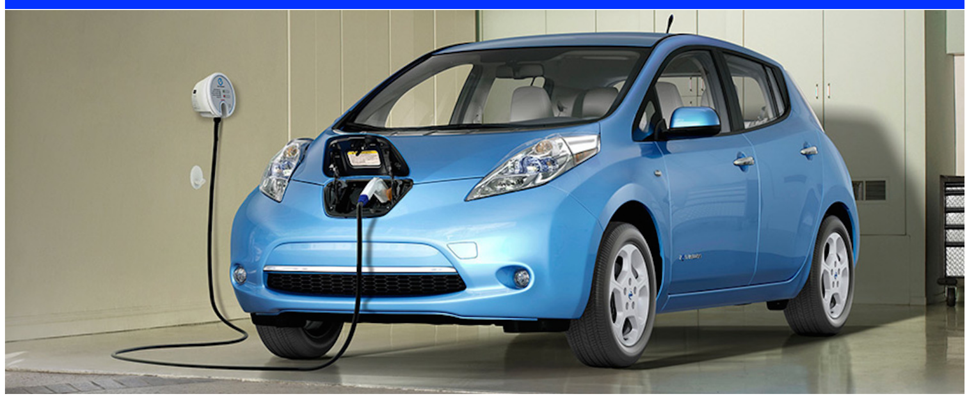
# Electric Vehicle Technology Program Guide



## The National STEM Consortium Electric Vehicle Technology Program

This Program Guide tells the story of the one-year, 30-credit model academic certificate created by the National STEM (Science, Technology, Engineering, Mathematics) Consortium (NSC) Electric Vehicle Technology Team. The NSC, a collaborative of ten colleges in nine states, has developed new workforce training programs in five technical fields. The NSC Electric Vehicle Technology program has two specialized tracks: (1) Electric Vehicle Development Technology, and (2) Electric Vehicle Service Technology. This guide provides information to help colleges decide whether to adopt the NSC Electric Vehicle Technology program, as well as suggestions on how colleges may adapt the program to suit their local needs.

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# Introduction

Welcome to the Electric Vehicle Technology program developed by the National STEM (Science, Technology, Engineering, Mathematics) Consortium (NSC). The NSC is a collaborative of ten colleges in nine states funded by a U.S. Department of Labor grant to develop new workforce training programs in five technical pathways: Composites Technology, Cyber Technology, Electric Vehicle Technology, Environmental Technology, and Mechatronics Technology. (For more information, visit the NSC website: http://www.nationalstem.org.) This guide focuses on the NSC program in Electric Vehicle Technology, and is intended to help college administrators—deans and department heads, as well as program chairs, directors, and coordinators—decide whether to adopt the program and how to adapt it to local needs.

The NSC academic model is built on **four research-based strategies that, when combined, yielded an average 69% completion rate** across its students nationwide.

First, **NSC instruction is outcomes-driven, delivering learning outcomes mapped to industry standards**. The NSC Electric Vehicle Technology curriculum is aligned to the skills and competencies embedded in several nationally-recognized industry-standard certifications, including the SAE International Vehicle Electrification Fundamentals and Safety Certificate of Competency, as well as certifications from NATEF/ASE (National Automotive Technicians Education Foundation/Automotive Service Excellence), Snap-On, S/P2, and EPA. In addition, NSC member colleges formed regional advisory boards to respond to industry needs and employer requests.

Second, NSC programs are **one-year, 30-semester-credit academic certificates**. Certificates are a highly effective tool for workforce development, and are most effective when they are long enough to be rigorous yet short enough to be achievable.[1] The certificate-level credential is a missing, but critical, on-ramp to career pathways for adult learners who often lack access to and awareness of high-demand careers in STEM fields. Graduates receive the greatest return on investment from certificates of one year or longer with a load of thirty-six semester credits or fewer. [2]

Third, NSC programs use a **built-for-completion structure** including a program navigator, cohort structure, block scheduling, compressed timeline, enhanced student support services, and employer partnerships. Research has shown that it is the combination of strategies, rather than any single strategy, that boosts student success. [3] Specifically, a growing body of evidence argues for "strategy intervention at a more *comprehensive and integrated level* that aims at simultaneous change focusing around whole program design and delivery – improving the coherency of instruction and educationally relevant services that students need as they move through their program of study." [4]

Last, NSC programs **embed contextualized refresher instruction in mathematics, communication, and professionalism** to eliminate traditional remedial courses and prepare students for success in demanding technical courses. The NSC STEM Readiness course enables students who are not fully college-ready in math to enroll and succeed in the technical curriculum, thus broadening the pool of potential students and opening STEM careers to a greater number of workers. The accompanying *NSC STEM Bridge Implementation Guide* provides complete information.

Colleges aiming for systemic change in their student completion and achievement levels are strongly advised to adopt the entire NSC academic model. However, NSC programs are flexible by design, allowing institutions to customize implementation to their regional economy and local conditions. For example, a college might choose to pursue implementation in stages. The goal of this Program Guide is to aid college faculty and staff in these decisions:

- Section 1 addresses the electric vehicle industry and labor market for entry-level technicians.
- Section 2 describes the NSC Electric Vehicle Technology academic certificate and its curriculum.
- Section 3 provides recommendations for program equipment, facilities, and personnel.
- Section 4 looks at the varied roles the local business community can play before, during, and after program implementation.
- Section 5 presents student success strategies such as built-for-completion structure and a program navigator.
- Section 6 discusses ways to enhance program sustainability by strengthening the student pipeline and engaging workforce agencies.

Each section includes recommendations, examples, and best practices to help colleges adapt the NSC model to meet their local needs.

# Section 1. The Electric Vehicle Technology Industry

Since the first hybrid electric cars were built for the mass market in 1999, more than 3 million electrified vehicles have been sold in the United States.[5] By 2014, manufacturers offered 60 different hybrid electric vehicles, 8 plug-in hybrid electric vehicles, and 9 fully electric vehicles. In addition, there are multiple models of electric scooters, dirt bikes, motorcycles, and all-terrain vehicles (ATVs), and even a Formula E Electric Vehicle Racing Circuit. Rising energy prices, environmental concerns, and fuel economy targets are driving demand for such alternatives to fossil fuel-based vehicles. For example, the corporate average fuel economy (CAFE) target for all new cars and light-duty trucks by Model Year 2025 is 54.5 MPG.[6]

Sales of electrified automobiles are thus increasing rapidly; in 2013, nearly 600,000 hybrid cars and plug-in electric cars were sold in the United States, up 21 percent from the previous year.[7] A 2009 study by the Center for Entrepreneurship and Technology (CET) at the University of California, Berkeley projected that, by 2030, electrified cars will comprise 64 percent of all light-vehicle sales in the United States and 24 percent of the entire U.S. light-vehicle fleet.[8] Moreover, the World Bank estimates that, globally, the electric vehicle value chain will likely exceed $250 billion by 2020.[9] This figure includes a projection of $185 billion in electric vehicle sales, $60 billion in lithium-ion battery and traction components, $13 billion in infrastructure investments, and $20 billion in electricity sales.

