University-Industry Collaboration to Meet Criterion 7 of an ETAC Accredited Program

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Abstract: With budget shortfalls for education and lack of sufficient funds from grants, institutions are eager to reach collaboration with engineering-related organizations and industries in order to adequately provide current and relevant instructional resources. Institutions are required to demonstrate their support to programs by providing adequate classrooms, laboratories and equipment to enhance students' hands-on experiences and facilitate the attainment of student learning outcomes.
This paper provides a chronicle of how this cooperation was accomplished to may serve as a reference for institutions seeking additional support for their programs. It also provides examples of how the laboratories and equipment made possible through this collaboration can support engineering technology classes. This facilitates a potentially case-study like approach with discussion on the implementation following the guidelines and framework proposed by Yu et al [1].

1. INTRODUCTION

Founded in 1968, Northern Kentucky University (NKU) is a metropolitan university with approximately 14,000 students, located in Highland Heights, Kentucky, in the greater Cincinnati area. NKU currently offers the following Bachelor of Science degrees in Engineering Technology:

- Electrical and Electronics – EEET (formerly Electronics Engineering Technology – EET)
- Mechanical and Manufacturing - MMET
- Mechatronics – MET

The programs count on the support of local industry, who provide most of the students with co-op opportunities. The MMET and the EEET are long-standing programs at NKU. These programs have catered to the manufacturing industries in Northern Kentucky / Southern Ohio areas for more than two decades. Certificate programs can also be tailored to local employers, in order to fulfill specific gaps in the workforce. Processes of continuous improvement and assessment of course outcomes as well as students learning outcomes are embedded in the program, to address the extent to which the programs meet applicable ABET Criteria and policies for accreditation.

2. 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 [2]. Mechatronics can be defined as the analysis, design, and integration of mechanics with electronics through intelligent computer control [3], as can be seen in Figure 1:

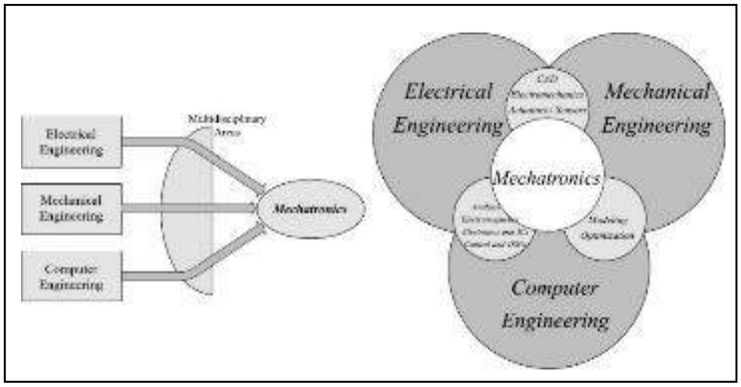

Figure 1 - Mechatronics integrates electrical, mechanical and computer engineering. ***(Source: Lyshevski, Sergey E., Mechatronics curriculum – retrospect and prospect (Mechatronics 12, 2002).***

A new Mechatronics Engineering Technology Bachelor of Science (BS) program has been developed and is being offered by NKU. A survey conducted among employers in the Northern Kentucky and Southern Ohio areas demonstrated very clearly the need of mechatronics professionals, as employers attempt to meet their capacity-constrained needs internally with 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 program was approved by the Kentucky Council on Postsecondary Education in March 2017 and was made available in the university catalog for the Fall 2017/2018 academic year. A pathway agreement with the Cincinnati State Technical and Community College (CSTCC) was developed to facilitate transfers for students who graduated in the CSTCC Electromechanical Engineering Technology in Applied Science program [4] [5] [5].

3. BUDGETARY CHALLENGES

Many, if not most, administrators in public higher education institutions struggle in states that are systematically reducing appropriations. The reasons for that are not in the scope of this paper.

