An Innovative Mechanical Engineering Technology Pathway Aligned with Industry Needs

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Abstract

As institutions of higher education strive to maintain effective and affordable educational pathways, innovative partnerships between associate and baccalaureate degree granting institutions can facilitate a student's progress while maintaining close alignment with industry needs. This paper details the continuing efforts of a multi-year project between a two-year college, a university and industry that has resulted in the creation of well-aligned associate and baccalaureate degrees in mechanical engineering technology. These offerings represent new degrees for both institutions, as well as an entirely new department of engineering technology for the university that complements its already existing engineering programs. Both degrees are based on a strong alignment with industry-defined requirements that have been identified through on-site forums and engagement with a robust industrial advisory board. The degrees emphasize technical and non-technical skills and competencies crucial to the practice of advanced manufacturing disciplines by mechanical engineering technologists. The delivery of the requisite content will be reinforced by the use of an applications database that will directly link course contents with industry practice in a clear and effective manner. Additionally, the outlined associate to baccalaureate degree pathway will be delivered through an innovative "3+1" model in which the two-year college will deliver the first three years of the program, and the university will then deliver the final year, on the two-year college's campus. This novel and innovative model will allow students to achieve a high-quality associate and baccalaureate degree in mechanical engineering technology for close to the cost of a single year at some institutions. Rigorous assessment methodologies have been included in both programs and will ensure the consistency of performance measures longitudinally between both institutions.

Background

In an effort to offer high quality and affordable educational pathways to students, Rowan College at Burlington County (RCBC) and Rowan University (RU) have partnered to offer engineering technology degrees supporting Advanced Manufacturing competencies. These efforts have stemmed from a National Science Foundation-funded project addressing the needs of the regional advanced manufacturing industries and began with an inventory of both non-technical and technical skills required by graduates (NSF Award 1601487). The focus on Advanced Manufacturing led to the development of a Mechanical Engineering Technology (MET) pathway from Associate degree to Baccalaureate degree, along with the creation and strengthening of an analogous Electrical Engineering Technology (EET) pathway. These academic disciplines and

educational pathways are expected to provide meaningful career opportunities for graduates as the US Department of Labor, Bureau of Labor Statistics (BLS) indicates a positive job outlook for MET careers that is expected to grow approximately 5% for the ten-year period 2016-2026 (1), while the outlook for EET careers is anticipated to grow 2% for the same period (2).

The new degree pathways are structured in a "3+1" format, where RCBC will deliver the first three years of the program, after which students will transfer to RU as seniors, and complete the fourth year on RCBC's campus at a discounted tuition rate. This innovative delivery model is supported by the recommendations of the New Jersey College Affordability Study Commission (3) in which the creation of "3+1" degree programs was identified as an opportunity to make college more affordable.

Innovative "3+1" Model

There are several key elements of the "3+1" delivery model, for both the associate degree and the baccalaureate degree-granting institutions, that must be firmly developed and followed to ensure the intended benefit to students.

Associate Degree-Granting Institution

For the associate degree-granting institution, the key elements include the sharing of course syllabi and outcomes, the demonstrated ability to provide high quality academic instruction that is aligned with rigorous academic outcomes, and the presence of highly qualified, well-trained, and passionate faculty members.

The associate degree-granting institution must have processes in place to create direct analogs of any needed junior-level courses and must have effective outcomes assessment processes as well. The close monitoring of the achievement of learning outcomes will ensure the intended purpose of the "3+1" pathway is achieved. The assessments must include the same activities and criteria for success as at the baccalaureate degree-granting institution, including pre-assessments in some courses, as well as the same benchmarks, measurement methodology, and targeted learning outcomes. A close relationship between both institution's assessment offices must be developed.

Finally, in order to receive Federal financial aid, students must pursue coursework applicable to a degree program in which they are matriculated. Therefore, in order to earn up to 90 credits to transfer to the baccalaureate degree-granting institution, students must maintain aid eligibility and matriculation status beyond the initial 60 credits for an associate degree. One manner in which this can be accomplished is through the pursuit of a second aligned associate degree, in which there is no duplication of credits and allows students to progress to the 90 credits needed for transfer to the baccalaureate degree-granting institution as a senior.

Baccalaureate Degree-Granting Institution

For the baccalaureate degree-granting institution, a close alignment with the associate degree-granting institution courses and outcomes must be developed. Additionally, the institution must share the content and the learning outcomes for any needed courses, ensuring that the learning outcomes will be the same between both institutions.

