Addressing Rural Industry and Student Needs through the Manufacturing of a Community College and University Partnership in Mechatronics and Robotics Systems

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Mark Kinney serves as the Dean for Business and Technology at Bay College in Escanaba, MI. He has successfully received over $2 million in grants for this small, rural institution, which have been used to transform the technical education the institution provides. Most recently, Mark successfully authored an OER Degree Initiative grant through Achieving the Dream to develop a complete degree pathway using nothing but open educational resources. Mark served on the development committee for the Voluntary Framework of Accountability, an initiative of the American Association of Community Colleges, and has also recently founded a non-profit community initiative known as the Upper Peninsula's World Improvement Scavenger Hunt, or UP WISH. Mark has also recently completed his dissertation on the roles of rural educators and rural community colleges, and believes this is an underrepresented segment of our national higher education system.

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Abstract

Meeting the employment needs of regional industries can be difficult in any environment, but doing so in rural locales represents an especially challenging, yet critically important, mission. Community colleges are generally well-suited to the task of producing graduates with the necessary skill sets for entering the workforce and meeting this demand, but rural institutions face a major barrier in the form of insufficient resources to purchase equipment, hire qualified staff, and provide facilities to support multifarious academic and technical programs. Additional challenges such as a lack of enrollment, student demographic homogeneity, and geographic isolation also disproportionately impact rural higher education. Faced with these challenges in 2014, Bay de Noc Community College developed an innovative partnership with a regional university to leverage economies of scale through the sharing of talent, resources, and even students, in order to address local workforce needs in the area of Mechatronics and Robotics Systems. This partnership has resulted in a stackable degree program that provides students with multiple exit points, the development of non-credit workshops for other educational faculty and incumbent workers, and even the creation of robotic simulation software.

Now, three years after the advent of this partnership, Bay de Noc Community College and Michigan Technological University are able to share their model of collaboration with other rural and urban communities to demonstrate how effective partnering between the two-year and four-year levels of higher education can alleviate many of the challenges that afflict community colleges, especially those from a rural environment. Co-developing curriculum, working with the same equipment, utilizing elective options effectively, and creating clear articulation agreements have all proven to be successful strategies for creating stackable credentials that cross institutional barriers. Furthermore, the work of these institutions has led to insights surrounding future improvements that can be implemented, such as by creating student-level partnerships that completely break down geographic, demographic, and philosophical barriers between community colleges and universities. This paper provides an overview of this partnership, a description of the successful strategies that should be scaled up elsewhere, and a researched discussion of how student-level partnerships may be the next big step for rural community colleges.

The Challenges of Rural Education

Providing postsecondary educational opportunities within a rural context presents numerous distinct challenges that educational institutions must address. Even defining the concept of rural can be inconsistent and challenging. The United States Census Bureau defines an urbanized area as being one of 50,000 or more people, while an urban cluster is an area of at least 2,500 people and less than 50,000 people[1]. By process of elimination, rural areas would include all areas not contained within either an urban area or an urban cluster, although further distinctions of fringe, distant, and remote rural environments are often made[2]. Regardless of its exact definition, persistent poverty within these communities has been an ongoing problem, with approximately

15% of rural counties having poverty rates of greater than 20% in each decennial since 1980[3]. These high poverty rates then lower property values, which in turn lowers millage revenues for colleges and exacerbates the inadequacy of the resources already in short supply[4]. Rural contexts also typically contain different types of industries than more urban environments, and within those industries exist a different set of expectations for the skill sets of entering workers[5]. Given the smaller size of these employers, employees often find themselves in less-specialized job roles, forcing them to have a broader knowledge base than is typical in more urban settings. Colleges in rural contexts also tend to have lower enrollments and fewer resources at their disposal, making it difficult to offer the full array of programs needed to meet these diverse industry needs. Failing to respond to regional employment needs is unacceptable, however, since no other educational institutions are locally available to fill this training gap. Furthermore, the ability of employers to recruit employees to the region is hampered not only by their geographic isolation, but also by their inability to pay employees as much as they might earn in urban locales. The local community college is often therefore faced with a nearly impossible task. They are the only source for practical education and workforce training, yet they do not have the resources needed to meet the diverse regional demands of the employment market.

