2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #37844

From Grant to Graduates: The Development of a Regionally Unique Siemens Level-3 Mechatronics Engineering Technology Program

Prof. Matthew S. Anderson, Austin Peay State University

Professor Matthew S. Anderson is an Assistant Professor in the Engineering Technology department at Austin Peay State University in Clarksville, TN. Professor Anderson's academic interests are in the field of Mechatronics, and he has completed up through Level 3 SMSCP training with Siemens. He has been a full-time faculty member at Austin Peay State University since 2016 and is currently working towards obtaining tenure while serving as the Mechatronics concentration coordinator in the Engineering Technology department. Additionally, he is currently completing the final year of an EdD in Educational Leadership. Other research interests include Industry 4.0, regional workforce development, and gender disparities in the engineering fields.

Alyssa Young, Austin Peay State University

From Grant to Graduates: The Development of a Regionally Unique Siemens Level 3 Mechatronics Engineering Technology Program

Abstract

As the result of a Department of Defense (DoD) grant in 2017, training and laboratory equipment were procured, and a curriculum was created to develop a new four-year Mechatronics Engineering Technology (ET) degree program. Specifically funded by the DoD entity formally known as the Office of Economic Adjustment, the new baccalaureate degree program provided a means for military-affiliated students to obtain a technical education at the four-year level in preparation for employment in regional industrial facilities. Under the grant, the degree program was to follow the Siemens Mechatronics Systems Certification Program (SMSCP) that offered student certification via an examination provided by Siemens in a tiered-level system, with Level 3 being reserved for the baccalaureate degree programs. The authors' home institution's ET department was chosen to host this SMSCP Level 3 degree program, with the program being regionally unique as the only Level 3 ET-based program. The pathway to the development of this program, as experienced by the lead faculty member and an early enrolled student employee, has been detailed in this composition. By weighing the strengths and weaknesses of the development and scheduling of the SMSCP-specific courses, the integration of these courses into the existing ET core courses shared by other concentrations, limited faculty availability, training equipment availability, and other aspects of degree development, an indication of the success of the program has been established. Further, through a successful transfer agreement with a surrounding two-year community college and other transfer pathways, the Mechatronics ET baccalaureate degree plan has had 10 graduates by the Spring of 2022, with three graduates taking and passing the pilot SMSCP Level 3 examination in the summer of 2022. An additional 11 students graduated in the Fall 2022 semester, and a location-specific faculty member will be hired in the spring of 2023.

Introduction

Due to the federally directed restructuring of the United States Army in the mid-2010s, military bases experienced reductions in personnel [1], [2]. As a result of these cuts, support organizations and grants were created to ease the economic burden of these reductions [3]. The effect of one of these federal grants was the procurement of approximately $300,000 in equipment slated for use in a newly revamped Mechatronics Engineering Technology (MCET) degree program at the author's home institution. The MCET program was to offer both an Associate of Applied Science (AAS) and a Bachelor of Science (BS). Since there was a connection to regional community colleges stipulated in the funding, the MCET program was to follow a common format in the state. That format was the Siemens Mechatronics Systems Certification Program (SMSCP), including their tiered certification program [4]. At the time of awarding the grant funding in 2017, a competing university in the region was beginning to offer a new level of the SMSCP certification aimed at the BS degree engineering graduate. The author's home institution took advantage of the newly developed Level 3 SMSCP tier when creating, at that time, the undeveloped four-year SMSCP BS MCET degree program curriculum.

The BS MCET curriculum was fashioned with advanced topics from the AAS SMSCP specified courses; additional topics relating to project management and capstone projects [5]; and integration of the general ET courses already offered. After completing the SMSCP instructor training needed to teach in the Siemens program, the lead Mechatronics faculty author began teaching the courses specific to the SMSCP in 2019. Through a strategic rotation of course offerings, the author could offer the SMSCP-specific courses at least every two years. Additionally, when possible, SMSCP-specific courses in the AAS MCET program were offered in this schedule. With external transfer pathways into the BS program as required by grant funding, students graduated from the program by 2021. Further, some students that started at the initiation of the BS MCET program at the author's home institution in 2019 graduated by the Fall 2022 term. One such academically talented student that began at the program's initiation and later chose to become a student worker for the department has detailed her experience with the program to present as a coauthor of this work.

