Implementation of a Bachelor of Science in Mechatronics Engineering Technology Program

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Abstract

The purpose of this paper is to provide an account of a project to develop and implement a multidisciplinary B.S. in Mechatronics Engineering Technology curriculum based on the needs of industry in Northern Kentucky / Southern Ohio regional areas. The main source of information for the assessment of region's industry needs for mechatronics professionals was a need assessment survey conducted by CSTCC and NKU, with the support of the Advantage Kentucky Alliance.
This paper will discuss in details steps taken to initiate the Mechatronics degree at NKU. We will layout the courses in the curriculum and explain what courses will be selected among existing courses in the associate degree programs at Cincinnati State Technical and Community College (CSTCC) and courses in the Engineering Technology bachelor degree programs at Northern Kentucky University (NKU). The paper will provide details of the curriculum updates and explain how these courses will provide students with hands-on experience in mechatronics fields such as: industrial controls & manufacturing systems design, integration, and evaluation in view of environmental and safety concerns. Addition of new courses will be considered based on educational and/or industry needs. A pathway to B.S. degree completion for graduates from CSTCC is also envisioned, in the form a transfer agreement.

Introduction

Founded in 1968, Northern Kentucky University (NKU) is a metropolitan university with approximately 16,000 students, located in Highland Heights, KY, in the greater Cincinnati area. NKU currently offers Bachelors of Science degrees in Engineering Technology (Electronics - EET and Mechanical and Manufacturing - MMET), with the support of local industry, who provide most of the students with Co-op opportunities. The MMET and the EET are long-standing programs at NKU. These programs have catered the manufacturing industry in Northern Kentucky / Southern Ohio areas for more than two decades.
Cincinnati State Technical and Community College (CSTCC) is a technical and community college located in Cincinnati, Ohio; it was chartered by the Ohio Board of Regents in 1969. The college offers over 75 associate degree programs and majors, and over 40 certificate programs, being one of the ten largest co-op education programs in the nation, as measured by the number of student placements. Recently Cincinnati State created a new division named the Center for Innovative Technologies (CIT), which combines the Engineering Technology and Information Technology divisions.
Internship experience opportunities are already available from industry partners to students from both institutions. New certificate programs could be designed upon local industry requests, in order to fulfill specific gaps in the workforce. Processes of continuous improvement and assessment of course outcomes as well as students learning outcomes will be embedded in the program, to address the extent to which the programs meet applicable ABET Criteria and policies for accreditation. Recruiting of non-traditional and underrepresented students will have precedence, in order to address the challenges posed by the workforce fulfilment requirements in our area. Mechatronics courses cover the multidisciplinary areas, and therefore, *mechatronics* has been enthusiastically explored and supported by educationally-oriented and research-oriented

universities [1] in graduating potential industry leaders, managers and supervisors with a broader view of STEM disciplines, which may provide additional incentive to prospective students to make their career decisions towards STEM areas.

What is Mechatronics?

The term mechatronics was first used in the late 1960s by a Japanese Electric Company to describe the engineering integration between mechanical and electrical systems. It is an integrated comprehensive study of electromechanical systems, integrating electrical, mechanical and computer engineering areas [1]. Mechatronics can be defined as the analysis, design, and integration of mechanics with electronics through intelligent computer control [2], as can be seen in Figure 1:

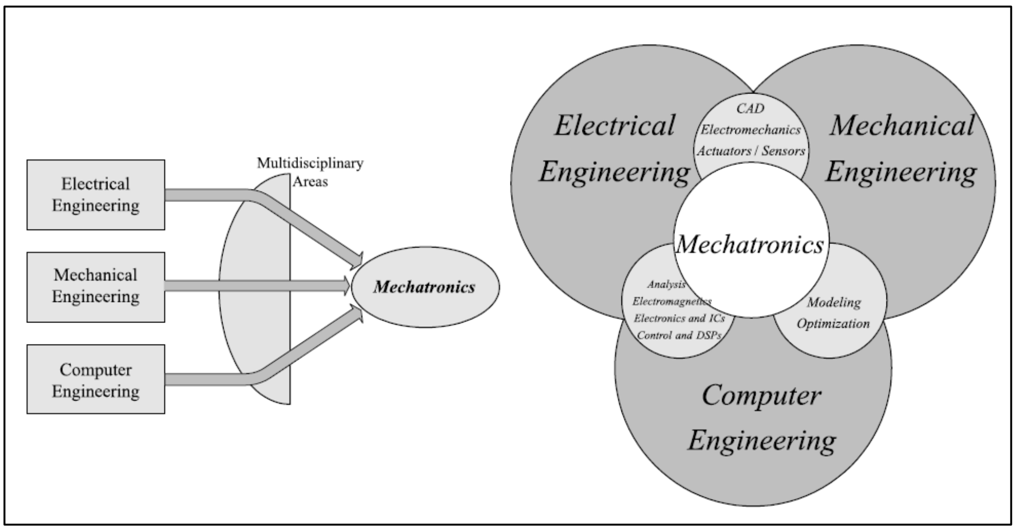

Figure 1 Mechatronics integrates electrical, mechanical and computer engineering. *Source: Lyshevski, Sergey E., Mechatronics curriculum – retrospect and prospect (Mechatronics 12, 2002).*

ASME describes mechatronics as "where electronics meets mechanical engineering, computing, optics, actuators, sensors, digital controls, and robotics. From its inception in computer-controlled machining and factory automation, mechatronics has incorporated these engineering disciplines and more, plus bioengineering and nanotechnology. Their complexity spurs the development of multiphysics in simulation and engineering analysis" [3]. Examples of mechatronic systems include aircraft flight control and navigation systems; automotive electronic fuel injection and anti-lock brake systems; automated manufacturing systems including robots, numerical control machining centers, packaging systems and plastic injection-molding systems; artificial organs; health monitoring and surgical systems; copy machines; power generation and sourcing management and storage; alternative energy sources and many more. A common element of all these systems is the integration of analog and digital circuits, microprocessors and computers, mechanical devices, sensors, actuators, and controls [4].

The ten specific topics identified under the general category of mechatronics are:

- Modeling and design;
- Motion control;
- System integration;
- Vibration and noise control;
- Actuators and sensors;
- Micro devices and optoelectronic systems;
- Intelligent control;
- Automotive systems;
- Robotics.

Justification for the Need of a Mechatronics Program

The National Council on Competitiveness estimates that 100 million new jobs will be created in the 21st century at the intersection of disciplines rather than in individual disciplines [5]. There is a critical shortage of students enrolled in Science and Engineering fields. The trend is significant to the point where the economic welfare and security of the United States is threatened [6] . To counter this trend, universities need to create interdisciplinary programs that will attract students and also meet the work force requirements of industry [4].

Northern Kentucky and Southern Ohio areas hosts many advanced manufacturing companies, producing high value-added products. Companies such as Mazak, ZF Steering Systems, General Electric, Procter & Gamble, Fives, Johnson Controls, Toyota and others play a significant role in the region's economy. The availability of adequately trained individuals is paramount to fulfill their human resources needs, as has been repeatedly expressed to the local institutions' faculty and administrators. [7].

Currently a Mechatronics Engineering Technology (either at B.S. or A.S. levels) is not offered in Northern Kentucky / Southern Ohio areas, and expanding our research area to the states of Kentucky, Ohio and Indiana, very few baccalaureate degree related programs are offered, as shown in Table 1. Worth of mention is the Mechatronics Engineering Technology program implemented by Purdue University Calumet in 2009, with the involvement of the local packing industry and in cooperation with the College of DuPage (IL) and Ivy Tech Community College [8].

