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Independent Mechatronics Education Curriculum (iMEC) Professional Development Platform for Engineering Technology

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Abstract

Engineering Technology Skill Sets span many applications within 21st-century manufacturing situations. These traditional technologies are now being modified and enhanced with Industry 4.0 (I4.0) technologies, with the expectation that many Engineering Technology (ET) technicians will address these I4.0-driven industry situations. To ensure that tomorrow's technician will service this expectation, today's ET preparation faculty must know how ET Skill Set skills are applied and adapted to prepare the rising technicians. Effective hands-on Professional Development (PD) for ET Technology faculty responsible for technician Skill Set education is a proactive 1st step. This PD must include the related hands-on experiences for students and facilitate faculty's subsequent transfer of skill learning at appropriate intensities to targeted student cohorts.

Introduction

The Professional Development Platform for Engineering Technology (PDPET) is designed to facilitate the transfer of the Engineering Technology (ET) Skill Sets requirement to faculty responsible for technician preparation. Objectives to be addressed by PDPET include (1) developing and implementing online remote access to the degree program and its Curriculum; (2) creating a skills-focused interactive system with regional education and industry partners; (3) providing targeted skill professional development; and (4) building institutional capacity. When PDPET elements consider these requirements, their application among ET technician preparation programs will create a broader skill impact on new technicians entering the workforce.

The "**i**ndependent Engineering Technology Curriculum" is an excellent example of PDPET. The **i**ndependent Engineering Technology Curriculum (**i**MEC) has been developed, created, and implemented by South Central College (SCC) in North Mankato, Minnesota. **i**MEC impressively integrates the above objectives. The College elected to target high schools via high school technical education educators and employs mechatronics as its instrument for teacher professional development. This target audience is significant to the College because its students will significantly contribute to SCC's ET degree program enrollment and regional industry workforce needs. Mechatronics was selected for three reasons. First, the topic is attractive to the educators and their students. Second, educators can easily blend the materials with courses already developed and delivered at SCC. Third, there is a high demand for skilled mechatronics technicians in Minnesota and nationwide. The **i**MEC platform has already been exported to Nebraska and introduced to other states. The impact of that expansion is summarized, and future developments for iMEC are outlined.

Independent Engineering Technology Curriculum Program (iMEC)

iMEC is an exciting new distance learning program that allows students to access instructors, participate in distance classes, and experience the actual hands-on training of on-site Mechatronics courses. South Central College (SCC) first developed iMEC as a distance learning educational tool with simulation lab kits and remote access delivery methods that allow students in institutions and industry partners to share Curriculum and specialized equipment. After the **i**MEC faculty professional development stage, **i**MEC lessons are used by part-time students as they obtain a Mechatronics Industrial Maintenance Certificate (25 credit hours) entirely online while receiving the same "hands-on" equipment operation and troubleshooting experiences as their on-site classmates. (Certificate courses with their curriculum content are available for review within the SCC mechatronics program website.)

Because of the high cost of equipment in STEM programs, it is difficult for high schools, community colleges, and universities to duplicate ET skill subset-focused laboratories on every institution's campus. Additionally, distance and travel time are barriers for employees to update the skills employers need them to acquire. Traditional students face some of these same barriers. To help remove barriers, South Central College considered how its successful Mechatronics program could be expanded to support industry directly and, additionally, high school students. IMEC was built on the existing in-person Mechatronics program to deliver a comparable experience for remote and virtual students. The **i**MEC “hands-on” trainer used by these distance learners in the Mechatronics Industry Maintenance Certificate program at SCC is shown in Figure 1. It is the initial example of a set of Workstations for Hands-on Learning Experiments (WHOLE) kits under development at SCC.