Further Context

As a result of defense restructuring in 2014 and 2015, Fort Campbell military base was required to cease operations of two of its major divisions [1], [2]. This reduction in personnel removed approximately 5,800 soldiers from the base, spurring plans to create organizations to support military-affiliated individuals in the region in various areas [3]. One such organization was the Fort Campbell Strong initiative which facilitated the procurement of equipment to assist in regional workforce development and form the Campbell Strong Defense Alliance [6]. The Fort Campbell Strong initiative was funded with $1.2 million by a grant from the Department of Defense through its Office of Economic Adjustment (OEA) division which was later renamed the Office of Local Defense Community Cooperation [6], [7]. The strategic goals of the Campbell Strong Defense Alliance included the support of growth in the region, developing educational and employment opportunities for displaced soldiers and families, strengthening the regional workforce, and leveraging collaborations with the installation and the community [8]. To support these goals, funding was used to purchase the equipment at a regional applied technology institution, a two-year community college, and the authors' home university [6], [9]. Moreover, funding was paid for training two instructors employed at the authors' home institution with Siemens in all three levels of the tiered SMSCP system. This training occurred in the summer of 2017 in the United States and Berlin, Germany over 1.5 months.

The SMSCP was developed around the systems approach used successfully by the Siemens company in which any Mechatronics concept is viewed through the lens of its role in a greater system [10]. Focusing on the idea as part of a greater process can make the concept less isolated, leading to a faster grasp of the notion in the context of a real-world application [11]. The SMSCP Level 2 tier featured a suggested curriculum consisting of approximately 10 courses that could be applied to an AAS degree program, and the 1000-level courses of the curriculum could also be used with a certificate program (SMSCP Level 1 tier) [4]. These 10 courses had varied Mechatronics topics, including industrial automation, electric motors/electrical systems, fluid systems, mechanical systems, and manufacturing processes [4]. The state governing agency for the community colleges and applied technology institutions where the authors' home institution is located adopted this curriculum in its standardized course catalog to facilitate ease of credit transfer among the schools [12]. Under the Fort Campbell Strong grant funding for equipment

purchase, a transfer agreement was to be created that allowed virtually all courses from a specific regional two-year AAS Mechatronics degree using the SMSCP curriculum to be transferred into the BS MCET program at the authors' home institution. Under the agreement, specific SMSCP AAS courses transferred in as credit for non-SMSCP ET courses that are part of the core ET BS degree, while other SMSCP courses transferred as electives or SMSCP courses at the BS level. The grant also required the authors' home institution to offer an AAS degree using the SMSCP curriculum in all possible aspects. Both the SMSCP Level 2 and Level 3 tiers would require that the respective institution allow access to the appropriate SMCP level student certification exam administered by Siemens online through the hosting degree-granting institution.

Approach

When tasked with creating the curriculum for the BS MCET program, faculty and administrators at the authors' home institution looked to the current ET BS degrees with concentrations in Electrical, Manufacturing, and Mechanical areas as a partial list. These concentrations shared a common ET core of 45 credit hours of courses, and the MCET degree was to follow this model. Within the 120 total credits required by ET BS degrees at the authors' home institution, each concentration needed approximately 33 credit hours of concentration-specific courses. These 33 credit hours of concentration-specific courses were to be occupied by courses covering the SMSCP suggested conceptual areas for the SMSCP Level 3 tier. These conceptual areas included advanced versions of the SMSCP Level 2 curriculum, project management, and continuous improvement objectives [5]. A list of the ET core courses and SMSCP-specific courses is shown in Table I. The culminating capstone project was spread over two courses, MET 4100 *Project and Process Management* and MET 4160 *Mechatronics Capstone,* which allowed the project's planning, design, fabrication, and testing combined with an SMSCP-provided Excel-based project management workbook along with a report for documentation of the process.

While five additional faculty members taught the ET core courses, the SMSCP-specific courses were taught solely by the lead author of this work. Although there had been two faculty members SMSCP trained under the grant funding, one of the faculty members was located on a satellite campus approximately 225 miles away. The satellite campus supported a 2+2 Mechanical BS ET partnership with another community college in the state. The original plans were to offer a BS MCET at that location, and the community college would feed students into the program. Unfortunately, that program never materialized, and the faculty member has since resigned when faced with a relocation to the main campus of the authors' home institution after the Mechanical BS ET 2+2 program was removed in 2022. A search for a replacement faculty member with Mechatronics expertise is underway as of Spring 2023.