Institution	State	Program Name	Degree
Big Sandy Community & Technical College	KY	Robotics & Automation	Diploma
Elizabethtown Community & Technical College	KY	Engineering & Electronics Technology - Robotics & Automation Specialization	Associate in Applied Science
Hopkinsville Community College	KY	Engineering & Electronics Technology - Instrumentation Specialization	Associate in Applied Science
Jefferson Community & technical College	KY	Robotics & Automation	Diploma
Maysville Community & Technical College	KY	Energy Systems Technology	Associate in Applied Science
Murray State University	KY	Electromechanical Engineering technology	B.S.
Owenboro Community & Technical College	KY	Mechatronic Systems	Certificate
Somerset Community Colege	KY	Robotics & Automation	Certificate
Southcentral Kentucky Community & Technical College	KY	Robotics & Automation	Associate in Applied Science
West kentucky Community & Technical College	KY	Mechatronic Systems	Certificate
Bowling Green State University	OH	Electromechanical Technology	Associate in Applied Science
Cincinnati State Technical & Community College	OH	Electromechanical Engineering Technology	Associate in Applied Science
Columbus State Technical & Community College	OH	Electromechanical Engineering Technology	Associate in Applied Science
Cuyahoga Community College	OH	Biomediacl Engineering technology	Associate in Applied Science
Cuyahoga Community College	OH	Integrated Systems Engineering technology	Associate in Applied Science
Cuyahoga Community College	OH	Mechatronics	Certificate
Eastern Gateway Community College	OH	Electromechanical Engineering Technology	Associate in Applied Science
Edson Community College	OH	Electronics Engineering technology - Automation and Robotics Option	Associate in Applied Science
Edson Community College	OH	Electronics Engineering technology - Electro-Mechanical Option	Associate in Applied Science
Lorain County Community College	OH	Automation Engineering Technology	Associate in Applied Science
Lorain County Community College	OH	Alternative Energy technology	Associate in Applied Science
Lorain County Community College	OH	Mechatronics Technology	Associate in Applied Science
Marion Technical College	OH	Mechatronics Engineering Technology	Associate in Applied Science
Miami University	OH	Electromechanical Engineering Technology	Associate in Applied Science
Shawnee State University	OH	Electromechanical Engineering Technology	Associate in Applied Science
Sinclair College	OH	Compter Numerical Control Technology	Certificate
Stark State College	OH	Electromechanical Engineering Technology	Associate in Applied Science
Stark State College	OH	Automation & Robotics Technology	Certificate
University of Akron	OH	Automated Manufacturing Engineering Technology	B.S.
Purdue University Calumet	IN	Mechatronics Engineering Technology	B.S.
University of Southern Indiana	IN	Engineering , Mechatronics	B.S.
Vincennes University	IN	Advanced Manufacturing Automation Technology	Associate in Applied Science

Table 1. Mechatronics Related Programs available in the KY, OH and IN areas (*source: "Find Engineering Schools and Degree programs"* - *http://educatingengineers.com*)

Institutions aiming to educate the nation's technical leaders must correctly assess and address the future needs for technology. This requires knowledge or new directions and developments in the basic sciences as well as an understanding of the needs of industry and society at a large, which calls for close links between industry and engineering schools [9].
Studies conducted by the Society of Manufacturing Engineers (SME) identified two high priority competency gaps between manufacturing industry's workforce needs and what is provided by educational programs on its Manufacturing Education Plan [10]. Availability of graduates in Mechatronics Engineering will help industry reduce the identified critical competency gaps [4] as well as comply with industry requirements for professionals with interdisciplinary thinking. A Mechatronics Engineering graduate will have knowledge of and be capable of applying engineering principles for design, modeling, and implementation of manufacturing automation systems and manufacturing process control.
The main source of information for the assessment of region's industry needs for mechatronics professionals was a survey conducted by CSTCC and NKU (with the support of the Advantage Kentucky Alliance [11]). The 14 survey participants represented a significant group of companies that may employ graduates in the mechatronics field. The purpose of this survey is to assess the workforce and curriculum needs of industry in the Northern Kentucky / Southern Ohio areas.
The survey shows very clearly the need for mechatronics professionals, as employers meet their needs by internal capacitation programs in the form of in-house training; they also favor the adoption of formal education programs, in order to accelerate the rate by which those professionals became capable to carry-out their tasks.
The new Mechatronics programs will graduate students who are prepared to be hired by industry as multi-disciplinary professionals. Colleges and universities currently offering electronics technology, electrical systems, mechanical & manufacturing engineering technology, electromechanical engineering technology, industrial engineering, robotics and computerized control systems are in an advantageous position to implement those programs.
The focus on formulation of mechatronics curriculum and defining its identity is, in a way, well-motivated because comprehending a multidisciplinary field is challenging unless a suitable curriculum that motivates the students is outlined. At the same time, it is essential that the formulated curriculum fulfils the expectations of the job market [12].

Survey results

As depicted in Figure 2 the companies surveyed are mostly medium to large sized (50% with more than 500 employees) and are primarily dedicated to manufacturing (57.1%).

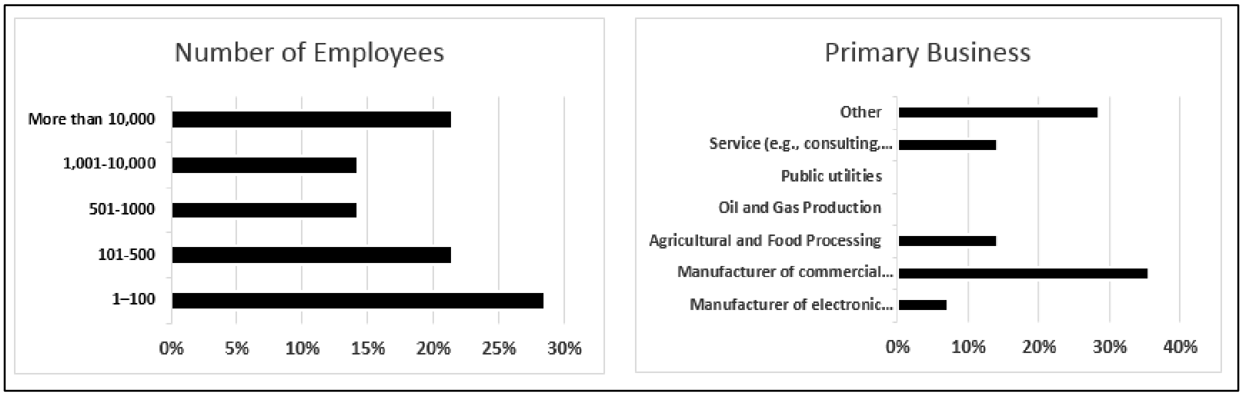

Figure 2 Characteristics of surveyed companies

Figure 3 shows the role played by mechatronics, where 88.8% of the companies use it in regular basis. Also, they are unanimous in emphasizing the importance of the practical aspects of the academic training, in line with the applied engineering education philosophy.