A study conducted by the Center on Budget and Policy Priorities (CBPP) shows that the majority of states promoted a significant reduction in funding, since 2008 [6] (Figure 2). The same study shows that tuition has increased sharply during the same period, evidencing an attempt to offset the budget cuts, as shown in Figure 3:

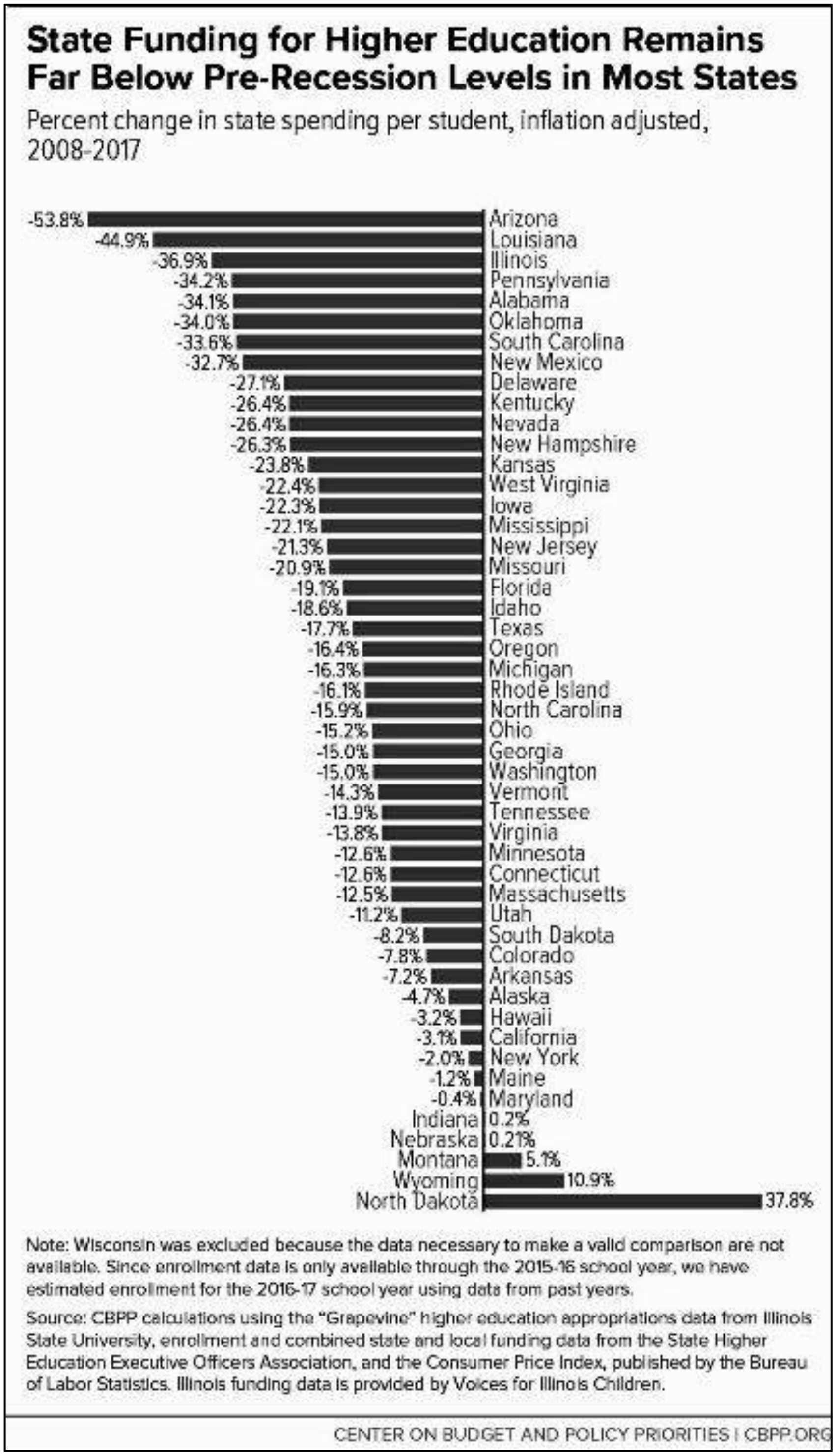

Figure 2 - State funding for higher education since 2008 - ***Source: This material was created by the Center on Budget and Policy Priorities (www.cbpp.org).***