Such a situation was encountered at Bay de Noc Community College (Bay College) in Escanaba, MI when the Dean for Business and Technology, Mark Kinney, began meeting with local employers to discuss their human resources needs. Whereas one employer needed one or two people with electrical skills, another employer needed one or two people with knowledge of fluid power systems. Still others needed blueprint reading, machine tool skills, knowledge of industrial motors, understanding of process control techniques, robotics and automation abilities, or a wide variety of other skill sets. Because Bay College supports a student population of just 1,700 during the typical fall semester and has a similarly limited set of financial resources available, creating a separate academic program to address each of these skill sets was impossible. For many years, these demands simply went unmet, creating a desperation among local industries to find affordable talent and putting tremendous pressure on the college to find a solution.

Fortunately, such a solution presented itself when Kinney visited Michigan Technological University (Michigan Tech) in the fall of 2013, meeting with Associate Professor of Electrical Engineering Technology, Aleksandr Sergeyev. As Sergeyev provided a tour of the university's facilities, the two began to craft a vision for a program that was broad enough to cover the diverse needs of regional employers, customizable enough for students to tailor their educational experience to the requirements of a specific industry or employer, and stackable in a way that allowed students to receive as little or as much education as they required. Furthermore, this educational pathway would represent a partnership between the community college and the university in an unprecedented sharing of curriculum, equipment, and knowledge. The two institutions soon pursued a grant through the National Science Foundation's Advanced Technological Education fund and, in 2014, received funding for their project. Now, three years later, the Mechatronics and Robotics Systems program at Bay College is one of the fastest growing programs on campus with new opportunities being discovered each day for student employment and educational partnering. The remainder of this paper describes the ways in which this program was designed, the results that have been realized thus far, and a description of several unexpected benefits that make replicating such a partnership at other rural community colleges a strong recommendation.

An Overview of the Program

The final grant award for the proposed project between Bay College and Michigan Tech totaled $702,324, much of which was dedicated towards personnel costs for designing curriculum, creating an articulation agreement between the institutions, and developing robotic simulation software that could be used both within the classroom and beyond. Money was also reserved for stipends to be paid to participants in non-credit workshops that the institutions committed to develop, for travel to conferences and meetings, and for instructor professional development. In order to truly align the curriculum and provide a seamless transfer experience for students, however, the institutions also decided that Bay College should possess and use the same robotics equipment as Michigan Tech. Approximately $100,000 was therefore allocated towards the purchase of three FANUC LR Mate 200iD robots, with roughly another $25,000 for add-on options like battery packages and pill sorting packages. Much to the benefit of Bay College, an additional three robots were later able to be purchased due to a successful Community College Skilled Trades Equipment Program grant application through the State of Michigan, thus outfitting their Mechatronics and Robotics Systems lab with a total of six robotic stations.

A stackable credentials model was then used for the program's curriculum, consisting of a one-year certificate, a two-year associate degree, and a four-year bachelor degree. The Mechatronics certificate consists of 24 contact hours and features three required courses and three elective options. This is an important design element, as the elective options give students the ability to customize their program to the specific requirements of whatever employer or industry they are targeting. For example, during an initial advisory board meeting for the program, numerous employers expressed that the inclusion of a then-required Blueprint Reading course was unnecessary. Soon after the course was removed from the program, however, other employers provided contradictory feedback that the inclusion of a course in blueprint reading would greatly enhance the certificate. This particular course is now included as an elective option, but the larger lesson learned was to keep the certificate somewhat customizable to help meet the diverse needs of area employers. A copy of the certificate program course list is included as Figure 1.