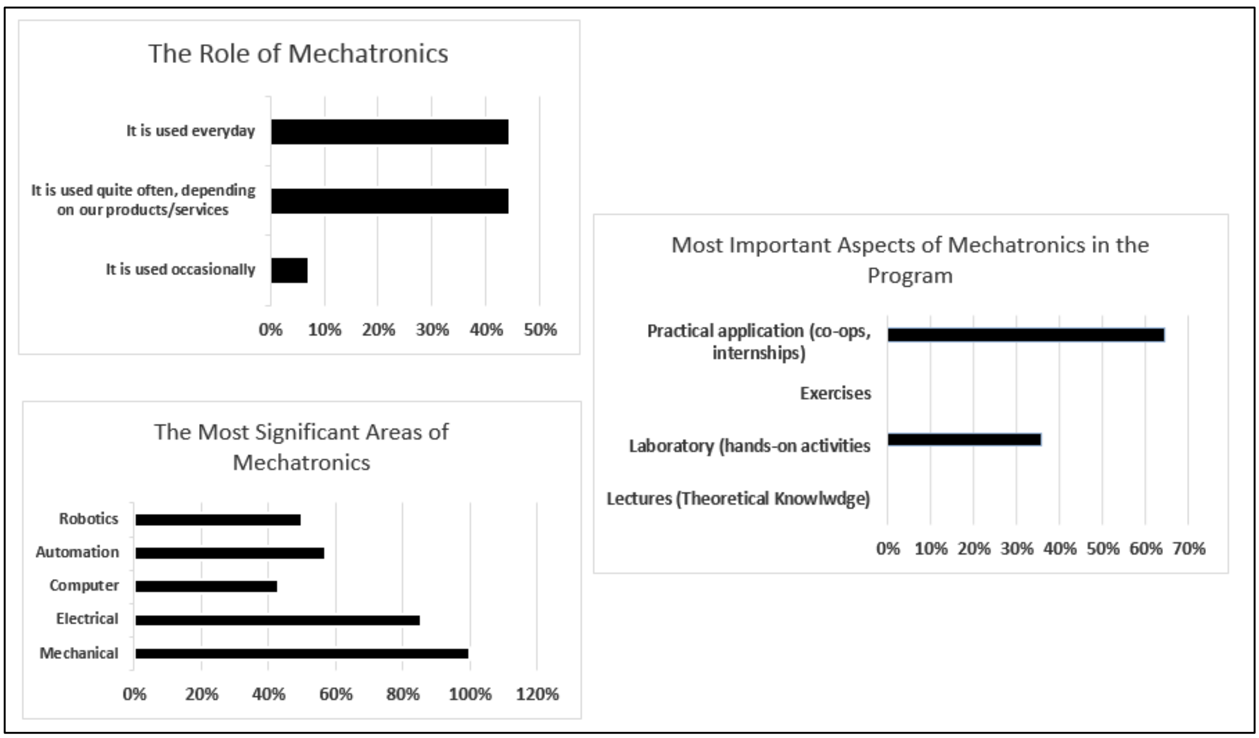

Figure 3 The Role of Mechatronics

Our combined surveys indicated that 84.7% of respondents anticipate the hiring (each one) of 1 to 15 mechatronics professionals and 7.7% will hire 16 to 50 in the next 5 years. Also, 28.6% of the employers train professionals in house and the same amount recruit employees in colleges or universities, as seen in Figure 4.

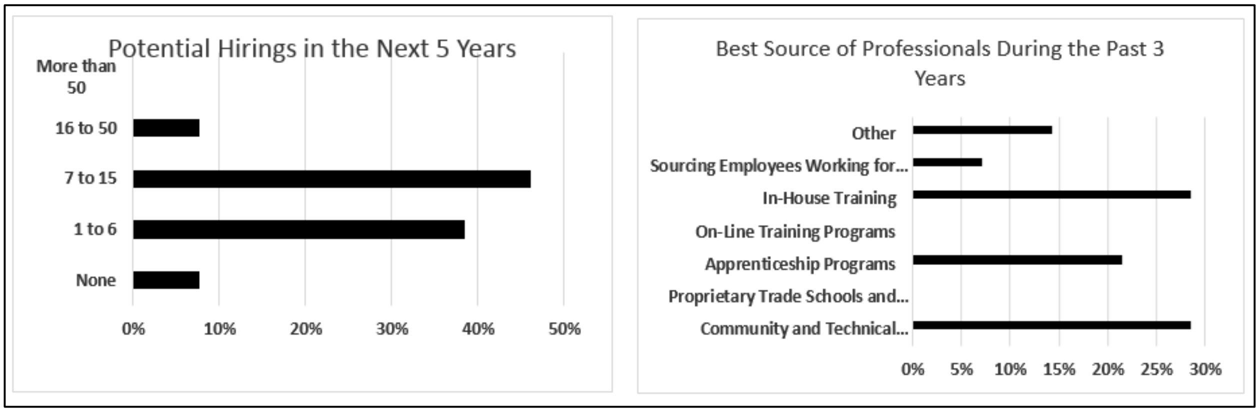

Figure 4 Prospective hirings and Preferred Sources for Mechatronics Professionals

Figure 5 shows that most employers (92.9%) agree that formal education programs can accelerate the qualification of individuals as mechatronics professionals. All of them also agree that a properly designed mechatronics program can provide the skills required for successful employment of individuals dedicated to the mechatronics area. We can also conclude that typically individuals who became mechatronics technicians went through on-job training programs to maintain job competency.

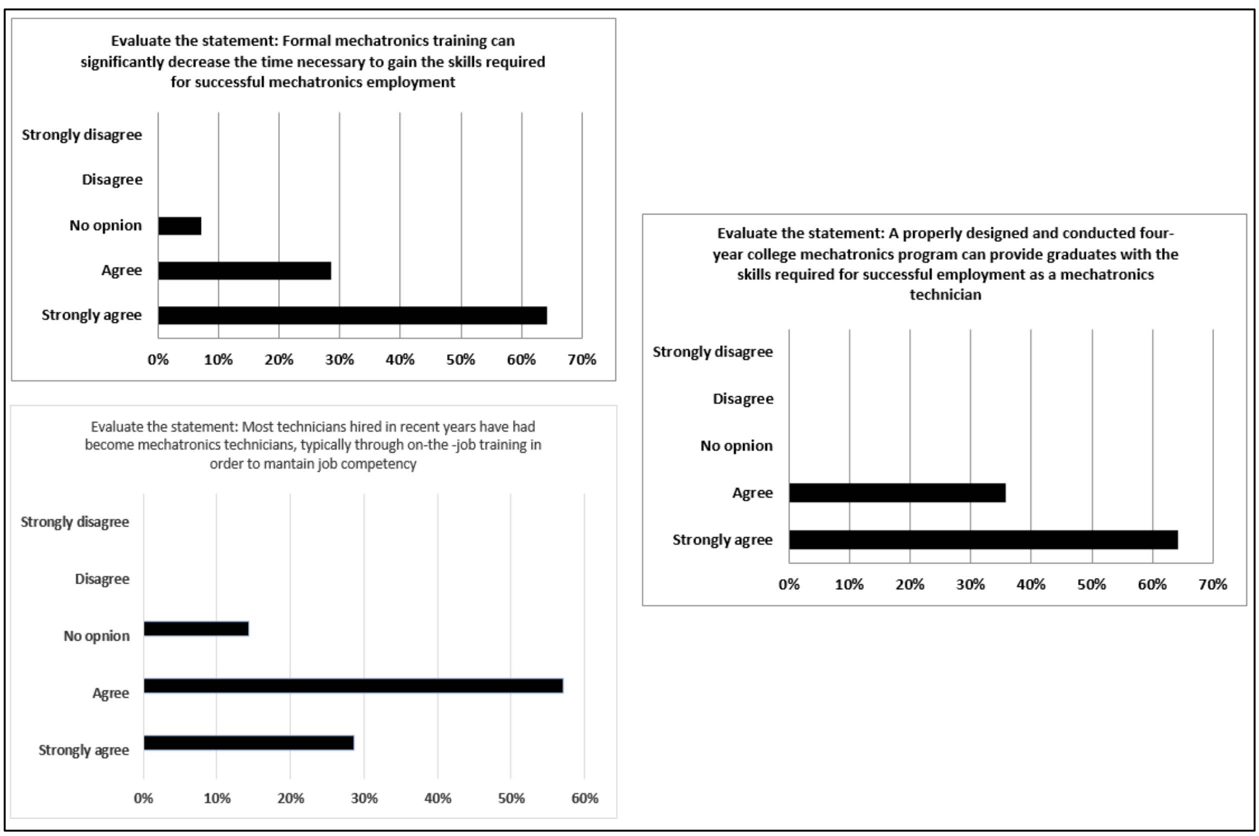

Figure 5 Expectations from Mechatronics Education

Project Plan

This project includes the development of one new program, the improvement and adaptation of existing facilities as well as faculty development.