## Electric Vehicle Terminology

The term “electric” or “electrified” vehicle commonly refers to all vehicles that receive part or all of their power from an electric motor and battery; conventional vehicles, by contrast, are propelled solely by an internal-combustion engine. There are four main types of electric vehicles. The *all-electric* or *battery electric vehicle* (BEV) runs entirely on an electric motor and must be plugged into an electrical source to charge. The other three types are all hybrid (dual-power source) vehicles combining a battery-powered electric motor with a traditional combustion engine. The *hybrid electric vehicle* (HEV) uses an electric motor and a combustion engine to drive the vehicle at lower speeds; the engine also powers a generator that charges the battery (along with regenerative braking). The *plug-in hybrid electric vehicle* (PHEV) uses a larger battery that can be recharged by connecting to an external power source. An *extended-range electric vehicle* (ER-EV) runs exclusively on its electric motor, using its combustion engine solely to power the electric generator that charges the battery. This Guide uses the terms “electric” and “electrified” interchangeably to refer to all types of hybrid and electric vehicles.

## A. Occupations

Many occupations within the electric vehicle industry are similar to those found in the automotive industry generally. However, given the complexity of electrified vehicle systems as compared to conventional automotive systems, electric vehicle-related occupations usually require specialized training or work experience in electrified vehicle technology.[10] Although the industry employs workers with a variety of educational backgrounds, two occupational areas in particular support a variety of jobs that are suitable for community college technical certificate holders such as those prepared by NSC programs.

### Design and Development

This occupational area employs technicians who assist electrical, electronics, and mechanical engineers in developing solutions to technical problems in the design, development, manufacturing, quality control, and maintenance of electric vehicles. For example, automotive engineering technicians help engineers analyze the impact of potential changes in product design and conduct tests to evaluate the performance of parts or systems. Electrical engineering technicians test the electrical equipment and circuitry that enable the combustion engine to charge the battery and power the electric motor, as well as electrical components in the heating, air-conditioning, lighting, and display systems. Other closely related occupations include electro-mechanical technicians and mechanical engineering technicians. Common tasks include setting up and operating test equipment, conducting experiments, analyzing test results and reporting findings, conducting inspections for quality control and assurance programs, calibrating and troubleshooting testing equipment, helping to build prototypes of newly designed equipment, and using computer-aided design and drafting equipment.

This area includes work with battery cell/pack, high voltage safety, electric motors, power electronics, AC-DC conversion, and controls and calibration. Sample job titles include:

- Development Technician.
- Electrical Test Technician.
- Mechanical Testing Technician.
- Sales Support.
- Service.

Related occupations include manufacturing technician, remote sensing technician, fuel cell technician and electronics engineering technician. See Appendix A: Resources for a list of related occupations and links to their O*NET reports.

The research and development (R&D) work central to this occupational area takes place primarily in automotive companies and their suppliers, which are heavily concentrated in Southeast Michigan and areas of Ohio such as Marysville, home to the Honda manufacturing facility. Additional clusters are located in the areas of Fremont, California, home to the Tesla plant, and Anderson, Indiana, home to Delphi and other vehicle suppliers. The United States' heavy concentration of engineering R&D in just a few regions is fairly unique in the world; in other countries, such as Germany and Japan, such activity tends to be more evenly dispersed.

### Service and Maintenance

This occupational area employs automotive service technicians and mechanics who inspect, maintain, diagnose, and repair electrified vehicles using computerized equipment and electronic components as well as traditional hand tools. While automotive service technicians trained in conventional automotive systems can perform much of the routine maintenance work on electrified vehicles, they need special skills and knowledge to work on the high-voltage electrical systems, lithium-ion batteries, electric generators, and drivetrains of these vehicles.

Sample job titles within this area include:

- Electric and Hybrid Vehicle Service Technician.
- Battery Service Technician.
- Electrical Test Technician.
- First Line Supervisor.
- Installer/Repairer.
- Parts Manager.

See Appendix A: Resources for a list of related occupations and links to their O*NET reports.

The labor market for the service and maintenance occupational area is even larger than that for design and development. These technicians service and repair electric and hybrid vehicles once they have been built and sold; thus, potential employers are automotive dealerships as well as independent and chain repair shops. At present, such employers are concentrated in California, along the East Coast, and in certain metropolitan areas (e.g., Atlanta), where the majority of electrified cars are bought and sold, although the application for this technology is nationwide.

## B. Jobs Outlook

Rising sales of electrified vehicles and the steady introduction of new models by manufacturers suggest that employment in electric vehicle-related occupations will continue its upward path. Although the U.S. Bureau of Labor Statistics (BLS) does not currently publish employment data for occupations specific to the electric vehicle industry, the Center for Entrepreneurship and

Technology study cited above forecasts employment growth in most occupations in the industry over the next several years, as well as a net employment gain of 130,000 to 350,000 U.S. jobs in the electric vehicle industry by 2030. Moreover, while BLS does not report wage data specifically for electric vehicle occupations, the wages of the larger industry groups that would employ such workers suggest that product development and service occupations within the industry are high wage.[11] For instance, the annual median wages for automotive engineering technicians and automotive service technicians and mechanics were, respectively, $52,390 and $36,710 in 2013.[12]

# Section 2. The NSC Electric Vehicle Technology Certificate

In response to industry demand for technicians trained in the design, development, maintenance, and repair of electric vehicles, the National STEM Consortium created an Electric Vehicle Technology certificate. It is a stackable academic certificate built on a one-year, 30-semester-credit model that combines rigorous academic experiences with hands-on projects. Its coursework partially prepares students for industry-standard certification exams.

## A. Academic Curriculum: One Certificate, Two Tracks

The certificate features two tracks, one in product development and the other in service and repair. Students take three core courses and then proceed to specialized courses in their track. The combination of core and track-specific courses allows adopting colleges to support their local employers by reconfiguring the curriculum to meet the needs of the regional economy. To read more, see the accompanying folder NSC Electric Vehicles Example Delivery Models.

The core courses are as follows:

- Introduction to Automotive Systems.
- Electronic Technology 1.
- Electronic Technology 2.

### Electric Vehicle Development Technology

The **Electric Vehicle Development Technology (EVDT)** track trains students to design, develop, and maintain electrified vehicles and components, preparing them for careers in the automotive industry and, secondarily, the communications, solar, wind turbine, and smart-grid industries. Track courses include:

- Introduction to Electric Vehicle Propulsion Systems.
- Motors and Controls for Electric Vehicles and Industrial Applications.

- Electric Vehicle Data Acquisition, Sensors, and Control Systems.
- Advanced Energy Storage.
- Technical Math – RCL Analysis.
- Lab VIEW Basics 1.

An adopting college could adopt the EVDT curriculum in its entirety provided that (1) the regional economy supports an automotive industry that is engaged in developing and testing new products for the electric vehicle market; and (2) there is sufficient local industry demand for product development technicians.

The EVDT curriculum instructs in the fundamentals of electrical, mechanical, and control systems, and thus is adaptable to a broad range of technologies and products, particularly in the renewable energy sector. Doug Fertuck, Assistant Director for the Energy and Automotive Technology programs at Macomb Community College, observed: "Automobiles today are essentially electro-mechanical systems with an overlay of digital. They used to be narrower, but now they're platforms for many other technologies that can apply to a range of products." These technologies include energy storage, torque production, and software controls.

Therefore, a college could adopt the curriculum even absent an automotive job base, provided there are sufficient employers hiring workers skilled in electro-mechanical systems. Some Macomb Community College students, for example, have found jobs in the marine energy sector working on the electrification of boats.