Requirements – Min 24 credits

ELEC-130	Circuit Fundamentals I	4
ELEC-180	Electrical Machinery and Controls	4
ELEC-285	Fluid Power	4
XXXX-XXX	Approved Electives	12

Approved Electives

ELEC-145	Basic Process Control	4
ELEC -290	Introduction to Programmable Logic Controllers	4
MATH-102	Introduction to Technical Math	4
TECH-100	Basic Machine Tool Operation	4
TECH-101	Blueprint Reading	2
TECH-105	Materials of Industry	4
WELD-110	Introduction to Oxygen-Fuel Welding and Cutting	3
WELD-120	ARC Welding	4

Suggested Sequences Per Semester

		Cr / Ct
First Semester		
ELEC-130	Circuit Fundamentals I	4/4
ELEC-285	Fluid Power	4/4
XXXX-XXX	Elective	X/X
		12/12
Second Semester		
ELEC-180	Electrical Machinery and Controls	4/4
XXXX-XXX	Elective	X/X
XXXX-XXX	Elective	X/X
		12/12

Figure 1: Course Overview of the Mechatronics Certificate

The associate degree program is a two-year degree comprised of 60 contact hours. Keeping with the tenets of the stackable credentials model, completers of the Mechatronics certificate are able to enter the Mechatronics and Robotics Systems associate degree as sophomores, with all courses from the certificate counting toward the associate degree. In order to advance the skill level of certificate completers, as well as to begin preparing students for their possible transfer to Michigan Tech, associate degree students are introduced to several courses in robotics and are required to take an assortment of general education courses. A complete course listing for the Mechatronics and Robotics Systems associate degree is included as Figure 2.

General Education Requirements – Min 15 credits

		Cr
ENGL-101	Rhetoric & Composition	3
BUSN-177	Mathematics of Business -OR- MATH-105 -OR- MATH-107	3/4
XXXX/xxx	Social Behavioral Science\Humanities	3
XXXX-xxx	General Education Electives	5-6

Program Requirements (Minimum 32)

ELEC 130	Circuit Fundamentals I	4
ELEC 145	Basic Process Control	4
ELEC 180	Electrical Machinery and Controls	4
ELEC 240	Real Time Robotics Systems	4
ELEC 245	Robotic Vision Systems	4
ELEC 285	Fluid Power	4
ELEC 290	Introduction to Programmable Logic Controllers	4
ELEC 295	Mechatronics	4
XXXX/xxx	Approved Electives	13

Approved Elective (13 Credits)

CNSS 130	Introduction to Networks	4
CNSS 150	A plus Computer Maintenance	4
CNSS 220	Network Design	4
ELEC 135	Circuit Fundamentals II	4
ELEC 160	Electronics I	4
ELEC 170	Digital I Fundamentals	4
ELEC 272	Mechatronics Co-op Internship	1- 8
TECH 100	Basic Machine Tool Operation	4
TECH 101	Blueprint Reading	2
TECH 105	Materials of Industry	4
WELD 110	Intro to Oxygen-Fuel Welding and Cutting	4
WELD 120	Arc Welding	4
XXXX xxx	Any General Education Course	

Suggested Sequences Per Semester

		Cr / Ct
First Semester		
ENGL 101	Rhetoric & Composition	3/3
ELEC 130	Circuit Fundamentals I	4/4
ELEC 285	Fluid Power	4/4
XXXX xxx	Approved Electives	4/4
		15/15
Second Semester		
XXXX xxx	Approved Electives	4/4
ELEC 145	Basic Process Control	4/4
ELEC 180	Electrical Machinery and Controls	4/4
BUSN 177	Mathematics of Business Or- MATH 105 Or- MATH 107	3-4/3-4
		15/15
Third Semester		
ELEC 240	Real Time Robotics Systems	4/4
ELEC 290	Introduction to Programmable Logic Controllers	4/4
XXXX xxx	Social Behavioral Science or Humanities	3/3
XXXX xxx	General Education Elective	3/3
		14/14
Fourth Semester		
ELEC 245	Robotic Vision Systems	4/4
ELEC 295	Mechatronics	4/4
XXXX xxx	Approved Elective	5/5
XXXX xxx	General Education elective	3/3
		16/16

All Internships and Co-ops may require that the student pass a criminal background check.