Additional Faculty for the Program

A new cross-disciplinary faculty member will be needed in the EMT program. This position will keep the new program current in the areas of automation and industrial controls, while incorporating aspects of electro-mechanical systems into the curriculum. The establishment of this faculty line is also aligned with the NKU College of Arts and Sciences Strategic Plan, in the Academic Innovation strategic direction. Also, for accreditation purposes, ABET also requires the programs to have full time dedicated faculty member(s) [13].

We expect to have an increase on students enrolled in the EGT programs as the new MET program is in place; we also expect some migration of students from the current programs (EET, MMET) to the MET program. An additional pressure on our faculty body can be anticipated, as we will be required to meet to the demand from our constituents, as suggested by the survey results. These facts fully support the creation of a new faculty line to be fulfilled by a new faculty member.

Faculty Professional Development

Currency maintenance involves continuing scholarly activities and/or professional interactions that strengthen the faculty member's knowledge of his/her field and its interdisciplinary advancements, best business practices, newest technology developments, best learning theory implementations and most effective teaching practices and innovations [14].

Due to the fast evolution in electro-mechanical and electronic systems, and the ever-changing aspects involved in modern industry, the maintenance of professional and academic currency is absolutely essential. An annual faculty professional development plan is proposed in a rotation schedule, in order to provide opportunities to faculty members to stay current. The plan follows the framework proposed by Odden et al. [15] (where applicable) and it is depicted in Table 2.

Provison for 2 faculty members per year in a rotation schedule, to be assigned by the program administration			
Cost Element	**Ingredient**	**How cost is calculated**	
Materials, Equipment and Facilities Used for professional Development	Materials	Materials for PD, including the cost of classroom and supplies.	Office materials, clerical supplies.
	Equipment	Equipment needed for PD activities	TI hardware, sampling equipemnt, lab kits
	Publications	Articles, books, subscriptions	
	Facilities	Rental or other costs for facilities used for PD	Conference rooms, teaching aids
Travel and Transportation for Professional Development	Travel	Costs of travel to off-site PD activities	Subsistence (4 days NKU rate, 3 trips)
			Lodging (4 nights, approx. rate, major metro area, 2 trips)
			Transportation (air ticket, taxi, rental car, 2 trips)
	Transportation	Costs of Transportation within the district for PD	200 miles @ $0.47 - NKU reimbursement rate
Tuition and Conference Fees	Tuition	Tuition payments or reimbursement for university-based PD	1 Conference fee
			1 Trade show admission + conference
			1 technical training fee

Table 2. Cost Structure for Professional Development

NKU Existing and Proposed Facilities for the Program

Engineering Technology Programs occupy 9 rooms on the second floor of the Business Center to accommodate the faculty and program secretary offices. All laboratory classes are taught in the following rooms, all located in the first floor: BC108, 115, 117, 121, 125. EGT also uses some conventional class-rooms on as-needed basis. The Business Center Building floor plan (first floor), as well as its location in the campus is depicted in Figure 6 and Figure 7. Student learning opportunities associated with the facilities mentioned above are:

- Material testing (tension, compression).
- Material Platting.

- Materials hardening
- Rockwell hardness testers.
- Material processing using Milling and Turning Machines
- CNC programming using multiple CNC machines
- Materials fabrications
- Welding
- Robotics programming and automation
- Electronic experimentations.
- Facility planning.
- Computer Aided Design and Drafting.
- Plotting high resolution drawings and posters.
- Rapid prototyping using the Dimension machine
- Use of Faro arm in learning precision measurements and geometric tolerances.
- Experiment by setting up different hydraulic control systems on Amatrol systems.
- Use of Electric Discharge Machines to remove materials.

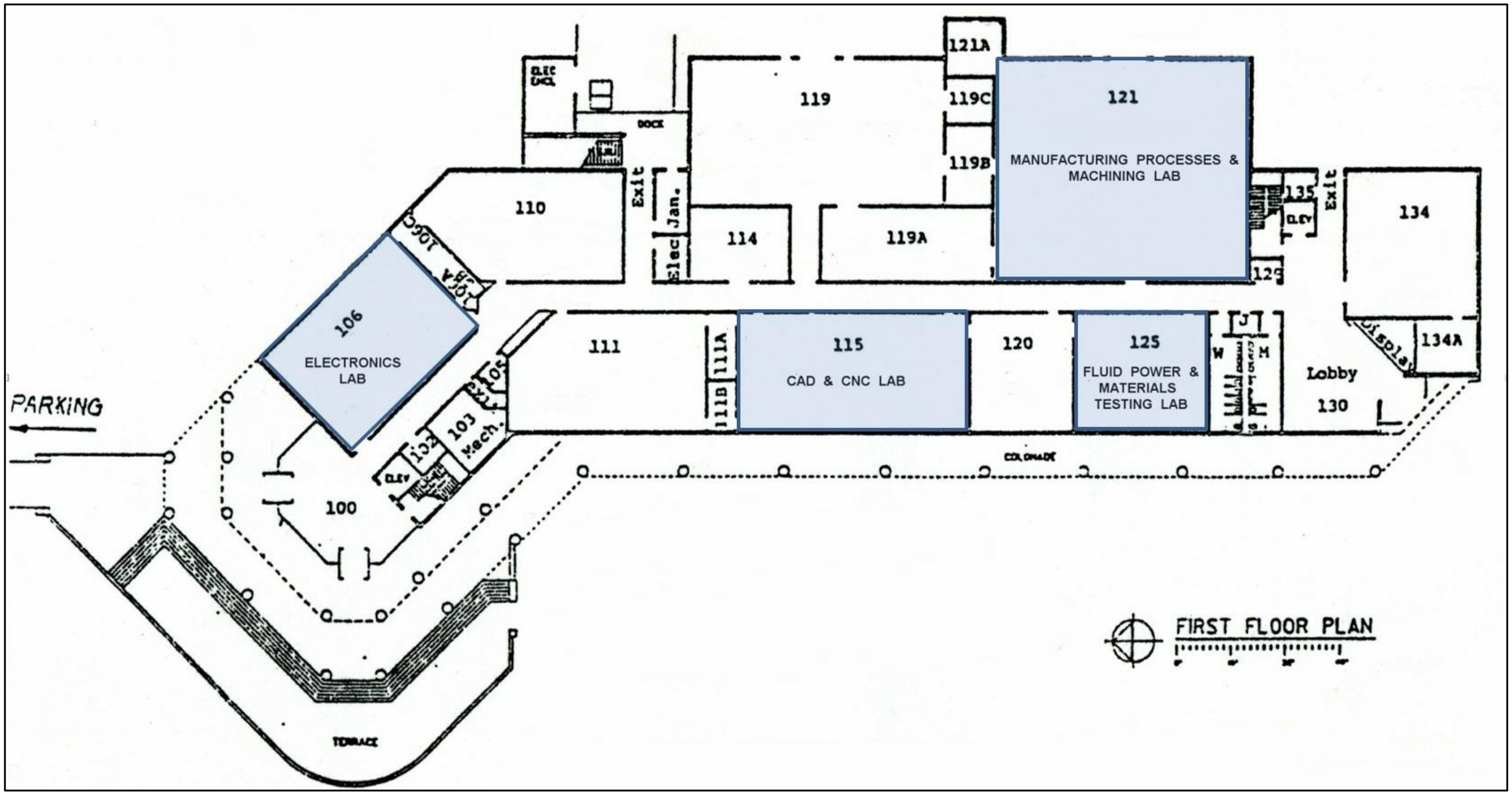

Figure 6. BC building' first floor. The lab spaces are shaded.