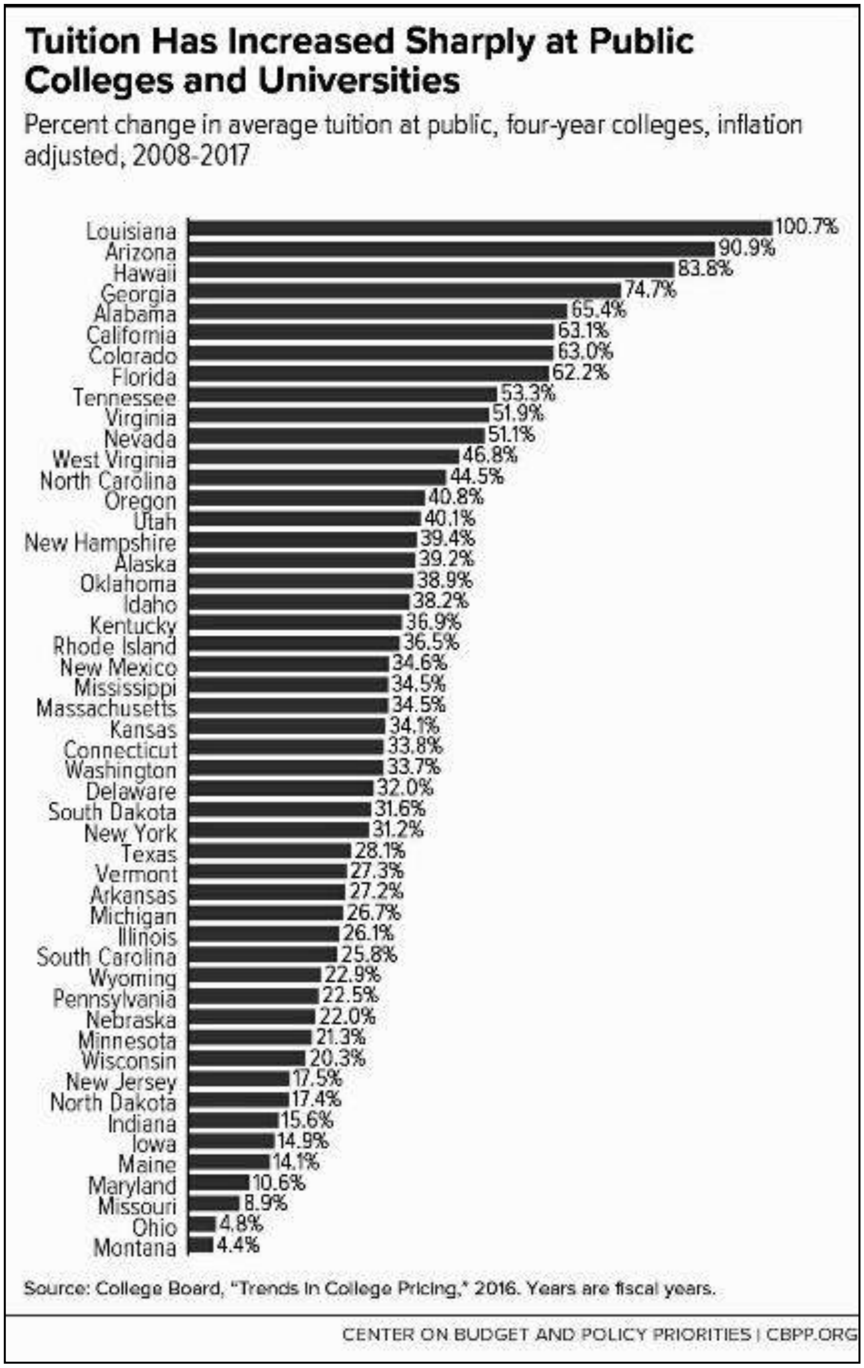

Figure 3 - State funding for higher education vs. tuition increase since 2008 - ***Source: This material was created by the Center on Budget and Policy Priorities (www.cbpp.org).***

However, tuition increases seemingly are unavoidable as many states or governing bodies impose caps on the institutions' freedom to establish them. Another factor to consider is the decrease in enrollment, which impairs attempts to offset budget cuts with tuition increases. It is important to notice that between the years of 2010 and 2017 the estimated growth in the U.S. population was approximately 5.5% [7]. National Center for Education Statistics (NCES) [8] data indicate a decrease in total enrollment in post-secondary education institutions during the same period, as shown in Figure 4. The reasons for that decrease are not in the scope of this paper; however, the secular trend is important for strategic planning.