Figure 2: Course Overview of the Mechatronics and Robotic Systems Associate Degree

In addition to the development of these degree offerings at Bay College and their accompanying pathway into the Electrical Engineering Technology bachelor degree program at Michigan Tech, the two institutions also partnered on the creation of several other educational opportunities. The first of these educational options are stand-alone, non-credit workshops – one for higher education faculty, and a separate one for high school juniors and seniors considering the pursuit

of a career in robotics. Thanks to the attainment of certified education training in robotics by Sergeyev and Bay College's primary faculty member for the program, Mark Highum, Bay College and Michigan Tech are now be able to offer reciprocal certification opportunities to attendees of the faculty workshop. This industry certification, provided by the robotics vendor FANUC, will help to broaden the scope of the project beyond just Bay College and Michigan Tech by encouraging other institutions to develop similar robotics pathways and by helping to create consistently high-quality robotics education programs across the country. The workshop aimed at K-12 students aims to not only teach young students some introductory skills in robotics, but also hopes to encourage new entrants into this growing field. Lastly, due to the difficulty of giving all students adequate time to practice programming on real robotic arms, there was a recognized need for lifelike and portable simulation software. Thus, a final aspect of this partnership was the development of such software at Michigan Tech. Titled RobotRun, this simulation software is now available through open source licensing to assist students and industry personnel in learning the basics of robotics programming.

Results of Academic Programming and Workshops

Nearly three full years has now passed since the development of this academic programming between Bay College and Michigan Tech, so initial data regarding enrollments, graduations, and workshop participation is now available. During the first year of the certificate in 2015-16, a total of five students majored in the new program. Given Bay College's small size and rural status, this was a modest but encouraging start. Several classes within the program also benefited from strong enrollment due to their inclusion in other degree programs on campus. This practice of including courses from the new major in other well-established degree programs proved to be a valuable lesson learned that is recommended for other colleges looking to replicate this model. For example, Circuit Fundamentals I had a total of 17 students enrolled during its initial offering due to its inclusion as an option within the water resource management program. This benefit of including courses within other degree programs was even more pronounced the following year, when two sections of Basic Process Control were required to support an enrollment of 37 students, again due to the course's inclusion in the water resource management program. During the first year of the Mechatronics certificate, three of the students finished the requirements of the program and were awarded their certificate. As an added benefit, all three of these students then registered for the associate degree program the following year. One additional student completed the requirements of the certificate during the 2016-17 academic year.

Beginning in 2016-17, the associate degree option became available and enrollment began to trend towards that option. Enrollment in the certificate declined to four students during this year, and dropped further to only three students during 2017-18. However, this small decline was more than made up for by the gains of the associate degree. In 2016-17, a total of 15 students enrolled in the Mechatronics and Robotic Systems associate degree. For 2017-18, this number has risen to 18 in the associate degree, meaning that a total of 21 students are now enrolled in either the certificate or associate option in just the program's third year of existence. By way of comparison, long-established programs at the college like business and computer networking only have enrollments of 49 and 35, respectively, suggesting that the Mechatronics and Robotics Systems degree is already supporting numbers that make it one of the college's signature offerings. As of the end of the Fall 2017 semester, a total of six students have graduated with the associate degree. These enrollments are only expected to increase in the coming years, given the

job growth being realized in this industry. Recent estimates by the International Federation of Robotics suggest that by 2019, more than 1.4 million new industrial robots will be installed in factories around the world[6]. Furthermore, 2016 saw a 14% growth in new robot installations worldwide, with average global growth of 13% expected annually until 2019[6].