Additionally, the baccalaureate degree-granting institution must be willing to share the credentials required for faculty, and have the ability to review and comment on the curricula vitae of those being considered to teach the third year of the curriculum.

The baccalaureate degree-granting institution will be solely responsible for delivering the senior year courses and will have an opportunity to evaluate the student's candidacy for transition to the baccalaureate portion of the pathway. The baccalaureate degrees coming from this program will be awarded solely by the baccalaureate degree-granting institution.

Overall, this innovative "3+1" delivery model will provide access to both affordable and high-quality educational pathways, leading to both associate and baccalaureate degrees, in academic disciplines that are in high demand and will provide employment opportunities for graduates.

The Needs of Industry

In order to maintain a strong focus on industry needs, both RCBC and RU have engaged industry partners in skills inventory activities that have identified the most important non-technical and technical skills. These identified skills were then used as the basis for the new degree programs, with appropriate competencies strongly linked to the course and program outcomes.

This important information was gathered through activities such as a technology conference in which 59 participants, including academic and industry partners, discussed the critical skills and competencies that are needed in industry and should be reflected in the new MET curriculum. Additionally, the Principal Investigator and Co-Principal Investigator have visited several industry partner sites to discuss the goals of the grant and to solicit input to the project.

Additionally, the creation of a robust industrial advisory committee in support of the new programs has had a far-reaching impact which includes support for RCBC's STEM division in a variety of ways, and the inclusion of networking and cybersecurity as a program of interest to industry partners.

The industrial advisory committee is also providing critical input to the development of another goal of the current project, i.e. the development of an applications database. The applications database will highlight the practical applications of important scientific and technical principles including vacuum and the Ideal Gas Law, optics and Snell's Law, Young's Modulus, applied

mathematics and physics, CNC programming, communication in the workplace, and workplace ethics, for example.

Engineering Technology Curriculum

The goal of RCBC's Engineering Technology pathway is to produce graduates who are able to obtain employment as a technologist or transfer to a four-year college. In addition, graduates will be technically competent, able to communicate effectively, work well with others and demonstrate professionalism. Additionally, students will understand how products and machinery work on a detailed level.

In considering the entire "3+1" pathway from associate degree to baccalaureate degree, both levels of ABET-ETAC outcomes and curricular topics have been considered in creating the new MET curriculum (4) in anticipation of seeking ABET accreditation.

MET Associate Degree

According to ABET-ETAC requirements, the following student outcomes and curricular topics are required in an associate degree:

Student Outcomes

(1) an ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve well-defined engineering problems appropriate to the discipline
(2) an ability to design solutions for well-defined technical problems and assist with the engineering design of systems, components, or processes appropriate to the discipline
(3) an ability to apply written, oral, and graphical communication in well-defined technical and non-technical environments; and an ability to identify and use appropriate technical literature
(4) an ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results
(5) an ability to function effectively as a member of a technical team.

Curricular Topics

(a) a minimum of three subject areas chosen from: engineering materials, applied structures, applied mechanics, applied aerodynamics, applied propulsion, and fundamentals of electricity
(b) assembly and support processes, industry standards, regulations and documentation, and computer-aided engineering graphics with added technical depth in at least one of these areas

(c) applied physics having an emphasis in applied mechanics and other technical topics in physics appropriate to the program objectives

MET Baccalaureate Degree

According to ABET-ETAC requirements, the following student outcomes and curricular topics are required in a baccalaureate degree:

Student Outcomes

(1) an ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems appropriate to the discipline
(2) an ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline
(3) an ability to apply written, oral, and graphical communication in broadly defined technical and non-technical environments; and an ability to identify and use appropriate technical literature
(4) an ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes
(5) an ability to function effectively as a member as well as a leader on technical teams

Curricular Topics

(a) engineering materials, statics, strength of materials, applied aerodynamics, applied propulsion, and either electrical power or electronics
(b) added depth in a minimum of three subject areas chosen from: manufacturing processes, vehicle design and modification, engineering materials, electromechanical devices and controls, industrial operations, and systems engineering including the appreciation of the engineering design cycle and the system life cycle relating to the manufacture and maintenance of aeronautical/aerospace vehicles and their components
(c) applied physics having an emphasis in applied mechanics, plus added technical topics in physics and other science principles appropriate to the program objectives

Table I. outlines the four-year MET degree pathway within the "3+1" framework, with years 1-3 delivered by RCBC and year 4 delivered by RU.