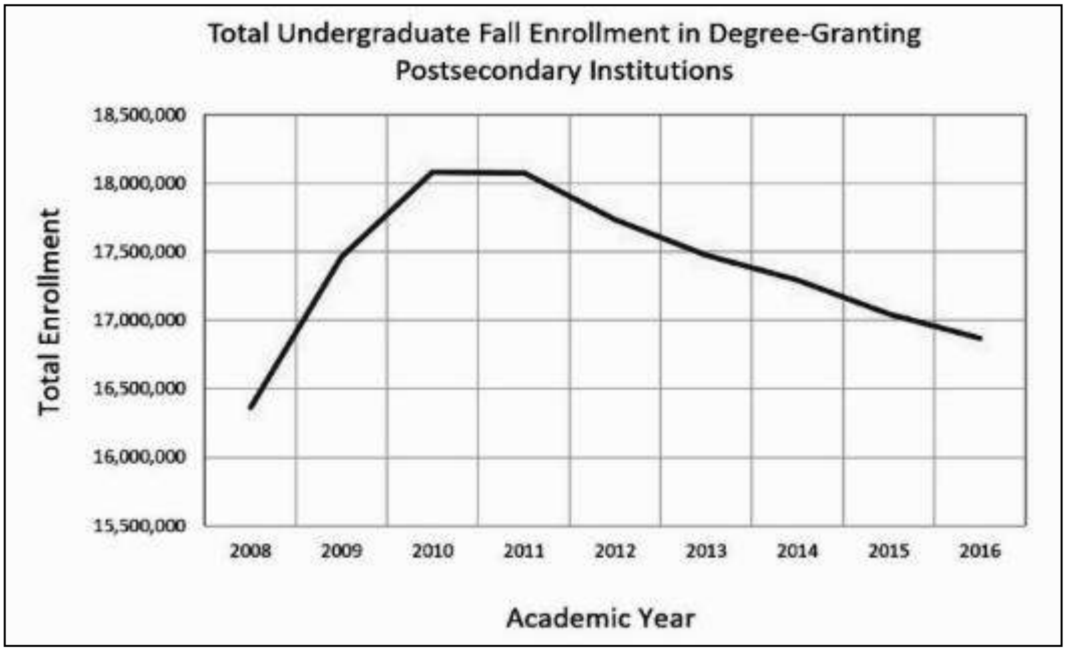

Figure 4 - Total undergraduate fall enrollment in degree-granting postsecondary institutions. ***Source: NCES***

In this scenario, administrators have to face difficult decisions, involving prioritizing resources to face non-discretionary expenses (e.g., utilities, health insurance premiums paid by employers, and many others) in lieu of investment in educational equipment and facilities.

With budget shortfalls for education, and lack of sufficient funds generated by grants, some institutions are eager to reach collaboration with private-sector organizations. Institutions are required to show (among other aspects) their support to programs by providing adequate classrooms, laboratories and equipment to enhance students' hands-on experiences to facilitate the attainment of student learning outcomes.

4. ETAC GENERAL CRITERION 7 – FACILITIES

Accreditation Board for Engineering and Technology (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 [9]. Nevertheless, the outcomes of the program are established and assessed through a process consistent with the current criteria and guidelines of ABET-ETAC [10] for accrediting engineering technology programs. These guidelines embrace all aspects in the program, and the ETAC General Criterion 7 [11] focus specifically in the facilities (and related resources) available to support it.

NKU Engineering Technology Programs (EGT) occupy 9 rooms on the second floor of the Business Center to accommodate the faculty and program's administrative specialist's offices. All laboratory classes are taught in the following rooms, all located in the first floor: BC108, 115, 117, 121, 125. The EGT also uses some conventional classrooms on an as-needed basis. The Business Center building floor plan (first floor is depicted in Figure 5.