Figure 3: Bay College's new Mechatronics and Robotics Lab

The non-credit workshops have also started successfully, with a total of eight people attending the initial workshop at Michigan Tech, which was titled *Revamping Robotics Education to Meet 21st Century Workforce Needs*. The primary idea behind the workshop was that there is a significant need for industrial certification programs in robotics, since it is increasingly used across industry sectors to improve production throughputs while maintaining product quality. The benefits of robotics, however, depend upon workers with up-to-date knowledge and skills to maintain and use existing robots, enhance future technologies, and educate users. It is therefore critical that education efforts respond to the demand for robotics specialists by offering courses and professional certifications in robotics and automation. In an effort to help meet this need, the workshop introduced participants to new approaches for teaching industrial robotics to match industry needs and provide a replicable model for programs around the US.

The workshop had a maximum class size of 12 and offered a stipend of $500 to attendees to offset their time and travel, thanks to available grant funds. However, despite this incentive, several people either did not show up for the workshop or canceled at the last minute, bringing the final attendance count to eight participants. It was therefore decided that a good practice might be to charge attendees a $200 deposit at the time of registration, to be returned to them with the additional $500 stipend once they successfully attend. This strategy was attempted when Bay College offered its first version of this workshop in December 2016. Unfortunately, attendance results were not improved. A total of just four participants made it to the workshop, despite a total of nine being registered. Incidentally, all five who dropped the course did so before paying the registration fee. Those who did attend the workshop gave positive reviews, however. On the affective post-test given to workshop participants, the average score given to all survey items was 4.77 out of 5, with 5 being a positive review of that course component. Furthermore, all four workshop participants gave a 5 out of 5 rating to the following questions: (1) The workshop gives experiences that could not be duplicated online, (2) Time was well-used during the hands-on workshop, (3) Overall, the hands-on workshop was well-designed and taught, (4) I have gained significant practical experience from this course, and (5) I learned a great deal from this course. From a knowledge and skills-attainment perspective, workshop

participants were given both a pre-test and post-test to measure their learning from the course. On the pre-test, the four workshop participants had an average score of 9.25 on the 20-question test, with two participants getting 15, one participant getting 4, and one participant earning a score of 3. On the post-test, the average score rose to 16.5, with two participants getting 19, one getting 15, and one earning a score of 13. Given the remote and wintery locale of Bay College, the college decided to attempt to increase enrollment by holding the following year's workshop during the warmer fall months. The change in timing, coupled with new marketing practices, seemed to pay off with a total enrollment for the 2017-18 workshop of eight participants.

Another non-credit workshop with much better attendance success was that which was aimed at K-12 students. This workshop was held on a Friday and attendees were excused from their regularly scheduled high school classes. The class ran completely full at 12 participants. In order to recruit participants, area high school instructors from several local schools were asked to invite their best students to the workshop, ensuring that those in attendance stood to benefit from the curriculum and also served as strong possible future college students. At the workshop, participants learned basic principles of industrial robots, including topics on robotic safety, basic mechanics and controls, robotic frames, and programming architecture. Hands-on activities that were age- and skill-appropriate for high school students taught them the basic concepts of optimal robot programming and manipulation utilizing industrial robotics. Students were introduced to basic programming functions and taught how to optimize a robotic path to conduct a simulated industrial task. Utilizing the RobotRun simulation software developed under the grant, students were able to play games and conduct basic programming tasks to simulate the robotically controlled process. Feedback received was very positive the day camp ran again during the spring of 2018, this time to a group of students from a local intermediate school district (ISD) who had recently started a mechatronics program.