### Electric Vehicle Service Technology

The **Electric Vehicle Service Technology** track trains students to diagnose, repair, inspect, and perform routine maintenance on electric and hybrid vehicles using manual and computerized equipment and tools, thus preparing them for employment as automotive service technicians working with alternative technologies. Track courses include:

- Principles of Alternative/Renewable Energies.
- Engine Fundamentals.
- Engine Performance 1.
- Electric and Hybrid Vehicle Technology 1.
- Electric and Hybrid Vehicle Technology 2.

Moreover, similar to the Electric Vehicle Development Technology track, the Service Technology track instructs students in the full range of advanced automotive skills and competencies, beyond those strictly related to electric vehicle technology. The reasons are that the NSC designed the curriculum in light of the present reality that the market share of electrified vehicles is small (albeit growing rapidly), not every dealership sells electric cars, and any individual auto repair shop is likely to experience relatively low demand for electric car maintenance. Indeed, the "corner garage" servicing electrified cars several times per month generally cannot afford to hire a full-time electric vehicle service technician. On the other hand, staying competitive with the larger dealerships required smaller garages to stay current with modern—especially electrified—technologies; having a technician on staff trained in such technologies thus bestows considerable advantage on the independent shop. Hence, students completing the Electric Vehicle Service Technology program are prepared to perform the advanced work of electric vehicle service, while also serving as multi-skilled technicians prepared for work in a range of automotive settings.

## B. Instructional Materials

Each course includes a downloadable Teaching Toolkit and accompanying Online Modules.

### Teaching Toolkits

NSC Teaching Toolkits feature a Course Introduction (READ ME FIRST) for instructors that explains the outcomes-driven instruction approach as well as any specific considerations for that course; a student Syllabus that may be customized by instructors; and instructor-focused Lesson Plans that provide a starting point for planning and delivering class sessions.

### Accessing NSC Teaching Toolkits

NSC materials are located in Platform+ by OLI, the Open Learning Initiative at Carnegie-Mellon University. To access NSC materials:

1. Navigate to the NSC Electric Vehicle Technology section of the OLI course library at http://oli.cmu.edu/learn-with-oli/see-our-free-open-courses/.
2. Explore courses and online modules as a guest.
3. Apply for an Instructor account to access Instructor Resources (i.e., the Teaching Toolkit) for a particular course.

### Online Modules

NSC online modules help prepare students for face-to-face instruction. They provide mini-lessons and interactive drills to help students through common sticking points:

- Identifying Hydrogen Fuel Cell Components.
- Identifying Hybrid Electric Vehicle Components.
- Describing Inverter Functions in Electric and Hybrid Vehicles.
- Reading an Outside Metric Micrometer.

- Explaining Planetary Gear Set Operation.
- Differentiating Propulsion Systems in Electric Vehicles.
- Calculating the Electrical Unknowns of a DC Series Circuit.
- Calculating the Electrical Unknowns of a DC Parallel Circuit.
- Applying Ohm's Law to Electronic Technology.
- Converting Time and Voltage Values of a Sine Wave.
- Debugging in LabVIEW Software.
- Converting Between English and Metric Units.
- Analyzing Time-Series Data for Distance, Speed, and Acceleration.
- Calculating Potential and Kinetic Energy.
- Identifying Internal Combustion Engine Components.
- Identifying Internal Combustion Engine Systems.
- Describing the Fabrication and Function of Engine Blocks.
- Describing Fuel Pressure Regulator Function.
- Describing Automotive Ignition Coil Operation.
- Working Safely on Electric and Hybrid Electrical Vehicle Components.
- Describing Continuously Variable Transmission Operation.
- Identifying Threads and Pitch on Bolts.
- Applying the Maximum Power Transfer Theorem to DC Circuits.
- Applying Ohm's Law to AC Circuits.
- Creating Arrays in LabVIEW Software.
- Explaining the Relationship of an Electromagnetic Field.
- Working with Boolean Algebra and Number Systems.
- Analyzing Valence Concepts Using the Periodic Table.

## Using NSC Online Modules for Instruction

NSC online modules are listed in Platform+ with courses they support. Platform+ integrates with common learning management systems so students only have to log in once. Adopting instructors should contact their college instructional technologist to enable single sign-on and set up Platform+ for use at their institution.

To use NSC online modules for instruction:

1. Read the OLI instructions at https://oli.cmu.edu/teach-with-oli/find-educator-resources/creating-a-customized-course/.
2. Follow the instructions to choose online modules to use, create a customized course, enroll students, and track their progress on the Instructor Dashboard.
3. Contact OLI with technical support questions.

### Licensing



## C. Pedagogical Innovation

The NSC academic model is based on best practices drawn from the literature and the real-world experiences of the NSC Electric Vehicle Technology Team:

- Macomb Community College, Warren, Michigan (lead college).
- Ivy Tech Community College – Lafayette, Lafayette, Indiana.

NSC programs are employer-centered and student-centered, focusing on the knowledge, skills, and attributes students will need to perform on the job.

### Outcomes-Driven Instruction

Outcomes-driven instruction forms the heart of NSC pedagogy. NSC programmatic learning outcomes are mapped to industry standards, such as the certifications discussed below. Adopting colleges are encouraged to convene advisory boards including regional and local employers who can verify and adapt learning outcomes to local needs. See Section 4. The Role of the Local Business Community.

The NSC Electric Vehicle Technology certificate program has learning outcomes in the categories of Vehicle Systems, Safety, High Voltage Systems, Battery Systems, Control Systems, Electronic Systems, Thermal Systems, System Integration, Engine Systems, Tool Usage, and Technical Math. These outcomes are broad themes of the program, achieved in one or more of its courses:

- Diagnose, repair, and test HEV, PHEV, BEV vehicles and subsystems.
- Safely store, handle, and dispose of high voltage battery systems.
- Diagnose, repair, and test high voltage battery systems.
- Diagnose, repair, and test HEV, PHEV, BEV battery controls.
- Use software for HEV, PHEV, BEV control systems (e.g., MatLab, Simulink, LabVIEW, and CANalyzer).
- Diagnose, repair, and test DC/DC converters.
- Diagnose, repair, and test vehicle charging interface/infrastructure.
- Diagnose, repair, and test regenerative braking.
- Diagnose, repair, and test power electronic circuitry for electric drive systems.

- Diagnose, repair, and test motor control electronic hardware.
- Diagnose, repair, and test thermal systems management and control.
- Integrate automotive systems, include mechanic certification and testing requirements.
- Diagnose, repair, and test high voltage electric distribution systems.
- Diagnose, repair, and install engines.
- Diagnose, repair, and test cylinder heads.
- Test and diagnose engine performance.
- Diagnose, test, and repair electronic systems.
- Use tools in automotive and electronic learning environments.
- Use technical math to solve for unknown values.

NSC learning outcomes are student-centered and measurable. They are established by, for, and with industry at the program level, then mapped in increasing granularity through the course and lesson levels. The learning outcomes map that accompanies this Guide links program to course learning outcomes and initiates an outcomes-driven framework in which each learning outcome is established, taught, and assessed.