Because a single faculty member was tasked with teaching approximately 12 SMSCP-specific courses in support of the BS MCET, the scheduling of courses was set up based on three factors. The first factor was a two year-rotation of single-section courses for most of the SMSCP-specific courses. This ensured that the courses would be taught at least once for each traditional four-year cohort and transfer groups enrolling with two years of credit. These transfer students tied into the second factor: the number of students requiring specific courses and coordinating prerequisites from the core ET and SMSCP-specific classes.

TABLE I
ET CORE AND SMSCP-SPECIFIC COURSES

Engineering Technology Core	Credit hours	Mechatronics Concentration	Credit hours
ENGT 1000 Introduction into Engineering Technology	3	MET 2100 Process Control Technologies	3
ENGT 1020 Computer Aided Design	3	MET 3200 Industrial Totally Integrated Automation	3
ENGT 2000 Manufacturing Processes	3	MET 3300 Advanced Automation Systems	3
ENGT 2010 DC Circuits and Applications	3	MET 3400 Electromechanical Power	3
ENGT 2020 Robotic Fundamentals	3	MET 3500 Machine Dynamics	3
ENGT 2030 AC Circuits and Applications	3	MET 3600 Integrated Manufacturing	3
ENGT 2730 Introduction into Solid Modeling	3	MET 4100 Project and Process Management	3
ENGT 3000 Materials Science	3	MET 4160 Mechatronics Capstone	3
ENGT 3010 Engineering Economics	3		
ENGT 3020 Statics and Strengths of Materials	3		
ENGT 3030 Thermodynamics	3		
ENGT 3040 Power Transfer Technology	3		
ENGT 3050 Problem Solving in Engineering Technology	3		
MATH 1730 Precalculus or ENGT 1200	3		
MATH 1810 Elements of Calculus or ENGT 1400	3	MET Electives: MET 1100, MET 1200, MET 1300, MET 1500, MET 2300, MET 2500. Additional MET electives are acceptable with department approval.	9
Engineering Technology Total Credits	45	**Mechatronics Total Credits**	33

For example, if a moderately-sized group of around five students transferred in from community colleges with the appropriate transfer credit, the decision was made to offer the upper 3000 level SMSCP-specific courses. Upper-level courses were chosen because, under the transfer agreement, transfer students would start with the MET 3400 *Electromechanical Power* course since students were given transfer credit for MET 2100, MET 3200, and MET 3300. The third factor considered when scheduling SMSCP-specific courses was the need to select 1000-level courses that did not require prerequisite courses for incoming first-year students into the AAS MCET and BS MCET degree programs. The authors' home institution participated in a state-funded scholarship applicable to two-year degree programs, and the AAS MCET program was one of only four offered. This led to many enrollees in the program, and the need to fill out a 12 credit hour schedule for full-time status supported the offering of those prerequisite-free SMSCP courses. These 1000-level courses applied to the AAS MCET as required courses and as available electives for the BS MCET degree program; however, some courses, such as MET 1500 *Digital Fundamentals and Programmable Logic Controllers* and MET 1200 *Mechanical Components and Electrical Drives,* also served as prerequisites for some upper-level SMSCP-specific courses. The academic advisor of the traditional four-year BS MCET students emphasized the need to complete these courses.

Many of the 1000- and 2000-level, and to a lesser extent, the 3000-level SMSCP-specific courses, relied on the initial $300,000 Mechatronics trainer equipment for lab exercises. This amount of funding procured a suite of eight Mechatronics integrated system modules with a Fanuc robot to transfer workpieces, an industrial electric motor trainer, a modular industrial electric motor control board trainer, and an associated lab curriculum. The Mechatronics system modules were the standardized, small-scale assembly line type that assembled a pneumatic valve in a series of steps using a variety of sensors and actuators in combination with programmable logic controllers (PLCs). In 2020, additional portable trainers for hydraulic and mechanical systems were incorporated into the courses. The authors' home institution already had other robots for additional industrial automation lab exercises.

By the Spring 2022 semester, the BS MCET program had graduated 10 students, two of which took advantage of the transfer agreement with the regional community college. The remaining eight students transferred internally from other concentrations in the ET BS programs. Further, by the Fall 2022 semester, the BS MCET program graduated an additional 11 students with one transfer agreement student participating. Currently, there are approximately five more students transferred in from regional community colleges. The student SMSCP Level 3 certification exam was first administered in the Summer of 2022, with all three participants passing the exam. The second round of the Level 3 certification exam will be offered in the Spring 2023 semester, with four students choosing to take the exam.