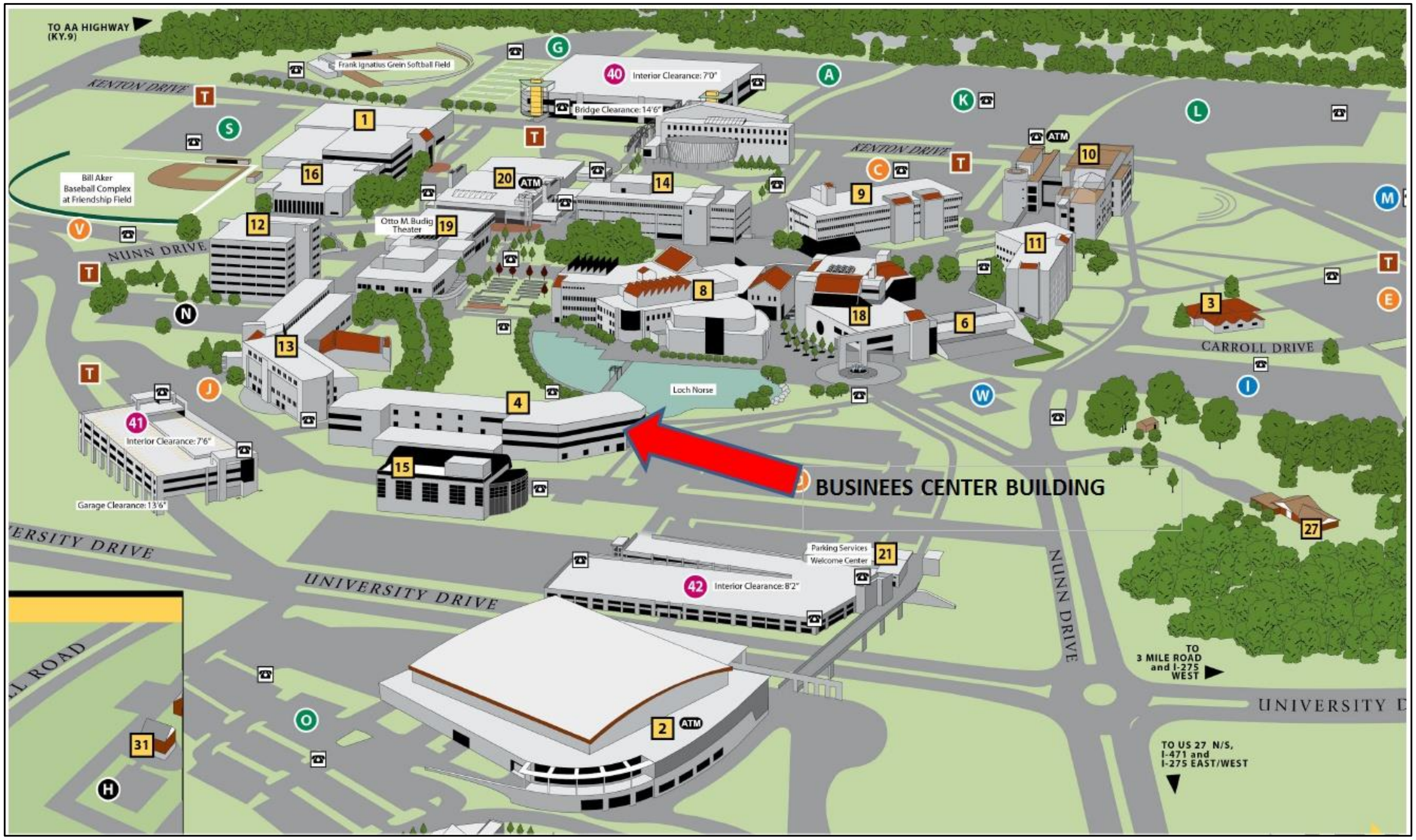

Figure 7. Location of the BC building at the NKU Highland Heights Campus

CSTCC Existing and Proposed Facilities for the Program

Over the past few years the EMET program at Cincinnati State has been retooling to reflect advanced manufacturing and automation needs of the Greater Cincinnati region including SW Ohio, Northern Kentucky and SE Indiana. One major piece to the retooling is and upgrade to their robotics laboratory. The following robotic equipment is needed:

- FANUC LR Mate w/Vision, quantity of 3.
- FANUC Touch Screen iPendant for RoboGuide quantity of 12.
- FANUC M-1iA w/Vision unit, quantity of 1.

Laboratory Implementation and Improvement Guidelines

A solid understanding of multi-domain dynamic systems with accompanying modeling and analysis techniques is the key technical skills that mechatronics engineers should master [16]. To support the classes in mechatronics systems, and to emphasize the correlation between different subjects (applied engineering and pure sciences) the implementation of new and/or improvement of existing facilities will follow the procedure adopted by Yu et al. [17] in designing each specific laboratory, as depicted in Figure 8:

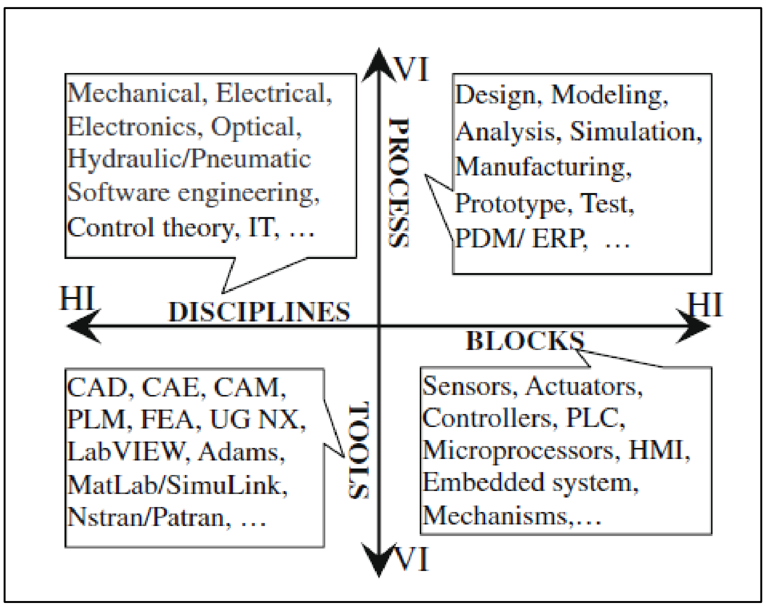

Figure 8. Horizontal integration (HI) and vertical integration (VI) of mechatronics

The NKU and CSTCC existing facilities offer support for their current engineering technology programs, however a dedicated mechatronics laboratory is necessary, not only to support the new program, but also to improve the classes that will became part of the new program. The proposed list of new and updated equipment is depicted in Table 3 and Table 4.