### Hands-on Learning

NSC instruction in Electric Vehicle Technology emphasizes skills transfer to the workplace. Technical classes are rich in hands-on laboratory work; a typical lab project, for instance, may involve converting a conventional car or truck into an electrified vehicle. STEM Readiness instruction (see below) focuses on real-world contexts and case studies. Moreover, the Electric Vehicle Technology Service program requires extensive lab instruction (1,080 hours) to meet its requirements for accreditation by NATEF, the National Automotive Technicians Education Foundation.

### Industry-Standard Certification

The NSC Electric Vehicle Technology certificate program is aligned to the skills and competencies embedded in several nationally-recognized, industry-standard certifications. The Development track aligns specifically with the SAE International Vehicle Electrification Fundamentals and Safety Certificate of Competency. The Service track aligns with certifications from NATEF/ASE (National Automotive Technicians Education Foundation/Automotive Service Excellence), and embeds various Snap-On certifications, including Mechanical and Electric Torque, Multimeter, and Wheel Service and Alignment. Students also may earn an S/P2 (Safety and Pollution Prevention) Automotive certificate, as well as the EPA 609 Technician Certification, which certifies them to handle refrigerants for automotive HVAC systems.

For an example of collaboration between an NSC partner college and an industry association to develop credentialing, see Section 4. The Role of the Local Business Community.

### Embedded Remedial Instruction

NSC programs feature embedded remedial instruction in the form of STEM Readiness, an online, interactive refresher course offering three one-credit units: Mathematics, Critical Thinking and Workplace Communication, and Professionalism. STEM Readiness enables students who are not fully college-ready in math to enroll and succeed in the technical curriculum. Specifically, STEM Readiness targets students who score at or above the highest developmental level on college math placement tests. For students scoring below that level, NSC STEM Foundations provides more intensive math and communication remediation. STEM Readiness and STEM Foundations were developed by the NSC STEM Bridge team: see the accompanying *NSC STEM Bridge Implementation Guide* for complete information.

## Section 3. Program Infrastructure

Before launching an Electric Vehicle Technology certificate, adopting colleges are strongly recommended to have an automotive technology program and technical programs in electrical systems or manufacturing technologies. Colleges offering automotive technical programs will already possess the standard equipment that an Electric Vehicle Technology program requires, such as diagnostic tools for servicing vehicles (e.g., alignment machines and wheel balancers), electrical lab equipment (e.g., scopes and fault meters), hydraulics, and the facilities needed to store and service the vehicles (e.g., a garage with hydraulic lifts). In addition, because electrified vehicles and conventional vehicles share many of the same components and subsystems, there is substantial curricular overlap between the regular automotive and electric vehicle programs, particularly regarding basic automotive and electrical systems concepts (e.g., all students must understand the fundamentals of engine performance, automatic transmissions, and climate control). Hence, rather than create its own introductory courses, an Electric Vehicle Technology program could opt to place its students in the automotive program's first-term courses, thus using the technical faculty already on campus.

The following sections discuss the essential infrastructure—related to equipment, classroom and lab space, and personnel—that a college needs to launch a certificate program.

## A. Equipment

### Vehicles

To understand fundamentally how electric and hybrid vehicles operate, students must be able to take apart the actual vehicles. Hence, a program's key equipment is a fleet of electric and hybrid vehicles. While there are different types of vehicles from which a program may choose (e.g., SI extended stop-start, battery electric vehicle, plug-in hybrid electric, and hybrid extended electric mass), the key objective is to offer students a combination of pure battery electric vehicles and hybrid electric vehicles. Also, to expose students to as broad a range of hybrid technologies as possible, the cars should come from different manufacturers; it no longer is sufficient to own only a Toyota Prius, for example, as Ford, Nissan, and other companies are now producing their own vehicles, each with different technologies. The program's fleet also should include a mix of vehicle types, such as hybrid trucks, SUVs, and sedans.

The recommended minimum number of electrified vehicles in a program's fleet is two, while the ideal number is four or five. Only one vehicle should be all-electric, but the remaining vehicle(s) should be hybrid(s). This recommendation holds whether the class size is five students or twenty-five students (or larger).

### Diagnostic Scan Tools

While such tools are an industry standard—all cars since the 1980s operate with computerized systems—there are components unique to electric vehicle technology (e.g., battery management, HVAC) that require specialized tools and software packages. Just as in the industry environment, the scan tools come in kits, and include a computer, wires, etc., which are wheeled around on mobile carts. The number of kits that a program needs corresponds to the number of bays that the program's garage/lab space contains (see description below).

### Computers and Software Packages

To simulate the heavily computerized service environment that exists today, in which technicians typically carry their own laptops or tablets, all program students should have access to a laptop or tablet. In some cases, financial aid may cover the cost of the laptop or tablet when the device is listed as required course material; hence, a program is advised to check the appropriate regulations. Ensuring that each student has access to such a device is especially recommended with respect to training in electric vehicle technology, which incorporates more extensive software than conventional automotive technology. In addition to the diagnostic lab work, students perform simulations on the computer before working on the actual vehicle for instruction and safety purposes. They also undertake online quizzes and other course activities (e.g., learning module/STEM Bridge material) on the computers.

Finally, like automotive repair shops nationwide, programs also will need subscriptions, updated annually, to one or more print and/or online packages of OEM (original equipment manufacturer) service and repair information, such as AllData, Chilton, and ShopKey.

### Trainers

Trainers are an important supplement to the curriculum, albeit not replacements for the vehicles themselves. Since each trainer simulates one particular automotive system (e.g., electrical, fuel injection, HVAC), a program can teach a specific concept in isolation, thereby enhancing instruction. Students typically master the concept on the trainer before working on the actual vehicle, which protects them from potentially dangerous accidents and reduces the likelihood of costly mistakes.

Some systems, like HVAC, are specific to electric vehicle technology, so the program must purchase those separately. However, most trainers used in a traditional automotive technical program can be adapted for use by an Electric Vehicle Technology program by adding on various components. Thus, the lowest-cost option for a program will be to share the approximately $15,000 trainer with the regular program and add the EVT extension, at an additional cost of approximately $5,000.

These trainers, known as table-top trainers, are generally small enough to fit on a desk, as their name implies. Given their size, the recommended number of students per trainer is two or three, with a maximum of four. As noted, while trainers support the curriculum, they are not a substitute for the actual vehicle. Hence, a program on a limited budget may choose to omit the trainer and instead have students work directly on the car.

When sourcing equipment, a college may purchase the trainers from an educational vendor (e.g., Adex, Pearson) or “off the shelf” from an industry provider. Decision criteria include cost, convenience, and access to supplemental material. For instance, the leading vendors provide all the equipment and supplies that an automotive service station uses in the corporate environment, while including a range of supporting materials, such as lab curriculum, worksheets, and quizzes. However, while purchasing from an educational vendor is convenient and all-inclusive, it also tends to be costlier than purchasing directly from an industry provider.

## B. Facilities

To replicate the business environment, automotive programs typically create an automotive services shop, complete with bays, hydraulic lifts, and the standard equipment. Ideally, a program will have at least four bays (the number in the average dealership or repair shop), in order to minimize the need to wheel the diagnostic scan tools in and out of their storage area when servicing the vehicles. Typically the Electric Vehicle Technology program will be in the same building as the regular automotive service program, which requires careful scheduling.