Observations and discussion

Judging the BS MCET SMSCP-based degree program overall, the lead author of this work and lead faculty member for the program sees the program as successful. Like any burgeoning program, it has strengths, weaknesses, and opportunities to improve and grow. Starting with its strengths, the program is a unique blend of theory and application-based instruction, as any effective ET BS program should be. However, the level of detail in industrial automation, especially with PLCs and robotics, is different than seen before. PLC instruction goes beyond simple ladder logic into more advanced applications involving mathematical and analog signal problem-solving. This level of industrial automation combined with classical theories such as statics, dynamics, and thermodynamics provides an excellent mix of knowledge. Another program strength is the real-world application of project management during the capstone course sequence. Graduates often cite that the Project Management Institute-based project management course gave them an advantage in the hiring process and is something they use on the job. Lastly, the uniqueness as the only ET-based SMSCP Level 3 program is a strength not only for the graduates of the program due to the SMSCP credential they can obtain but also for the authors' home institution in terms of recruitment. These strengths lead to graduates' satisfaction in finding employment in the industry. Informal polling of students indicated that approximately 33% of graduates were hired before graduation, and 80% of all graduates stated that they had secured a job placement in the region and beyond within the semester following graduation.

The BS MCET program's weakness begins with the limited faculty and its effect on enrollment. The lead faculty often experiences instances where students want to progress through the program more quickly than the standard four years. The current course offering schedule discourages that action. Summer courses are required to meet the four-year timeframe as the

program is structured now. Results have shown that success is achievable through summer courses and independent study course offerings, but these steps are not ideal. Fortunately, the current hiring process will alleviate some of these concerns. Another lesser weakness is the limited availability of training equipment for the lower level SMSCP-specific courses compared to other institutions, such as community colleges of applied technology institutions, where a significant amount of the total budget is allocated for training equipment. The limitation of training equipment availability reduces the total interaction with the equipment per student, often expressed as an issue in student reviews of the courses using the equipment.

This issue highlights another concern about the program's SMSCP aspect, and that is its considerable cost to the authors' home institution and the students. A substantial annual fee is associated with the school's participation in the SMSCP program. This cost draws the attention of administrators when budget allocation is performed. There is also an additional cost for the graduates as students must pay for their own certification exam. The nontrivial expense is a factor in the low number of students taking the certification exam, which is also tied to a regional problem inherent to the SMSCP program. Most industrial employers in the region have a Siemens competitor, Allen-Bradley, as the automation equipment supplier in their facilities. However, this tends not to be an issue regarding graduates securing employment; it simply lessens the attractiveness of the SMSCP certification exam for graduates when combined with the cost of the exam. The final weakness of the BS MCET program at the authors' home institution is the current lack of full Accreditation Board for Engineering and Technology (ABET) accreditation. While all other ET BS concentrations have full ABET accreditation, ABET currently lacks the program-specific criteria for programs named similarly to Mechatronics. However, the author's home ET department has been collecting assessment data for the scheduled publication of Mechatronics program criteria in the coming year for ET degree programs. This should allow full ABET accreditation of the BS MCET program then. Once again, students have consistently cited this issue as a concern in terms of recruitment and the success of graduates.

An academically excelling student began with the 2019 cohort of traditional four-year BS MCET students. She has provided her perspective on the BS MCET program in her own words.

> As a student-worker for the ET department at the host institution, I have learned more about the program and the MCET concentration through more hands-on time with equipment and mentoring from the MCET advisor. It is always my intention to leave something better than I found it, which happened to apply in this context through helping the instructor be more prepared for a course, offering extra course-based help to students if requested, and encouraging others to participate and be not only mentally, but physically engaged in the classes. Further, as a student enrolled in the first complete run of the program, I have experienced first-hand both strengths and weaknesses during my educational path. As a student who elected to enroll in Engineering Technology over the more widely-known traditional Engineering program, an attractive strength of the program was the blend of theory and application. While we learned the theory through more traditional courses, such as those aforementioned, we were encouraged to apply the knowledge using various trainers and equipment

> specifically intended for that purpose. We were not only taught to memorize and recite but also to employ and practice the skills we were learning in the classroom. There are drawbacks to the program, however, with the main dilemma, from my perspective, being that Siemens is not as common as Allen-Bradley controllers in the industrial region. While this may be unfavorable, the training and logic used with Siemens controllers can be fundamentally applied to logic controllers that function with the same concept. As a traditional full-time student, the course scheduling was ideal for me, as all of the Mechatronics concentration-specific classes were offered as sixteen-week courses. Though not ideal, the required summer courses were not too much of a burden as I could still work around the class meeting times. Regarding the ABET accreditation, I chose to complete the Electrical concentration as well to attain the mark of a vetted educational foundation for employers. Alongside its current strengths, the few drawbacks listed above will be minute in relation to the many benefits of potential ABET accreditation and the successes of the program's SMSCP format. [13]