Figure 1. iMEC Electronics Trainer

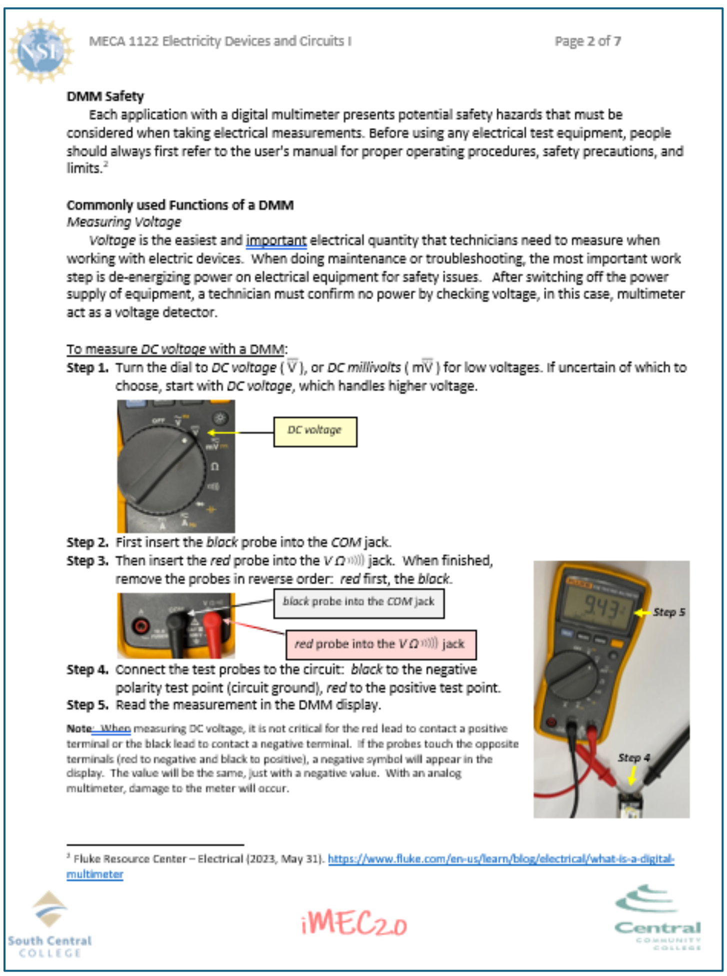
High school Learning and eventually mastering the many technical skills within the Mechatronics umbrella requires "hands-on" experiences using integrated equipment. This requirement poses several teaching challenges. Table 1 below captures some of those challenges.

Table 1 iMEC Addressed Curriculum Pedagogy Issues

1.	High school dual-enrolment program usable in community college services regions.
2.	Learning language levels applicable in high school teaching environments.
3.	Curriculum content that supports academic credit and program continuity.
4.	Seamless prior experience and/or credentials integration into curriculum package.
5.	Flexibility to the "what, when, where, and how" high school courses are executed.
6.	Curriculum transparent to constraints imposed by various accrediting agencies.
7.	Curriculum that supports dual enrollment pathways for high school students.

MECA 1122 Electricity, Devices and Circuits, a course required in SCC's Mechatronics two-year degree program, represents the typical target for **i**MEC modules. (This course’s learning objectives mimic any technician preparation targeted circuits course presented around the country.) These modules are good examples that address technical content and the Table 1 issues. The remote location instructor has a 200-page workbook resource for this course that serves the SCC Mechatronics program Electronics 1 course. For other institutions, this workbook includes 65 circuit curriculum topics typically covered in college-level introductory electronics courses. Instructors select topics and adopt and/or adapt them to their courses based on local and regional industry needs and any curriculum requirements.

Figure 2 is an example of the specific digital multimeter (DMM) lesson element developed for and used in the SCC's MECA 1122 Electricity, Devices and Circuits course. (The source of the figure is at the bottom of the figure.) This DMM lesson is fundamental to any class, including a high school class, that presents basic electrical and/or electronic measurement concepts. Topics are presented in a "snapshot" mode with any "hands-on" reinforcement exercises compatible with any brand of multimeter (including low-cost meters from local hardware stores). The actual DMM-connected activities will merge with the basic mathematical model manipulations that students employ to predict circuit resistance/impedance, charge flow rate (current), and potential drop (voltage drop) in instructor-created circuit scenarios. The **i**MEC workbook includes additional lesson-tagged support items available to the instructor, including laboratory, reinforcement, reflection, and application modules, with detailed attention directed to the targeted Curriculum. From a curriculum coverage perspective, the complete package can easily be integrated into Electronics courses delivered at remote locations while meeting the target expected learning objectives of the SCC associate degree mechatronics program.