### From Commercial Garage to Classroom Lab

Rather than house its lab and classroom space in the same building used by the college's automotive program, Ivy Tech Community College's Electric Vehicle Service Technology program rented an automotive garage, complete with hydraulic lifts and bays, from a local business that had closed. The program added its specialized equipment to the existing infrastructure and converted the former employee break room to the lecture space, adding tables, chairs, and projection screens. Such spaces can be found around the community in dealerships and car maintenance service shops that have permanently closed.

## C. Personnel

Compared to just ten years ago, a single auto manufacturer today may offer multiple electrified vehicles. Recruiting instructors trained in the proliferating electrified vehicle technologies thus represents a challenge, affecting job search strategies and salary levels. Automotive technology instructors without expertise in electrified vehicles content must be willing to undertake a significant amount of professional development. The recommended number of full-time faculty for the program is one, so long as that person has the requisite electric vehicle expertise. Otherwise, the program must hire multiple instructors to teach the basic electrical/electronic and auto technology courses, in addition to the specialized electric vehicle courses.

Regarding the service track, it is highly advisable for a program to hire a full-time laboratory technician, particularly when it adopts the entire NSC curriculum. The reason is that the curriculum aligns with NATEF certification, which requires 1,080 hours of hands-on time. Since students tend to work in small groups, having a full-time lab technician to supervise and support students is a critical program feature. The advantage of hiring one full-time technician over multiple part-time assistants concerns the level of electric vehicle-related expertise that a full-time position, albeit at a higher salary, can command. For example, Ivy Tech Community College's Electric Vehicle Service Technology program recruited its lab technician directly from the city bus company, where he had gained significant experience working on the company's fleet of hybrid, electric, and alternative fuel buses.

NSC certificate programs also benefit from having a program coordinator or Navigator to facilitate program delivery, from recruitment and enrollment to student support and job placement. Section 5. Student Success Strategies details this role.

# Section 4. The Role of the Local Business Community

It is essential for adopting colleges to cultivate strong ties with an array of partners to ensure success in developing, launching, and sustaining a program that connects students to the workforce. Such partnerships ensure that the program has a deep understanding of the target occupation. Even when a college chooses to adopt the NSC curriculum in its entirety, assembling a program advisory committee is still highly recommended. Such a committee is ideally composed of eight to ten employers and others from the local business community. The role of the committee is to offer advice regarding the initial development of the curriculum as well as ongoing program delivery and eventually job placement of graduates.

To read more, see Appendix B: Creating a Demand-Driven Program.

## A. Locally-Responsive Curriculum

Together with program faculty and staff, the advisory committee should assess the curriculum's relevancy to local skills needs, identify any gaps in the curriculum, guide the program's choices regarding electives and national certification(s), and advise on the types and brands of equipment that the program should purchase.

To illustrate, a college whose local industry is engaged in developing technologies besides those explicitly related to electric vehicles will need clear guidance from an advisory committee concerning such issues as the following: the feasibility of offering a reconfigured program given the demand, an identification of potential courses that the program might substitute for the curriculum's introductory automotive courses, and the availability of qualified instructors. The committee also may determine that mechatronics training is a better fit for local industries and thus recommend that the college adopt the NSC Mechatronics Technology certificate program instead. The advisory committee's role extends even to colleges whose industry base includes electric vehicle manufacturers. For instance, a college in California located next to Tesla Motors, which develops and manufacturers all-electric vehicles, would still benefit from industry advice regarding how best to adapt the curriculum to focus more on electric and less on hybrid technologies.

Accordingly, verifying local and regional labor market demand for electric vehicle technicians is a crucial first step in deciding whether to adopt an Electric Vehicle Technology program. If employers have not approached an adopting college to request training opportunities for incumbent and prospective workers in the electric vehicle field, the college should reach out to employers directly for their input. Such employer information, as well as labor market analyses from government agencies or industry groups, can form the basis for the type of needs assessment that colleges typically must conduct to gain local and state administrative approval of new programs. For a description of one NSC partner college's efforts to develop its certificate program with strong industry input, see Appendix B: Creating a Demand-Driven Program.

Finally, there are numerous companies that provide sophisticated labor market analysis tools and services. For instance, Macomb Community College utilizes Burning Glass Labor/Insight™ software to better understand labor market demand and the hard and soft skills required for talent in the regional economy.

## B. Ongoing Program Delivery

Involving employers promotes crucial buy-in, motivating members to champion the program among their peers and engage in activities that strengthen program delivery. For example, employer partners may:

- Provide updates on the local economy and projected areas of employment growth.
- Serve as guest speakers to introduce students to their organizations, identify and discuss in-demand skills sets, outline their expectations as employers, and describe the hiring process.
- Host tours of company facilities for faculty, staff, and students. For example, General Motors has provided tours of its Hamtramck Chevy Volt plant to the Macomb Community College Electric Vehicle Development Technology certificate program students.
- Donate specialized lab equipment and supplies and help with equipment upgrades.
- Assist in program marketing.
- Serve as adjunct instructors.
- Provide job-shadowing opportunities and serve as mentors to students.
- Offer internships to students.

## C. Internships

In addition to providing students with critical hands-on, industry-relevant experience, internships serve as a useful recruitment tool for companies, help certificate programs engage with employers, and generate key feedback loops between the programs and employers, which can heighten the program's demand responsiveness. For example, students enrolled in Ivy Tech Community College's program must complete a weekly report on topics related to the internship site, such as the types of equipment used and the pay structure for technicians—information that can help the certificate program stay current. Students at Macomb Community College must research potential employer candidates, which helps the program develop outreach to additional employers for internships and job placement. As the majority of interns tend to receive employment offers from their employers, this program feature is highly recommended, albeit one that is often challenging to implement. For further discussion, see the box below and Appendix C: Internship and Job Placement Challenges and Strategies.

### Institutionalizing Internships

Two strategies for successfully implementing and ultimately institutionalizing an internship program are dedicating staff to the endeavor and incorporating it as a formal part of the certificate program. For example, Macomb Community College's (MCC) Electric Vehicle Development Technology certificate program hired two part-time staff to conduct internship and job placement services. The Adjunct Internship Coordinator (AIC) offers students internship preparation and placement and develops new industry contacts for future internships. This person also introduces students to the college's Career Services offerings; assists with résumé writing and interview preparation; and helps students access the college's online employment database and other online and social media resources. The program's Job Developer assists the AIC by conducting employer site visits one day per week and cold–calling employers using lists of employers who have hired program graduates, as well as those accessed through the college's employment database and provided by other staff.

Although not a requirement to earn the certificate, an internship has been a formal part of the program, taking place as a final, 16-week course.[13] To participate in an internship, students must meet certain eligibility requirements. Specifically, they must have completed 12-credit hours, six in core classes; have a 2.0 GPA; meet with the AIC; complete the Career Experience Online Session; upload their current résumé into the college's employment database; and conduct a mock interview with the AIC. Once accepted into the internship program, students receive additional internship preparation from the college's Career Services office, including assistance with job search skills and additional mock interviews with two different Career Services staff members. Finally, students must maintain ongoing dialogue with the AIC during the academic program for the development of workforce strategies, employer engagement workshops, and feedback on placement outcomes.

