180	1150
Strength Lab	Moser Hall	0400	3675
Machine Shop	Moser Hall	0050	1876
Robotics Lab	Moser Hall	0060	1400
CAD Drawing/PC Lab	Moser Hall	4200	1150

Table 8 – PUC Laboratories

Laboratory	Building	Room	Area (Sq. Ft.)
Manufacturing Lab	Anderson	140	4000
Quality Control	Anderson	145	
Materials Testing	Anderson	149	
CAD	Anderson	216	
Fluid Power	Anderson	217	
CAD	Anderson	220	
Integrated Design	Anderson	229	
Industrial Engineering Technology	Anderson	244	

VI. Faculty

The previous comparison of the capstone classes highlights an important difference in the circumstances that each department is in. The YSU MET program has 62% the enrollment that PUC has while PUC has twice the number of full-time tenured faculty. Both of YSU's full-time faculty are recently hired pre-tenure. This seems to have resulted in a lag between YSU and PUC regarding the implementation of updated pedagogical techniques. YSU experienced a turnover in faculty in Fall 2006 where both MET full-time faculty members left and two new junior faculty members were brought in. Coming from industry, the traditions and unique idiosyncrasies of academia needed to be learned before curricular progress could be made. Comparisons such as this one involving assistance from other programs and faculty has proved to be a significant help in adapting to the academic environment in addition to providing invaluable insight to class improvements. Key to these improvements was leveraging recent industry experience and bringing it into the classroom.

VII. Assessment

Assessment of the two programs follows similar lines. Since both are ABET accredited, assessment criteria are the same. Within the ABET assessment framework, there are some differences in the programs that come from the geographical and economic regions each program serves. These regions' needs are largely determined by regular meetings of the respective Industrial Advisory Boards (IAB) as required by ABET. Since these boards are comprised of members of local industry representatives, the specific concerns between the two programs vary. The variation shows that the IAB has value in communicating societies' needs to the program.

Both programs convene IAB meetings at least once a year. Participants are selected from local industry. Participants whose academic background is from a different university is valued so that ideological inbreeding can be avoided. Also, those that have recently and/or regularly hire graduates from each program provide current insight into successes or failures of new pedagogy as it relates to them. Complaints are discussed with possible solutions and successes are analyzed for application to other issues. Program coordinators collect the data and, with other faculty, determine a course of action to address issues and concerns. The internal assessment data that each faculty member records during the year is also incorporated into the process. When

significant changes are proposed, the IAB may be reconvened to review the changes and offer suggestions.

VIII. Conclusion

The MET programs at Youngstown State University and Purdue University Calumet show remarkable similarities as one might expect from two ABET accredited programs. The primary differences are YSU's additional credit hours, primarily from general education requirements. The technical areas are very similar with YSU concentrating on machine design and automation while PUC moves more into project management and related areas. As part of this benchmarking activity, PUC is looking to see if more technical content similar to YSU's automation area might be appropriate. YSU is considering a more formal senior project as PUC has. All of this comes from continuous improvement, and benchmarking is just one step in the process.

Bibliography

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