MECA 1122 Electricity Devices and Circuits I — Page 2 of 7

DMM Safety

Each application with a digital multimeter presents potential safety hazards that must be considered when taking electrical measurements. Before using any electrical test equipment, people should always first refer to the user's manual for proper operating procedures, safety precautions, and limits.[2]

Commonly used Functions of a DMM

Measuring Voltage

Voltage is the easiest and important electrical quantity that technicians need to measure when working with electric devices. When doing maintenance or troubleshooting, the most important work step is de-energizing power on electrical equipment for safety issues. After switching off the power supply of equipment, a technician must confirm no power by checking voltage, in this case, multimeter act as a voltage detector.

To measure *DC voltage* with a DMM:

Step 1. Turn the dial to *DC voltage* ($\overline{V}$), or *DC millivolts* (m$\overline{V}$) for low voltages. If uncertain of which to choose, start with *DC voltage*, which handles higher voltage.

Step 2. First insert the *black* probe into the *COM* jack.

Step 3. Then insert the *red* probe into the *V Ω* jack. When finished, remove the probes in reverse order: *red* first, the *black*.

Step 4. Connect the test probes to the circuit: *black* to the negative polarity test point (circuit ground), *red* to the positive test point.

Step 5. Read the measurement in the DMM display.

Note: When measuring DC voltage, it is not critical for the red lead to contact a positive terminal or the black lead to contact a negative terminal. If the probes touch the opposite terminals (red to negative and black to positive), a negative symbol will appear in the display. The value will be the same, just with a negative value. With an analog multimeter, damage to the meter will occur.

[2] Fluke Resource Center – Electrical (2023, May 31). https://www.fluke.com/en-us/learn/blog/electrical/what-is-a-digital-multimeter

South Central College — iMEC2.0 — Central Community College

Figure 2. Digital Multimeter Visual Tool for iMEC Workbook Lesson

Although **i**MEC lesson materials are scripted with SCC two-year degree courses in mind, they are also open-ended to permit instructor-created applications that blend with advanced topics within that instructor's domain. For example, one author of this paper is interested in content related to high-voltage alternating current (HVAC) and high-voltage direct current (HVDC) concepts and applications. Advanced mathematical manipulations of HVAC and HVDC circuit scenarios can be presented and reflected in "hands-on" DMM measurements. These circuit model predictions may not match student expectations of the circuit behavior. However, subsequent DMM measurements of circuit components will match model predictions, creating "eye-opening" moments for the students.

iMEC Impact

iMEC objectives frame the initial intent to educate and influence high school students within the SCC service area. These two components merge if students pursue their education within the SCC academic structures. Since **i**MEC was developed with the aid of the National Science Foundation Advanced Technological Education (NSF-ATE) program funds, an external evaluator was required to define the project's impacts on students, faculty, and other stakeholders. The 1st year project evaluation report indicated that 18 high school students attended the SCC Mechatronics iMEC/Learning Academy: Ten have committed to enrolling in the Mechatronics program; Four will pursue related education at Minnesota State University, Mankato; and four remain undecided.

iMEC 2.0, the NSF-ATE follow-up of **i**MEC, also used its resources to conduct its Learning Academy (LA) in Minnesota and Nebraska. The evaluator's fourth (final) year report indicated the project "had a strong Year 4, and noteworthy results and accomplishments have built institutional sustainability of the iMEC 2.0 curriculum and coursework in both states". The enrolment in the fourth year of the Learning Academy was 250 students, bringing **i**MEC 2.0 total enrolment to 1200 students. The project also administered a post-LA attendee survey with 370 responses. This survey included participant satisfaction questions with responses that resulted in highly positive responses. However, it also allows future contact with attendees to help track

Table 2. iMEC 2.0 Project Impacts

The delivery system permits student access to equipment not found in the high school environment.
The complete learning platform was installed in stages, if necessary, to significantly lower the impact on the high school's usually limited annual laboratory equipment acquisition budget.
The seamless connection of the Learning Academy completers to the mechatronics program at SCC was important to students with geographic and time limitations related to participation in the on-campus Mechatronics curriculum.
The LA successful insertion into another state initiated an awareness and interest of high schools at the national level.