Conclusion

Stemming from federal military reductions in 2014 and 2015 that led to a regional United States Army installation deactivating two divisions, national initiatives were implemented to ease the burden on the displaced personnel and their families [1], [2], [3]. One such initiative produced a grant that stipulated the creation of new postsecondary technical education-based degree and certification programs in the region [6], [9]. The authors' home institution was the recipient of funding for Mechatronics training equipment and instructor training for the SMSCP, which featured a systems approach to technical education. An AAS and BS ET degree program was created using the SMSCP-suggested content areas [4], [5]. This curriculum was chosen because community colleges already used the SMSCP areas for AAS degree programs, and a transfer agreement between a regional community college was a condition of grant funding.

Based on the strengths indicated by the uniqueness of the program regionally and by the success of the graduates of the program securing employment, the BS MCET program is successful despite weaknesses such as limited faculty, limited equipment, the cost of SMSCP membership, and accreditation delays. However, the program's weaknesses are addressable, and currently, progress is being made toward resolving these weaknesses. Furthermore, the program's significance is supported through student testimonials such as from the coauthor of this work and through the success of the 21 graduates from the program since 2019.

References

[1] A. Bushatz. "Army moves to shut down 159th Combat Aviation Brigade." military.com. https://www.military.com/daily-news/2014/11/20/army-moves-to-shut-down-159th-combat-aviation-brigade.html (accessed Feb. 13, 2023).

[2] Y. Smith. "Preserving a legacy: 4th Brigade Combat Team inactivating." army.mil. https://www.army.mil/article/125422/preserving_a_legacy_4th_brigade_combat_team_inactivating (accessed Feb. 13, 2023).

[3] Campbell Strong Defense Alliance. "History." fortcampbellstrong.org. https://fortcampbellstrong.org/about/history/ (accessed Feb. 13, 2023).

[4] Siemens Professional Education, "Siemens mechatronic systems certification program: Program overview," Accessed: Feb. 13, 2023. [Online]. Available: https://www.siemens-certifications.com/content/0/6/7/3391/2876_Overview%20Document_Level1_2.pdf

[5] Siemens Professional Education, "Siemens mechatronic systems certification program: Level 3 (mechatronic systems professional)," Accessed: Feb. 13, 2023. [Online]. Available: https://siemens.dkut.ac.ke/wp-content/uploads/2019/09/SMSCP-Level-3.pdf

[6] T. S. Grace. “Fort Campbell initiative gets funding.” kentuckynewera.com. https://www.kentuckynewera.com/ep/news/article_f2452f2c-7cb6-11e7-83c2-8f9d6635a0be.html (accessed Feb. 13, 2023).

[7] U.S. Department of Defense. "Office of Economic Adjustment is now..." oldcc.gov. https://oldcc.gov/oea-name-announcement (accessed Feb. 13, 2023).

[8] Campbell Strong Defense Alliance, "Strategic goals," Accessed: Feb. 13, 2023. [Online]. Available: https://s42055.pcdn.co/wp-content/uploads/2022/04/campbell-strong-strategic-goals-2022.pdf

[9] Campbell Strong Defense Alliance. “Post-secondary education.” fortcampbellstrong.org. https://fortcampbellstrong.org/workforce-development/post-secondary-education/ (accessed Feb. 13, 2023).

[10] Siemens. "SMSCP: Making tomorrow's workforce fit for the future of industry." siemens.com. https://www.siemens.com/global/en/products/services/digital-enterprise-services/training-services/sitrain/smscp.html (accessed Feb. 13, 2023).

[11] S. R. Haasler, "The German system of vocational education and training: Challenges of gender, academisation and the integration of low-achieving youth," *Transfer: Eur. Rev. of Labour & Res.*, vol. 26, no. 1, pp. 57-71, Feb. 2020, doi: 10.1177/1024258919898115.

[12] Tennessee Board of Regents. "Community college course inventory." tbr.edu. http://catalog.tbr.edu/content.php?catoid=1&navoid=2&p4=11#ent_courses4 (accessed Feb. 13, 2023).

[13] A. K. Young, private communication, Feb. 2023.