Laboratory Upgrades				
Hydraulic / Electro-Mechanic Systems Learning Equipment Retrofit				
Brand	Item	Description	Qty.	Classes where the item will be used
Amatrol	850-CTBU	Controls Technology Double Sided A-Frame Bench Upgrade for Older 850-C1	3	EGT361, EGT386, EGT417
Amatrol	85-BH	Basic Hydraulics Learning System	3	
Amatrol	16019	24VDC Power Supply	3	
Amatrol	N/A	Repair parts for 85EF panels	1	
Test Equipment				
Instrom		Load Frame for Monotonic and Fatigue Loading	1	EGT300, EGT261, EGT280, EGT417
New Equipment				
Mechtronics Learning Equipment				
Amatrol	870-PS731	Mechatronics Learning System for Siemmens S7-300 with Profibus Platform	7	EGT267, EGT320, EGT365, EGT386, EGT465, EGT408, EGT448, EGT417
Amatrol	82-900-12	Siemens Step 7 PLC Software - 12 seats	1	
Amatrol	72024	PC programming interface for Siemens S7 PLCs	7	
Amatrol	87-MS1	Pick and place feeding station	1	
Amatrol	87-MS2	Gauging Station	1	EGT267, EGT320, EGT365, EGT386, EGT465, EGT408, EGT448, EGT417
Amatrol	87-MS3	Orientation-processing station	1	
Amatrol	87-MS4	Sorting-Buffering Station	1	
Amatrol	87-MS5-C1	Servo robot assembly station for existing Fanuc cart	1	
Amatrol	87-500F	Amatrol-Fanuc integration Package	1	
Amatrol	87-MS6	Torque assembly station	1	
Amatrol	87-MS7	Inventory Storage Station	1	
Amatrol	90-START-	Start-up and installation	1	

Table 3. Proposed list of new and updated equipment for the MET program at NKU

New Equipment				
Robotics Learning Equipment				
Brand	Item	Description	Qty.	Classes where the item will be used
FANUC	LR Mate w/ Vision	Electric Servo Drive Mini-Robot	3	Various
FANUC	I-Pendant	Touch-Screen Controller	12	
FANUC	M-1iA w/ Vision	Light-Weight Assembly Robot	1	

Table 4 . Proposed list of new equipment for the MET program at CSTCC

Recruitment and Dissemination Initiatives

NSF statistics on the state of education in the United States indicate a decreasing tendency in domestic students enrolling in and concluding successfully degrees in Science and Engineering [18]. There is a gap between the number of vacant positions in industry and the number of graduates with the right qualifications to fulfill those positions. In order to revert that trend, initiatives are being proposed, in order to increase high-school students' awareness on STEM disciplines, as well as to attract students from minority groups to the new program, within NKY and Southern Ohio areas. The initiatives and respective activities are depicted in Table 5.

<table>
<tr><th>Initiative</th><th colspan="2">Description</th><th>Qty.</th></tr>
<tr><td>STEM Summer Camp</td><td colspan="2">Camp 1: Grades 7 and 8, hands-on 5 day, 4 hours per day summer camp. This camp could be run at Cincinnati State and/or NKU 98 t0 12 students)</td><td>1</td></tr>
<tr><td rowspan="4">Host Women in Trades, Technology and Sciences Workshop</td><td rowspan="4">Cincinnati State National Institute for Women in Trades, Technology and Science (IWITTS) two-day training workshop</td><td>IWITTS Workshop Trainer, trainer travel and lodging</td><td>1</td></tr>
<tr><td>IWITTS Workshop Breakfast (40/Day)</td><td>80</td></tr>
<tr><td>IWITTS Workshop Lunch(40/day)</td><td>80</td></tr>
<tr><td>IWITTS Workshop room rental, housekeeping, and A/V needs, etc.</td><td>1</td></tr>
<tr><td rowspan="4">Dual Enrollment Courses Offered in Grade 12</td><td rowspan="2">CIT 105 OSHA 10 General Industry Safety (1 Credit. 1 Lecture Hour. 0 Lab Hour). No text required. May need to get high school teacher trained to teach OSHA, but initially Cincinnati State could supply instructor. OSHA 511Occupational Safety and Health Standards for the General Industry</td><td>CIT-105 Dual Enrollment Course OSHA 501 OSHA Course</td><td>2</td></tr>
<tr><td>CIT-105 Dual Enrollment Course OSHA 511 Trainer Course</td><td>2</td></tr>
<tr><td rowspan="2">EMET 150 Introduction to Controls and Robotics (2 Credits. 1 Lecture Hour. 2 Lab Hours)</td><td>EMET-150 Dual Enrollment Course Text Book: Basic Robots 1st Edition ISBN13: 978-1-133-95019-6</td><td>26</td></tr>
<tr><td>EMET-150 Dual Enrollment Course Lab Equipment</td><td>26</td></tr>
</table>

Table 5. Recruitment and Dissemination Initiatives

Proposed Curriculum Structure

Curriculum at NKU and CSTCC follow the general guidelines for accreditation defined by the Accreditation Board for Engineering and Technology (ABET) [19]. Mechatronics curriculum design includes development of goals and objectives, programs of study and curriculum guides, courses, laboratories, textbooks, instructional materials, experiments, instructional sequencies and othe supplemental materials focusing to accomplish a wide range of educational goals [1].
The cross-curricular approach reflected at the level of the targeted goals, of the targeted contents, the use of new technologies, of the computer as a working tool which will determine the student's educational course [20].
The mechatronics courses are intended to develop a comprehensive understanding and the ability to apply theoretical and experimental concepts in design, optimization and implementation of electromechanical systems posing different levels of complexity. These objectives are achieved by the delivery of electromechanical systems theory, as well as fundamentals of engineering programing and software. In power systems, dominance of control and monitoring systems is essential to manage sources of energy and storage methods [21]. A balanced coverage can be assured by a careful blend of courses, chosen from the ones offered by NKU and CSTCC, as shown in Table 6, below.

Core Courses in Mechatronics Engineering Technology			
NKU Course	**Description**	**CSTC Equiv.**	**Credits**
EGT 161	D.C. Circuit Analysis	EET 131	3
EGT 212	Computer-Aided Drafting and Design	PSET 110 or MET 131	3
EGT 261	Engineering Materials	MET 140	3
EGT 265	Manufacturing Processes and Metrology	MET 111	3
EGT 267	Programming for Engineering Applications		3
EGT 300	Statics and Strength of Materials	MET 150	3
EGT 301	Cooperative Education in Engineering Technology	NKU CEP 300, EMET 291	3
EGT 310	Project Management and Problem Solving		3
EGT 340	Applied Dynamics	MET 260	3
EGT 343	A.C. Circuit Analysis	EET 132	3
EGT 345	Digital Electronics	EET 121	3
EGT 361	Fluid Power	MET 240	3
EGT 367	Microprocessors	EET 220	3
EGT 380	Machine Design		3
EGT 408	Network Hardware		3
EGT 417	Senior Design in Technology		3
EGT 448	Network Hardware		3
Core Credits in Mechatronics Engineering Technology			**51**

Core Courses in other Disciplines			Credits
MAT 119	Precalculus Mathematics	MAT 125, MAT 126	3
INF 120	Elementary Programming		3
CHE 120/120L	General Chemistry with Laboratory I	CHE 120/131 Lab	4
MAT 128 and	Calculus A	MAT 251	
MAT 227	Calculus B		4 or 6
OR			
MAT 129	Calculus I	MAT 252	
STA 205	Introduction to Statistical Methods		3
PHY 211	General Physics with Laboratory I	PHY 201	5
PHY 213	General Physics with Laboratory II	PHY 202	5
Core Credits and other Disciplines			**27 or 29**

Students are required to select one track plus elective EGT and/or EMET (*) courses (in tracks below) for the respective credit hours total.