Table I. Four-Year MET Degree Pathway within the "3+1" Framework

Mechanical Engineering Technology			
	As of 4/15/19		
FIRST YEAR- RCBC			
FALL	**CR**	**SPRING**	**CR**
Freshman Engineering Clinic I **EGR 151**	2	Freshman Engineering Clinic II **EGR 152**	2
Precalculus (Inc. Trig, LA) **MTH 130**	4	Calculus I & Analytical Geometry **MTH 118**	4
General Chemistry I w/Lab **CHE 115/116**	4	Humanistic Lit: Society, Ethics & Technology **SOC 160**	3
College Comp I **ENG 101**	3	Intro to Mechanical Design **MET 220**	3
Introduction to Computer Science **CSE 110(*)**	4	Artistic Literacy: **ART/MUS/THR 101**	3
**Must be C++ or Java Based*			
TOTAL	**17**	**TOTAL**	**15**
SECOND YEAR-RCBC			
FALL	**CR**	**SPRING**	**CR**
Sophomore Engineering Clinic I **EGR 251**	1	Sophomore Engineering Clinic II **EGR 252**	1
College Comp. II or Tech. Writing **ENG 102/105**	3	Public Speaking **SPE 102**	3
General Physics I w/Lab **PHY 210/211**	4	Mat Sci and Manufacturing **MET 235**	3
Engineering Statics **EGR 201**	3	Free Elective	3
CNC Programming I **MET 210**	4	Applied Thermal Energy I **MET 215**	3
TOTAL	**15**	**TOTAL**	**13**
	2 year AAS degree program total credits	60	
THIRD YEAR-RCBC			
FALL	**CR**	**SPRING**	**CR**
Junior Tech. Clinic I - **EGR 351**	2	Junior Tech. Clinic II - **EGR 352**	2
General Physics II with lab **PHY 212/213**	4	Applied Thermal Energy II **MET 301**	3
Calculus II and Analytic Geometry **MTH 119**	4	Applied Fluid Mechanics **MET 311**	3
Engineering Dynamics **EGR 202**	3	Machine Design **MET 312**	3
MET Lab I **(NEW) MET 3XX**	3	Principles of Microeconomics **ECO 203**	3
TOTAL	**16**	**TOTAL**	**14**
FOURTH YEAR- Rowan University			
FALL	**SH**	**SPRING**	**SH**
Senior Tech. Clinic I / Senior Design I **EGR 451**	2	Senior Tech. Clinic / Senior Design II **EGR 452**	2
Advanced Manufacturing **MET 400**	3	Global Literacy Elective **GENED**	3
Applied Heat Transfer **MET 312**	3	Fundamentals of Circuits & Electronics **EET 2XX**	3
CNC Programming II **MET 351**	2	Quality & Reliability **MET 342**	3
MET Elective II **MET 4XX**	3	MET Elective III **MET 4XX**	3
Literature/Core Elective **GENED**	3		
TOTAL	**16**	**TOTAL**	**14**
Total program credits/semester hours:	**120**		

Next Steps

With the MET curriculum fully developed, the focus of the project will now turn towards the final development of the Applications Database. The database will serve as a resource for faculty

to illustrate real-world examples of the applications of scientific and technical principles contained within the curriculum.

With relevant input from industrial advisory committee members, the development of several meaningful applications of scientific and technical principles have been framed according to the designed format and will:

1) Have readily identifiable significance
2) Be summarized and communicated effectively
3) Have significance to an emerging student
4) Follow a sound pedagogical approach

Fully developed and available applications will be widely disseminated through a web page that will be created for this purpose.

Summary

The current project describes an innovative approach to creating and delivering a MET program that is comprised of meaningful technical competencies and an affordable and accessible educational pathway. This unique pathway involves a "3+1" linkage between an associate degree-granting institution (RCBC) and a baccalaureate degree-granting institution (RU) in which the first three years are delivered by RCBC, and the fourth year is delivered by RU, on RCBC's campus.

The new program was created with significant industrial partner input and is aligned with the ABET-ETAC criteria for MET programs. Both non-technical and technical competencies, as are important in industry, are a focus of the program.

Finally, the interest and excitement focused on the new engineering technology program has had a positive impact on the STEM division and RCBC overall, through collaboration between faculty and staff, as well as through an increased focus on the importance of technical and non-technical skills.

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(4) ABET Engineering Technology Accreditation Commission, Criteria for Accrediting Engineering Technology Programs, 2018-2019.