## D. Job Placement

Multiple organizations must collaborate for certificate programs to succeed in placing graduates in positions within the target sector. The workforce system, college career development staff, and industry partners all play important roles in providing job search and placement assistance, ranging from helping students prepare résumés to connecting them to internships and full-time employment**.**

Assembling a strong network of employer partners who rely on the program to supply their entry-level technicians is critical to successfully placing graduates. It is especially important to engage with local industry associations, economic development organizations, and regional membership organizations, such as the Chamber of Commerce and Small Business Association, to raise awareness of the program and recruit members to join its advisory board. Ideally, a program would fund a full-time job developer to work closely with local employers to identify job opportunities and build the trust necessary to convince them that program graduates are good candidates for the positions. Otherwise, the program could task a staff member, such as the program coordinator or Navigator, with building ties to the business community.

To read more, see Appendix D: Job Placement Best Practices**Error! Reference source not found.**.

# Section 5. Student Success Strategies

NSC programs improve student persistence by creating a built-for-completion program structure that guides students toward graduation and career entry in an accelerated time frame. While it is best to implement all of the following student success elements in concert, NSC certificates are designed to be nationally portable and locally customizable. Accordingly, adopting colleges are encouraged to work closely with their internal and external partners to develop a certificate program that best meets their college and local labor market needs.

## A. Built-for-Completion Structure

### Cohort Model

A hallmark of NSC programs is their unified cohort structure, in which students are recruited and enrolled as a cohort, taking all courses together in sequence. The cohort structure can be a selling point during recruitment, as it offers a community atmosphere and an opportunity for students to build relationships with other students, faculty, and staff. Students hold one another accountable, can develop study groups, and support each other.

Of course, instructor and room availability impact not only the amount of equipment and number of students that a program can accommodate, but also the number of cohorts that it can operate simultaneously. Where possible, running simultaneous cohorts maximizes the use of facilities, although it does increase the number of instructors needed. A program with only one classroom reserved for its exclusive use would find it challenging—though not impossible—to teach more than two cohorts simultaneously, particularly under a block scheduling system.

### Block Scheduling and Compressed Schedule

NSC has designed a recommended course sequence to enable students to complete all required courses in one year. The one-year timeframe is based on a block-scheduling scheme that has both advantages and disadvantages. Benefits include convenience for students who take all courses at the same time each day. Students with a part-time job or family care responsibilities often prefer block scheduling due to its consistency. Recruiting adjunct faculty in a block scheduling system may be challenging, however, as it can limit an instructor's flexibility and hence availability.

## B. Recruitment Strategies

Particularly when a college uses a cohort structure, recruiting students committed to completing the full program year is critical for their success. Employers and workforce agencies can be effective recruitment partners, as can campus staff, faculty, and even students. A best practice is to identify target groups of potential students (e.g., veterans), and then create a marketing plan specifying outreach activities for each group. Outreach activities comprise materials, methods, and venues. **Materials** could include print (brochures, fliers, postcards, banners, posters), multimedia (website, videos, slide presentations), and social media (LinkedIn, Facebook, Twitter, Pinterest). **Methods** could include advertising, earned media (issuing a press release that leads to free or "earned" media coverage), calling, emailing, meeting, posting, and/or presenting. **Venues** could include campus, libraries, community organizations, workforce agencies, veterans' offices, places of worship, local retailers, restaurants, coffee shops, thrift stores, and high schools.

The accompanying folder NSC Electric Vehicle Technology Example Recruitment Materials provides ideas for flyers, brochures, and posters. Other effective recruitment, marketing, and outreach activities were the following:

- To advertise an upcoming information session, a Macomb Community College (MCC) Dean sent a mass email to faculty and staff asking them to notify their students about the session, while the program's Navigator emailed 3,000 targeted students in undecided or related majors. In less than 24 hours, this joint effort resulted in a near-tripling of the number of students registering for the current session.

- MCC obtained approval from Ford and GM to use their corporate materials in the program's recruitment video, which the college considered critical to the video's effectiveness.
- In addition to its online recruitment efforts, Ivy Tech Community College (ITCC) has continued to pursue traditional advertising with great success. For example, over 80 percent of attendees at one open house indicated that they had learned of the event from a radio advertisement on a local rock station, prompting the college to undertake a formal radio marketing campaign.
- ITCC conducted a successful recruiting event for its next cohort by working with an employer partner—a local Chevrolet dealer—at the Alternative Fuel Day, a 12-hour event held at a local mall, which was designed to promote electric and hybrid vehicles.
- To build its base of employer partners, MCC regularly attends networking and seminar events at venues such as Automation Alley, a Southeast Michigan technology business accelerator, and the Detroit area-based Battery Show, an annual conference showcasing advanced battery technology.

### Internal Industry Promotion

Industry partners' websites can offer programs valuable online visibility. For example, an advanced energy technology business accelerator in Michigan agreed to feature Macomb Community College's electric vehicle program on its website, and several Ivy Tech Community College Automotive Institute Steering committee members placed the NSC program logo and website link on their respective corporate websites. Low-tech program promotion is also useful. Ivy Tech enlisted several partners to keep promotional materials at their places of business for distribution to employees, as well as to applicants to the company lacking the requisite skills.

## C. Screening and Guided Enrollment

Colleges may use a variety of screening techniques to ensure that prospective students are capable of—and committed to—completing the one-year program and succeeding on the job. The ideal candidates for Electric Vehicle Technology training are individuals who have an analytical nature and good mathematical skills, enjoy working with their hands, like cars, and are interested in working with innovative technologies. Candidates also should have the personal circumstances, including family support if needed, to devote an entire year to completing the program.

It is ideal to assign student screening and enrollment to a specific staff member, whether a dedicated Navigator (as described in the next section) or other personnel. Under this **guided enrollment approach**, the staff member meets with each applicant to communicate the program's requirements, learning environment, expectations, and rigors.

### Selective Program Enrollment

Macomb Community College instituted a rigorous recruitment process that resulted in a lengthy waitlist for its second and third cohorts. Working with the local workforce agency (MichiganWorks!), the program prioritized all applicants based on their WorkKeys placement test scores, employment status (e.g., TAA-eligible or dislocated veterans), work histories, educational backgrounds, and written 500-word essays explaining why they should be accepted into the program. To prepare accepted applicants for the accelerated nature of the program, students attended mandatory orientation sessions several weeks prior to the start of the term.

## D. Navigator Responsibilities

A key best practice for helping students succeed is employing a Navigator, whose role is to coordinate local student support services from initial contact as part of the marketing and recruitment process, through program completion and eventual job placement. Given the range of academic and personal challenges confronting many community college students, having a personal advocate can boost students' level of commitment and chances of success.

Typically, colleges offer students an array of services, distributed over multiple offices and departments, such as health care, counseling, tutoring, and veterans' support. The innovation embodied in the Navigator position is to offer each student a single point of contact to whom s/he can turn for anything. Specifically, the Navigator helps assemble each program cohort by recruiting students and assisting them in the admission, enrollment, and financial aid processes. Once the program begins, the Navigator connects students with academic and any other support services needed to help them complete the program. A program that does not fund a Navigator should nevertheless assign the key activities that a Navigator performs to various staff members. The sections below outline key responsibilities; see Appendix E: Navigating Student Success to read about Navigator services in depth.

### Academic Support Services

Working with other student support staff, Navigators can arrange for tutoring assistance with the help of student academic support or teaching and learning centers; obtain accommodation for students with learning or physical disabilities in conjunction with the college's disability services office; offer academic advising services to students; and develop relationships with program instructors to learn about student progress.