Automated Systems Track			Credits
EGT 320	Robotic Systems and Material Handling		3
EGT 365	CNC & Manufacturing Process Planning		3
EGT 386	Electromechanical Instrumentation and Control		3
EGT 465	Automated Manufacturing Systems		3
Select 9 additional credit hours of EGT and/or EMET(*) courses			9
	Total Track Credits		**21**
	Total Core Credits in Mechatronics Engineering Technology		**51**
	Total Core Credits in other Disciplines		**27 or 29**
	TOTAL CREDITS		**99 or 101**

Alternative Energy Track			
CIT 105(*)	OSHA 10 General Industry		1
EMET 210(*)	Energy Efficiency and Audits		3
EMET 225(*)	Solar and Renewable Energy		3
EMET 275(*)	Electric Drive Mechanisms		3
EGT 450	Thermodynamics and Heat Transfer	MET 260	3
Select 9 additional credit hours of EGT and/or EMET(*) courses			9
	Total Track Credits		**22**
	Total Core Credits in Mechatronics Engineering Technology		**51**
	Total Core Credits in other Disciplines		**27 or 29**
	TOTAL CREDITS		**100 or 102**

Laser Technology Track			
CIT 105(*)	OSHA 10 General Industry		1
EMET 245(*)	Laser Foundations and Safety		3
EMET 255(*)	Optical Components, Geometrical and Wave Optics (prereq. EMET 245, EMET 140)		4
EMET 265(*)	Industrial Laser Systems (prereq. EMET 245)		4
Select 9 additional credit hours of EGT and/or EMET(*) courses			9
	Total Track Credits		**22**
	Total Core Credits in Mechatronics Engineering Technology		**51**
	Total Core Credits in other Disciplines		**27 or 29**
	TOTAL CREDITS		**99 or 101**

Computer Science Track			
INF 260	Object Oriented Programming I		3
CSC 360	Object Oriented Programming II		3
CSC 362	Computer Systems		3
CSC 462	Computer Architecture		3
Select 9 additional credit hours of EGT, INF, CIT, CSC and/or EMET(*) courses			9
	Total Track Credits		**21**
	Total Core Credits in Mechatronics Engineering Technology		**51**
	Total Core Credits in other Disciplines		**27 or 29**
	TOTAL CREDITS		**99 or 101**

Table 6. Degree Requirements for the B.S. in Mechatronics Engineering Technology

The new program will be described in the catalog as follows:

> "Bachelor of Science with a major in Mechatronics Engineering Technology – MET.
> This program provides students with skills necessary to enter careers in design, application, installation, operation, and maintenance of electronic and electro-mechanical systems. Graduates gain skills to analyze, design and implement systems with digital, analog, microcontroller, software, and mechanical components. Graduates are benefited with theoretical education on diverse technical skills and practical training in implementation of a wide range of systems and applications. Students are required to co-op in industry starting with their second year at school, which often continues and leads to full-time employment. Students are required to complete the core and a track. A minor is not required."

A Pathway to Degree Completion – 4-year plan

NKU offers Bachelor of Science degrees in Mechanical and Manufacturing and Electronics Engineering technology; CSTCC offers Associate of Applied Science degree in Electromechanical Engineering Technology. The new B.S. program in Mechatronics Engineering Technology to be offered by NKU carefully incorporate existing engineering technology courses in order to approach the ASME concept on this discipline and meet the industry expectations in multidisciplinary education [3].
Currently a Mechatronics Engineering Technology (either at B.S. or A.S. levels) is not offered in Northern Kentucky / Southern Ohio areas, making the NKU / CSTCC pathway initiave. A 4-year plan to satisfy the requirements for the A.A.S.in Electro-Mechanical Engineering Technology degree at CSTCC, leading the Bachelor of Science in Mechatronics Engineering Technology degree at NKU will be implemented in the form of a transfer agreement. By completing the Associate of Applied Science degree at CSTCC with a satisfactory GPA, students will receive credit for the as many courses in the bachelor's degree program as possible. Transfer credits will be based on approved course equivalencies to be defined.

Evaluation and Assessment

ABET has recognized the emerging importance of mechatronics engineering and has recently proposed specific evaluation criteria for "Mechatronics Engineering and similarly named programs" that are in the review process [4]. Nevertheless, the outcomes of the Program will be established and assessed through a process consistent with the current ABET criteria for accrediting engineering technology programs guidelines of ABET-ETAC. [13]. It involves identification of the needs of Program constituencies, the accomplishment of Program objectives, alignment with the ABET-ETAC Criteria "a" through "k", and consistency with the recommended outcomes for Mechanical Engineering Technology as well as Manufacturing Engineering Technology.

Program Educational Objectives

The program objective is to produce graduates with knowledge, hands-on skills, problem-solving, technical and leadership skills to enter careers in the design, installation, manufacturing, testing, evaluation, technical sales, maintenance, processes and system design. These graduates will:

- PEO1. Attain a gainful employment in technical or leadership careers where they continue to enhance their knowledge in the Mechanical, Electronics, Industrial Controls and/or Manufacturing disciplines.

- PEO2. Attain an ability to work effectively in cross functional teams and communicate effectively in oral, written or visual forms.
- PEO3. Attain an awareness of ethical, professional, and social responsibilities in their professional lives and community services.
- PEO4. Attain skills necessary to engage in lifelong learning activities coupled with commitment to continuous improvement in their professional lives.

Student Outcomes (ABET-ETAC Criterion 3)
By the time of graduation, students in the MET program will provide:

- SO1. An ability to select and apply the knowledge, techniques, skills, and modern tools of mechanical and manufacturing engineering technology to the design, manufacturing, testing, evaluation, and maintenance of mechanical and manufacturing systems;
- SO2. An ability to select and apply a knowledge of mathematics, science, engineering, and technology to selection of materials, manufacturing processes, tooling, automation, production operations, maintenance, quality, industrial organization, management and statistics to solve mechanical and manufacturing problems;
- SO3. An ability to conduct standard tests and measurements of engineering materials, statics, dynamics, fluid power, and electronics;
- SO4. An ability to:
  - I. Design systems, components, or processes for use in mechanical and manufacturing projects;
  - II. Produce drawings and related electronic data files in the areas of mechanical design, tool design and machine design;
- SO5. An ability to function effectively as a member or leader on a technical team;
- SO6. An ability to identify, analyze, and solve engineering technology problems in:
  - I. Mechanical and manufacturing processes, planning, optimization and automation;
  - II. Facilities planning, materials handling and robotics;
- SO7. An ability to apply written, oral, and graphical communication in both technical and nontechnical environments; and an ability to identify and use appropriate technical literature;
- SO8. An understanding of the need for and an ability to engage in self-directed continuing professional development;
- SO9. An understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity;
- SO10. A knowledge of the impact of engineering technology solutions in a societal and global context; and
- SO11. A commitment to quality, timeliness, and continuous improvement.

The mapping of Program outcomes to the ABET-ETAC Criterion 3 is presented in Table 7. A short description of the relevance of the Student outcomes to Criterion 3 is presented here:

- Criterion 3-a will be met through the Student Outcome 1.
- Criterion 3-b will be met through the Student Outcome 2.
- Criterion 3-c will be met through the Student Outcome 3.
- Criterion 3-d will be met through the Student Outcome 4.
- Criterion 3-e will be met through the Student Outcome 5.
- Criterion 3-f will be met through the Student Outcome 6.

- Criterion 3-g will be met through the Student Outcome 7.
- Criterion 3-h will be met through the Student Outcome 8.
- Criterion 3-i will be met through the Student Outcome 9.
- Criterion 3-j will be met through the Student Outcome 10.
- Criterion 3-k will be met through the Student Outcome 11.