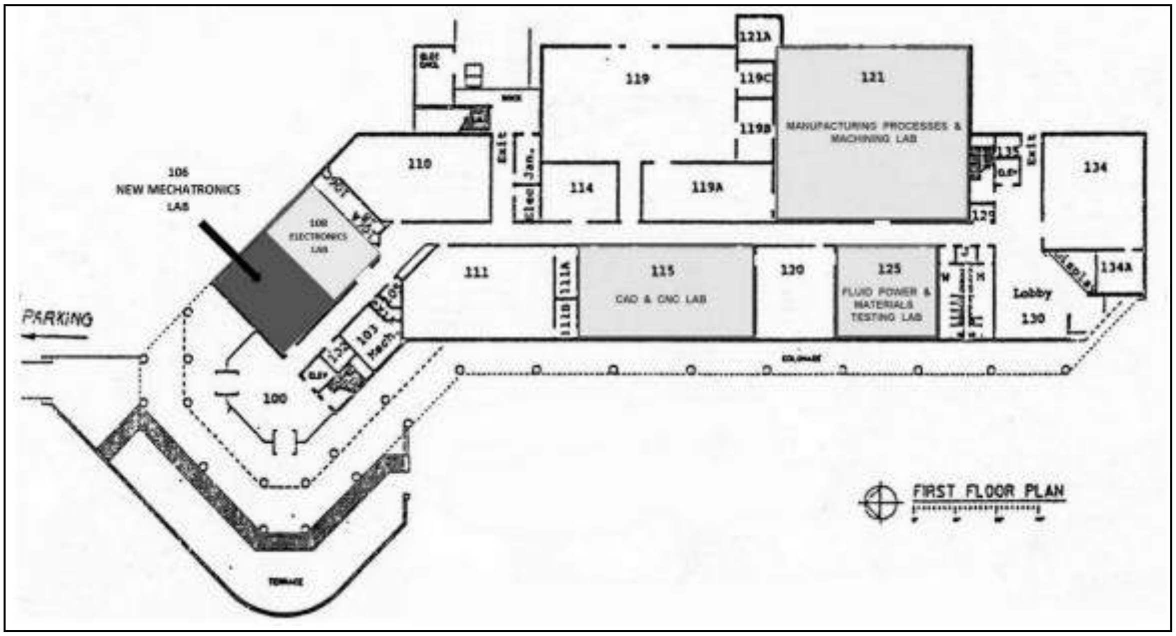

Figure 5 - BC building floor plan - New mechatronics laboratory location

These facilities support the long established MMET and the EEET programs; however, the newly established Mechatronics Engineering Technology (MET) still lacks a dedicated automation laboratory.

5. LABORATORY IMPLEMENTATION AND IMPROVEMENT GUIDELINES

A solid understanding of multi-domain dynamic systems with accompanying modeling and analysis techniques is the key technical skills set that mechatronics engineers should master [12]. 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. [1] in designing each specific laboratory. The planning and implementation of the mechatronics laboratory should follow the following guidelines, which were adapted to the NKU context:

- The laboratory should be designed to support a set of experiments to enable application of the concepts presented in the lecture part of course.
- The laboratory should be designed to use equipment from world-class enterprises and leading and popular technology in the market to the maximum extent possible.
- Instead of just a demonstration or validation of learned theory, the laboratory equipment and devices should be developed to be as close as possible to the real-world industrial situations.
- The laboratory should have enough sets of instrumentation and components to provide each student with a significant hands-on experience.
- The laboratory should provide enough space and equipment so that teams of two to three students can work together on experiments or projects.
- The laboratory should be planned to be consistent with the orientation of the mechatronics program at the institution (e.g., NKU).

6. UNIVERSITY-PRIVATE-SECTOR COLLABORATION (UIC)

According to Liew et al. [13], UIC is largely reliant on the ability to identify the common denominators between the university and the industries that rely on the expertise and graduates on engineering-related programs. They will become the parameters that will be prioritized in the collaboration framework to ensure the resources of both collaborators are sufficient. An opportunity was devised by Rockwell Automation, Inc. in the sense that students training in Rockwell's equipment will likely be in decision-making positions few years after graduation, which may affect selection of equipment and systems for future needs.

The Allen-Bradley brand of programmable logic controllers (PLC) and automation systems [14] are owned by Rockwell Automation and it is widely adopted by industries that employ engineering graduates. To carry out this initiative a collaborative agreement between NKU and Rockwell Automation was reached. Under this agreement Rockwell provided state of the art automation and control equipment at subsidized cost and NKU agreed to provide the laboratory space, infrastructure support as well as the complementary funds for hardware and software renewal fees. The Rockwell offer have included equipment for 10 workstations, as per Table 1:

Table 1 - List of equipment for the mechatronics laboratory

Item	Descriptio n	Qty.	Notes
1	Allen-Bradley 5580 controller w/ power supply, 7 slot chassis and analogic input & output modules	1	Supplied by Rockwell
2	Human Machine Interface (HMI) w/ power supply	1	Supplied by Rockwell
3	Variable frequency Drive	1	Supplied by Rockwell
4	PC desktop computer	1	Supplied by NKU
5	Ethernet switch	1	Supplied by NKU

A homemade commonly used input/output device box/panel is being developed by students under faculty supervision, funded by an internal research grant. A mini- conveyor belt, photoelectric and color sensors and motors are also included to closely simulate real industrial control systems. The integration with existing Fanuc robots is also envisioned.