For example, to catch potential problems early on, a Navigator might ask program instructors at the beginning of each course to inform him/her if a student is having any difficulty. Follow-up with instructors throughout the course can reveal whether a student is on track, staying focused, putting forth sufficient effort, and maintaining his/her grades. Regular, one-on-one meetings with students can allow the Navigator to ascertain the cause of a student's struggles and suggest appropriate measures, such as joining a study group, working with a tutor, or simply finding someone who can help him/her figure out when to undertake assignments amid life's daily demands.

### Financial Assistance

Navigators and other student support staff can help students obtain financial assistance, including third-party/workforce agency funding, state-level funding, unemployment insurance, and college financial aid.

### Social Services

Navigators and other student support staff can connect students with the full scope of social services, including housing, food, clothing, transportation, and medical services. For an elaboration of this holistic approach to student support, see Appendix E: Navigating Student Success.

### Career Planning

Navigators and other student support staff can help students articulate their career goals. For instance, they might talk with students about whether they are willing to relocate, how far they are willing to commute, whether they have any targeted companies, and their minimum salary. Navigators also can probe whether the students seek further certifications or degrees and the role that the college may play in meeting these goals.

### Job Preparation

Many community college students benefit from job preparation assistance that goes beyond traditional career services offerings, such as help identifying prospective employers and generic résumé and interviewing advice. Instead, the Navigator or other support staff can offer more tailored assistance, such as instruction in job search protocols and industry conventions; help conducting job search using social media; and, particularly for students enrolled in STEM programs, help translating technical skills from the programs to their résumés. For more about helping students secure employment, see Appendix D: Job Placement Best Practices.

# Section 6. Enhancing Program Sustainability

An essential approach to ensuring program continuation involves successful outreach to prospective students and the intensive support of students once enrolled. In addition, it is important to engage workforce agencies, and broaden program appeal.

## A. Strengthen Student Pipelines

To build a pipeline of students prepared to enter an Electric Vehicle Technology certificate program, an adopting college might make connections with local technical high schools offering automotive and related programs. A particularly useful strategy is to establish a dual-credit program with high schools, particularly when the community college certificate program does not require cohort enrollment.

Partnering with other postsecondary education and training providers also holds promise for enlarging the potential student pool, as well as increasing the availability of shared resources. For example, Ivy Tech Community College formed a partnership with the Lafayette Adult Resource Academy, which agreed to refer its students (adults completing their GED) to the certificate program. In addition, Ivy Tech Community College, Macomb Community College, Purdue University, and Wayne State University are sharing electric vehicle curricula that will be used within their respective programs.

In this and other ways, the college can build awareness of the program among candidates, recruit them to apply and facilitate their enrollment. Of course, successfully retaining students through program completion and placing them in high-demand jobs will both enhance program sustainability and strengthen the student pipeline.

## B. Engage Workforce Agencies

State and local workforce systems are key partners in colleges' efforts to sustain certificate programs due to their ability to assist in all phases of program delivery. With their links to organizations responsible for analyzing labor market information, workforce staff can provide the program with ongoing labor-market data, as well as information on prospective candidates for training. With their close ties to economic development organizations, agency staff can help programs identify key industry employers. Finally, as the entity that oversees and provides the full spectrum of employment and training services, the agency can assist colleges across the program continuum, from recruitment to retention to job placement. [14]

### C. Broaden Program Appeal

To enhance program sustainability, programs are advised to undertake more systemic and, often, longer-term job development strategies. These go beyond offering certificate training to include efforts to meet the full range of employers' education and training needs, as well as to connect the college's workforce development efforts with broader economic development activities. See Appendix D: Job Placement Best Practices for an illustration of one NSC partner college's efforts to engage in such systemic work.

## Conclusion

The National STEM Consortium has a key aim of redesigning community college program structure to encourage student completion. Its innovative change strategy was based on the hypothesis that interventions that are comprehensive and integrated build the most effective pathways to credential attainment and positive labor market outcomes. Conversely, as a growing body of evidence demonstrates, reform initiatives that are limited in scope and scale produce limited outcomes. For example, interventions reaching a small fraction of targeted students or focusing solely on discrete aspects of their college experience—e.g., entry, tutoring, or developmental education—do not improve performance.

The NSC's effort to restructure the entire student experience is grounded in four research-based strategies. First, NSC instruction is outcomes-driven, delivering learning outcomes mapped to industry standards. Second, NSC programs are one-year, 30-semester-credit academic certificates. Graduates receive the greatest return on investment from certificates of one year or longer with a load of thirty-six semester credits or fewer. Third, NSC programs use a built-for-completion structure including a program navigator, cohort structure, block scheduling, compressed timeline, enhanced student support services, and employer partnerships. Research has shown that it is the combination of strategies, rather than any single strategy, that boosts student success. Last, NSC programs embed contextualized refresher instruction in mathematics, communication, and professionalism to eliminate traditional remedial courses and prepare students for success in demanding technical courses. The NSC STEM Readiness course enables students who are not fully college-ready in math to enroll and succeed in the technical curriculum, thus broadening the pool of potential students and opening STEM careers to a greater number of workers.

By adopting as many of these strategies as possible, and adapting them for local needs in consultation with employers, colleges may see impressive results in student engagement, completion, and satisfaction, leading to success on the job and a healthy, sustainable program.


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Ivy Tech Community College (ITCC), Lafayette, Indiana:

- Susan Ely, Dean, School of Technology.
- Carl Booker, Navigator.


## About These Materials

### Copyright




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## Disclaimer

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# Appendix A: Resources

## Occupations

Occupations relevant to the NSC Electric Vehicle Development Technology track, listed by their Standard Occupational Classification (SOC) codes, include:

- SOC 17-3023.03 - Electrical Engineering Technician: http://www.onetonline.org/link/summary/17-3023.03
- SOC 17-3027.01 - Automotive Engineering Technician: http://www.onetonline.org/link/summary/17-3027.01
- SOC 17-3024.00 - Electro-Mechanical Technician: http://www.onetonline.org/link/summary/17-3024.00
- SOC 17-3027.00 - Mechanical Engineering Technician: http://www.onetonline.org/link/summary/17-3027.00
- SOC 17-3029.09 - Manufacturing Production Technician: http://www.onetonline.org/link/summary/17-3029.09
- SOC 19-4099.03 - Remote Sensing Technician: http://www.onetonline.org/link/summary/19-4099.03
- SOC 17-3029.10 - Fuel Cell Technician:
- http://www.onetonline.org/link/summary/17-3029.10
- SOC 17-3023.01 - Electronics Engineering Technician: http://www.onetonline.org/link/summary/17-3023.01
- SOC 17-2072.01 Radio Frequency Identification Device Specialist: http://www.onetonline.org/link/summary/17-2072.01

Occupations relevant to the NSC Electric Vehicle Service Technology track include:

- SOC 49-3023.00 - Automotive Service Technicians: http://www.onetonline.org/link/summary/49-3023.00
- SOC 49-9051.00 - Electrical Power-Line Installers and Repairers: http://www.onetonline.org/link/summary/49-9051.00
- SOC 17-3023.03 - Electrical Engineering Technician: http://www.onetonline.org/link/summary/17-3023.03

For additional information, see the Occupational Information Network (O*NET) database at http://www.onetonline.org and U.S. Bureau of Labor Statistics data at http://www.bls.gov/.