Map of Course Competencies with Program Objectives					
		PO1	PO2	PO3	PO4
List of courses in the Program		A	B	C	D
EGT 116	Intro. to Industrial Materials & Processes	x			
EGT 212	Computer Aided Drafting & Design	x			
EGT 261	Engineering Materials	x			
EGT 265	Manufacturing Processes & Operations	x			
EGT 267	Programming for Engineering Applications	x			
EGT 300	Statics & Strength of Material	x			
EGT 301	Cooperative Education in Eng. Technology	x	x	x	x
EGT 310	Project Management & Problem Solving	x	x		
EGT 320	Robotic Systems & Material Handling	x	x		
EGT 340	Applied Dynamics	x			
EGT 343	A.C. Circuit Analysis	x			
EGT 345	Digital Electronics	x			
EGT 361	Fluid Power	x			
EGT 365	Tool Design & Computer Numerical Control	x			
EGT 367	Microprocessors	x			
EGT 380	Machine Design	x			
EGT 386	Electro-Mech. Instrumentation & Control	x			
EGT 408	Mechatronics Topics	x			
EGT 417	Senior Research & Design in Eng. Technology	x		x	x
EGT 450	Thermodynamics and Heat Transfer	x			
EGT 465	Automated Manufacturing Systems	x			
MAT 119	Pre-Calculus	x			
INF 120	Elementary Programming	x			
CHE 120 & 120L	General Chemistry	x			
MAT 128 & MAT 227	Calculus A / Calculus B	x			
MAT 129	Calculus I	x			
PHY 211	General Physics with Lab I	x			
PHY 213	General Physics with Lab II	x			
STA 205	Introduction to Statistical Methods	x			

Table 7. Map of Course Competencies with Program Objectives

The mapping of Program Student Outcomes to the Program Objectives is provided in Table *7* and Table 8. A short description of the relevance of the Student Outcomes to Program Objectives is presented here:

- Program Objective 1 is addressed by Students Outcomes SO1-11
- Program Objective 2 is addressed by Students Outcomes SO5 and 7
- Program Objective 3 is addressed by Students Outcomes SO9 and 10
- Program Objective 4 is addressed by Students Outcomes SO8 and 11

Map of Course Competencies with Student Outcomes												
Course	MET Outcomes	SO1	SO2	SO3	SO4	SO5	SO6	SO7	SO8	SO9	SO10	SO11
		a	b	c	d	e	f	g	h	i	j	k
NKU Courses												
EGT 161	D.C. Circuit Analysis			1								
EGT 212	Computer Aided Drafting & Design	1			1							
EGT 261	Engineering Materials	1	1	1								
EGT 265	Manufacturing Processes & Operations	1					2					
EGT 267	programming for Engineering Application											
EGT 300	Statics & Strength of Material	1	1	1	1							
EGT 301	Cooperative Education in Eng. Technology	1	1	1			1	1	1	1	1	
EGT 310	Project Management & Problem Solving							1				
EGT 320	Robotic Systems & Material Handling					1	2	1				
EGT 340	Applied Dynamics	1	2	1								
EGT 361	Fluid Power	1	1			1						
EGT 365	Tool Design & Computer Numerical Control					1	1					
EGT 380	Machine Design	1		1								
EGT 386	Electro-Mech. Instrumentation & Control	1										
EGT 417	Senior Research & Design in Eng. Technology	1			1		1	1	1	2		1
EGT 450	Thermodynamics and Heat Transfer		1		2							
EGT 465	Automated Manufacturing Systems		1			1						
CHE 120 & CHE 120L	General Chemistry		2									
INF 120	Elementary Programming											
MAT 119	Pre-Calculus		2									
MAT 128 & MAT 227	Calculus A / Calculus B		2									
MAT 129	Calculus I		2									
PHY 211	General Physics with Lab I		2									
PHY 213	General Physics with Lab II		2									
STA 205	Introduction to Statistical Methods		1									
EGT 343	AC Circuit Analysis	2	1	2								
EGT 345	Digital Electronics	2	1	2			2					
EGT 367	Microprocessors				1							
EGT 448	Network Hardware				1				2			
EGT 408	Mechatronics		2		1		1			2		

Table 8. Map of Course Competencies with Students Outcomes

Evaluation Plan - Goals and Objectives

Local Industry have been supporting both NKU and CSTCC by providing scholarships to students, materials and equipment donations; also, internship experience opportunities are available from industry partners to students from both institutions. Local industries are also our constituents, having their representatives seating in the respective advisory boards. Faculty members and administrators strive to provide the human resources demanded by them.
The main goals of the proposal are:

Goal one: Implement the new curriculum by combining and updating existing electronic and mechanical manufacturing engineering technology courses; developing four mechatronics engineering technology tracks; update current engineering technology laboratories and establishing one new mechatronics laboratory facility to provide hands-on experience in designing, implementing and integrating industrial controls & manufacturing systems.

- Objective 1: Establish an industrial advisory board consisting of representatives from industry, committed to provide experiential learning opportunities, as well as alumni, students and representatives from local colleges to examine and ensure the alignment of the MET program objectives with their needs. This board should meet once a year
- Objective 2: Implement adequate laboratory facilities for mechatronics instruction, Update the existing Adapt and implement an instructional mechatronics laboratory with an emphasis on industrial controls & manufacturing systems, in accordance local industry needs.
- Objective 3: Enhance existing curriculum by providing the students with hands-on experience in mechatronics towards industrial controls & manufacturing systems design, integration, and evaluation in view of environmental and safety concerns. Enhance existing curriculum by providing the students with hands-on experience in mechatronics and machinery design, integration, and evaluation including environmental, green technology, and safety issues.

Goal Two: Incorporate elements of experiential learning in the curriculum so that the courses are in compliance with expectations from employers, as well as attractive to potential traditional and non-traditional students.

- Objective 1: To provide at least ten experiential learning opportunities in industry in year one, and at least fifteen in year two of the project
- Objective 2: To expand the companies offering experiential learning opportunities (co-ops, internships, senior project subjects) from at-least three companies in year one to at-least 5 companies in year two of the project.
- Objective 3: To assure that at least 40% of courses in the proposed curriculum include an experiential learning component.
- Objective 4: To conduct, through experiential learning opportunities and curriculum, at least six projects that effectively integrates the theoretical and practical aspects of mechatronics and industrial controls & manufacturing systems by the end of the second year.

- Objective 5: To serve as a resource center for university-industry collaboration, and for outreach and marketing activities to increase interest in STEM education among traditional and non-traditional high school students.

Conclusion

A chronicle on the process for the implementation of a multidisciplinary B.S. in Mechatronics Engineering Technology program is provided in this paper. It can be used as a model for implementation of similar programs in medium sized institutions. It also describes how a community college and a four-year university can cooperate to meet the needs of the industry in Northern Kentucky / Southern Ohio regional areas.

The implementation of this new program is in line with the goals established by the 2013 – 2018 NKU Strategic Plan and therefore is supported by the administration, at both university and college levels. An NSF Advanced Technological Education (ATE) grant proposal was submitted for founding the curriculum development, faculty professional development and acquisition of new and upgrades on existing laboratory equipment. At this time no decision was made yet by NSF on the support of the grant proposal and the new curriculum is under analysis by the Kentucky Council of Postsecondary Education. We expect the new program will start in the Fall 2016 and students' outcome data will be collected for assessment purposes and for ABET accreditation.

The evaluation of the implementation of this project, as well as budgetary considerations will be subject of further academic work.

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