LA's influence on their initial career intentions. Table 2. assembles the **i**MEC 2.0 evaluator's summary points that emphasize the project's impact on several fronts. Additional impact details can be found in Dr. Neal Grandgenett's NSF Advanced Technological Education Program **i**MEC 2.0 Report.

Future Developments

iMEC is now sustained within Minnesota and Nebraska. This reality steers the ongoing development of additional lessons with platform equipment and cooperative facilitating efforts between the college faculty and partner high schools to incorporate their existing high school laboratory equipment and experiments into this technician skills-focused learning environment. Those efforts will heighten the high school's general science, biology, chemistry, and physics faculty's awareness of the connection between science concepts and practical applications. In addition, the student's effort to complete an **i**MEC structured assignment matches, if not exceeds, the current academic classroom work and course rigor that technical educators expect to have in their educational environment.

The **i**MEC community of practice within two states can lead to a broader network of states participating in the Learning Platform with similar high school participation objectives, but not necessarily post-secondary Mechatronics degree programs. Florida's state colleges with two-year Engineering Technology (ET) degree programs represent a good example. These ET technician programs have already expressed an interest in adapting **i**MEC practices. This interest resulted in the presentation of SCC's introduction to the **i**MEC professional development workshop at Hillsborough Community College in Tampa, Florida, for ET degree faculty and high school teachers from across the state. Figure 3 shows a high school faculty member and a guiding SCC workshop instructor working with the **i**MEC "hands-on" trainer. The photograph shows the trainer's "small parts" support components for targeted lessons.

Figure 3. iMEC Workshop in Florida

South Central College is creating an **i**MEC application for the Agricultural Department within the College. The College's industry advisory board has indicated a need for agriculture technicians to have stronger backgrounds in basic electricity, sensors, and fluid power as an entry requirement into the workforce. The Agricultural Department will address this issue by utilizing the **i**MEC structured application of MECA 1122 Electricity Devices and Circuit I, MECA 1122 Electricity Devices and Circuit II, MECA 1223 Sensors and Controls, and MECA 2120 Fluid Power I.

Summary

The Engineering Technology (ET) Skill Sets application is ubiquitous within the Industry 4.0 (I4.0) equipment, subsets, and integrated systems environment. New professionals entering this world must apply skills from these Skill Sets quickly and effectively in any operation, troubleshooting, repair, or maintenance scenario generated within any I4.0 situation. Technicians facilitate successful scenario resolutions by promptly applying the appropriate ET skill.

The Professional Development Platform for Engineering Technology (PDPET) is designed with this technician's responsibility in mind. Faculty exposure to PDPET opportunities that are subsequently adapted and inserted into their teaching practices at the intensity level that matches the target student population's learning profile is an excellent initiator in creating the technicians I4.0 requires.

The **i**ndependent Engineering Technology Curriculum (**i**MEC) was developed, created, and implemented by South Central College (SCC) in North Mankato, Minnesota, before the assembly of the PDPET development teams. This instructional platform foreshadowed the objectives of a PDPET with an excellent extension into actual classroom instruction tools and supported activities. **i**MEC also meets the PDPET's second criterion to create skills-focused interactive systems with education and industry partners. Current **i**MEC lessons were created with resources, direct help, and interactions with the SCC Mechatronics Industry Advisory Board. One PDPET technician education opportunity now under development fits this **i**MEC profile.

This new project will support ET skill training within vacuum technology I4.0 applications. Manufacturers within this category in the SCC service area include Nortech Systems, Colopast Manufacturing US, and Thin Films Technology Corporation. For this electronics mechatronics-related manufacturing arena, the atmospheric pressure situations below range from I4.0 subsystems that control production facility humidity and temperature to very low-pressure pump combinations needed for various semiconductor production stages. The additional ET-skilled technicians and B.S. degree production engineers now required are significant. Still, there is no hint that this personnel shortage will be reduced because of the current creation rate of employees who possess the ET skills to be productive in these situations. PDPET with iMEC is a practical starting point for 2-year and 4-year degree programs to address this skilled employee shortage.

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