RobotRun Software

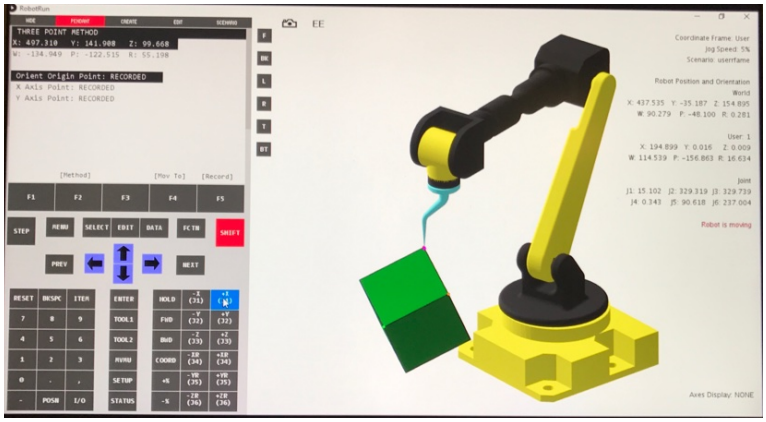

Figure 4: A screenshot of the RobotRun software

Another aspect of the grant partnership between Bay College and Michigan Tech is the development of robotics simulation software, titled RobotRun (Figure 4). This software has been fully developed and is available for free download under an open source license. The software simulates the programming and operation of a robotic arm, allowing students and industry personnel to craft programs and test them from the comfort of their home or office without taking up valuable time on an actual robot. Instructional lab exercises that have been co-developed by Bay College and Michigan Tech faculty also provide practice opportunities for students that teach them about common programming mistakes and the proper technique to perform certain actions.

Other Developments

One of the most important steps taken at Bay College during the grant period was to send its primary faculty member to receive training and certification from Integrated Systems Technologies (IST). This training not only prepared him to teach the courses now offered at Bay College, but also enables the institution to offer that same certification to its students and non-credit workshop participants. Given the limited number of locations available that offer this certification, the hope is that this training will pay off in the form of increased participation at workshop events in the future.

An unexpected development in 2017-18 has been the increasing level of interest on the part of area employers to develop quasi-apprenticeships in which employees of the organization take a customized selection of courses from the certificate in order to pick up new skills. While the certificate was intentionally designed with this sort of customization in mind, the anticipation was that students would choose courses based on the employer or industry they were *targeting*, not that the employer/industry would customize the courses and send current employees to take them. Still, this growing interest is a welcome addition to the program and several partnerships are currently in development, with one already firmly established.

Area high schools and ISDs have also started expressing an interest in the program and several early colleges are now in development. These early colleges will allow students to start taking college-level courses in their junior year of high school and will have them complete the Mechatronics and Robotics Systems associate degree after a fifth year that is paid by the high school. Students will therefore earn their high school diploma and a college associate degree at the same time, without ever incurring any cost of their own. While this program is still in development at Bay College, one area ISD has already applied for and received a grant that will allow them to purchase their own version of the equipment being used for the Mechatronics program. Students will therefore begin their studies during their high school years at the ISD, then will articulate that credit to Bay College to complete their associate degree.

Next Steps

Now that the academic curriculum and non-credit workshops have been developed, much of the work moving forward will focus on enhancing the partnerships that have already begun to take place with local employers and K-12 institutions. Continuing to grow the enrollment in the program will also be a primary focus, as the number of employer requests for graduates currently greatly exceeds the number of graduates available for work. Additional non-credit workshops will be held for both higher education faculty and K-12 students, and the possibility exists to offer workshop training sessions for current employees of local industries.

Another exciting possibility for the future of this partnership is the development of student-level collaboration between the programs at the community college and university. In its current form, the partnership exists on an institutional level, with students benefitting from shared curriculum and similar equipment, but only experiencing the transfer institution upon their actual transfer to the university. The proposed development would create a partnership at the student level, in which students who are currently enrolled at the community college work alongside those who are freshmen and sophomores at the university. This type of partnership would not only help the

two institutions to further align their curriculum and ensure consistent student progress is being made, but would also help to alleviate some of the fear that community college students often feel towards the larger university environment. Becoming acquainted with both students and faculty at the university might also help encourage more students to take advantage of the transfer pathway, thus encouraging higher levels of education in the robotics industry. Given these developments, and the continued efforts between these institutions to enter into further partnerships in an ever-broadening range of academic programs, the benefits of this community college and university partnership continue to pay off in unexpected ways. Replicating such a model of collaboration at other colleges and universities, especially in rural contexts such as that surrounding Bay College and Michigan Tech, is highly recommended.

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