It is expected that this lab will:

- Support laboratory-based experiential learning in state-of-the-art Allen-Bradley PLCs, ladder diagram PLC programing within Studio 5000 environment, instrumentation and control systems design, etc.
- Provide a real industrial automation environment for EGT students to assemble, program, and operate integrated manufacturing systems.
- Give capstone design students the opportunity to facilitate their design of systems, development, and testing to meet the needs of project sponsors.
- Allow the EGT faculty top conduct all sorts of applied research in manufacturing, intelligent product design, networks, and mechatronics engineering.

Moreover, the lab can be used to support K-12 STEM education and recruit more students from the area community and technical colleges in an effort to create awareness of STEM disciplines in general and in engineering in particular.

After a procurement for a suitable space, the campus planners decided to proceed with the installation in an existing classroom located in the BC building, as indicated in

Figure 5. This decision was based on the resources needed for renovation and network/electrical connections availability. The layout for the laboratory is depicted in Figure 7 below:

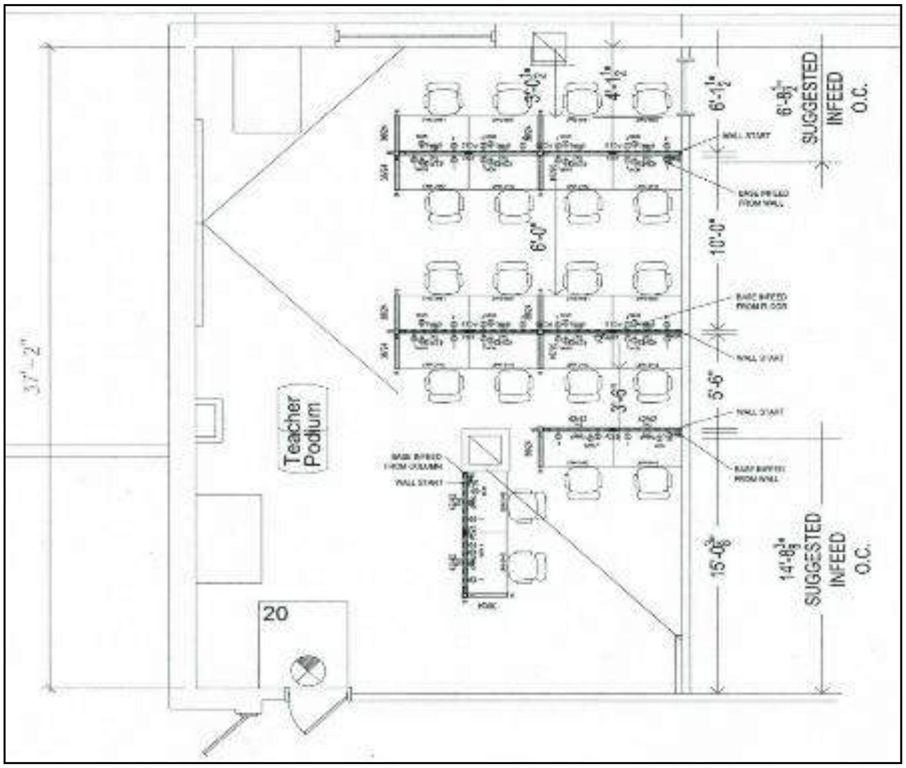

Figure 7 - Mechatronics laboratory layout - room BC106

Figure 8 depicts the mechatronics laboratory at an advanced stage of completion.

Figure 8 - Mechatronics laboratory - general view

Existing furniture sourced from an existing computer lab was retrofitted with slot panels to accommodate the equipment, which was inspired in the PLC laboratory implemented at Kent State University under a similar UIC initiative. This arrangement allows flexibility for future expansion or upgrades in the workstations.

7. CONCLUSION

The Mechatronics lab is designed to meet the needs of industries employing engineering graduates in Northern Kentucky, Southern Ohio and Southeast Indiana areas; skilled mechatronics engineers and technologists are in demand to support their integrated manufacturing industry needs. This facility is equipped to prepare students to fill positions in automation, control, instrumentation design, and robotics areas.

A dedicated mechatronics laboratory is necessary, not only to support the new Mechatronics program, but also to improve the classes from the other programs that will become part of the curriculum; the design of laboratories like this one is also important.

Other mechatronics programs may find aspects of the NKU design of educational spaces and framework useful. Moreover, collaboration with the private sector expands and enhances the academic experience of students. The embedded workforce development opportunities are advantageous to the students, institutions, and employers in ways far beyond what was articulated here.

8. FUNDING

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