## Certifications

- SAE International Vehicle Electrification Fundamentals and Safety Certificate of Competency: http://training.sae.org/credentialing/veprogram/
- National Automotive Technicians Education Foundation/Automotive Service Excellence: http://www1.natef.org/about/achieving_ase_cert.cfm
- Snap-On Certification program: https://www1.snapon.com/Education/Certifications.html
- S/P2 (Safety and Pollution Prevention): http://www.sp2.org/site/school
- EPA 609 Technician Certification: http://www.epatest.com/609/

# Appendix B: Creating a Demand-Driven Program

Industry demand and collaboration are hallmarks of all NSC Certificate programs. This brief sketch of the demand-driven origins of Macomb Community College's (Macomb) Electric Vehicle Development Technology (EVDT) certificate program seeks to illuminate this key feature of program success.

## Assessing Need

Early in the program development phase, Macomb worked with several employer partners to develop a survey to ascertain industry need for product development technicians. To reach as many employers as possible while conducting the survey, Macomb relied on its rich network of partners to distribute the survey instrument to their respective members. These partners included Southeast Michigan's Workforce Intelligence Network (WIN), a coalition of local community colleges and state workforce and economic development agencies that conducts labor market analysis for regional stakeholders; Macomb's Automotive and Electric Advisory Councils; SAE International; and the Michigan Academy for Green Mobility Alliance (MAGMA), a partnership among automotive manufacturers, educational institutions (including Macomb), and Michigan's state workforce agency.

Macomb later used this survey instrument during planned visits to local and regional employers to validate the EVDT curriculum (once created). In addition, as a member of WIN, Macomb helped to plan a "talent summit" for engineers, technicians, and designers, which the network's partners designed to identify hiring gaps and develop solutions to challenges facing the regional talent pipeline.

## Responding to Industry Demand

Catalyzing Macomb's decision to create the certificate program was MAGMA's issuance in early 2012 of a Request for Proposal (RFP) for electric vehicle technician training. (A central MAGMA activity involves identifying in-demand skills and competencies and endorsing education and training programs meeting industry skills needs through a competitively-based RFP process; an industry panel makes the final determination regarding the training programs that MAGMA endorses.) Macomb responded to the RFP under the auspices of the Center for Advanced Automotive Technology (CAAT), an NSF-funded partnership between Macomb and Wayne State University, and one of around 42 Advanced Technological Education Centers nationwide. In developing the curriculum, Macomb matched existing college courses to the skills and knowledge that the RFP identified as essential for product development technicians, creating new classes or content where there were gaps. In August 2012, the MAGMA Advisory Board endorsed Macomb's certificate program with high marks.

### Partnering to Develop Industry Certification

To develop credentialing in the electrified vehicles area, the Society of Automotive Engineers International (SAE), an organization that sets automotive and aerospace standards, enlisted the help of CAAT (see description above). Using students in Macomb's EVDT program as test cases, the two organizations developed the SAE Electric Vehicle Electrification Fundamentals and Safety Certificate of Competency, the first of three levels of certification and the one most relevant to certificate training. As part of the development process, Macomb certificate students took the two-hour examination for free. SAE is revising the exam in light of student responses and feedback, and has agreed to allow future Macomb cohort students to retake the examination if they do not pass or are interested in retesting.

Collaboration between the two partners continues, ensuring that Macomb's EVDT program remains current and in demand. For example, Macomb worked with SAE to cross-review the EVDT curriculum against SAE's certification; the review showed that the content closely aligned, except in the area of first responder competencies. Since any person working in a setting where an electric and hybrid vehicle-related accident occurs may have to function as a first responder until the professional team arrives, Macomb added a non-credit First Responders training course to the EVDT curriculum.

# Appendix C: Internship and Job Placement Challenges and Strategies

Particularly within knowledge-intensive industries such as the electric vehicle development industry, certificate programs often encounter a lingering industry preference for hiring engineers with a four-year degree over technicians with a certificate—even for internships and entry-level work. The Macomb Community College Electric Vehicle Development Technology (EVDT) certificate program discovered early on, for instance, that the internship programs of the Big Three automakers recruited exclusively among engineering students pursuing a four-year degree. While many students enter the EVDT program with an associate's or bachelor's degree, the program has worked to expand opportunities for all students by pursuing a three-pronged approach—outreach to smaller companies, outreach to staffing agencies, and building trusted relationships—based on its identification of several salient industry dynamics.

## Outreach to Smaller Companies

Vehicle manufacturers often outsource their R&D work involving the testing of subsystems and components, such as batteries, to suppliers (the manufacturers themselves generally undertake final assembly of parts and overall testing, however). Accordingly, the EVDT program works actively to connect with the smaller Tier 1 and Tier 2 companies in its region to develop student internship and employment opportunities. For example, the program successfully placed several student interns at Energy Power Systems, a company specializing in the development of advanced energy storage systems in support of renewable energy sources like solar and wind. Interns helped company engineers design and test electric battery systems and products in the effort to make electrical power transmission more efficient and reliable.

## Outreach to Staffing Agencies

As in other industries, vehicle manufacturers and their suppliers increasingly are using a contingent workforce, often to perform the company's technician-level work. Hence, while a company's direct hires may be limited to engineers and other advanced-degreed positions in the relevant occupational areas, the company typically will rely on recruiting and staffing agencies, such as Aerotek, to supply its technician workforce.  Consequently, the EVDT program works closely with such agencies to raise awareness of the curriculum and preparedness of certificate students for product development work. In fact, recruiting agency representatives initially expressed interest only in students with a prior associate's degree, leading program staff to work hard to convince them that their students, with or without such a degree, but often with extensive work histories, were well-qualified for entry-level technician jobs. The program is now placing interested students in such contract positions (frequently "temp-to-perm" positions that convert to full-time employment). For instance, five students recently joined General Motor's Pontiac, Michigan location as contract hires.

### Building Trusted Relationships

Community colleges have a tremendous role to play in shifting perceptions about the suitability of certificate program students for technician-level work in advanced economy industries, such as the electric vehicle industry. To illustrate, the Director of the Center for Advanced Automotive Technology (CAAT) at Macomb Community College, who sits on the advisory board of the Michigan Academy for Green Mobility Alliance (MAGMA), observed that fellow MAGMA board members representing the industry's major employers are all strong proponents of the EVDT program. Yet, the CAAT Director's pitch for these employers to restructure their company internship programs to accommodate technicians met with initial resistance. He noted, however, that attitudes are changing. As certificate program staff and other advocates build personal connections with employers in the effort to secure internship and employment opportunities for graduates—and as program alumni succeed in employment—employers come to trust the recommendations of staff regarding the quality of program graduates, which leads to a growing, industry-wide recognition that community college programs are supplying a well-trained technician workforce.

For example, the EVDT program has been working with a leading global automotive manufacturer of testing systems in such areas as engine, brake, emissions, and wind tunnel systems. Despite its normal practice of only hiring graduates of four-year engineering programs, the company indicated that it has come to recognize the significant value in the EVDT curriculum and thus was willing to hire a certificate program student and provide any necessary on-the-job training. In addition, Energy Power Systems, noted above, has been so pleased with the caliber of hires from the program that it has begun serving as the program's employer advocate to other companies within its network.

# Appendix D: Job Placement Best Practices

The National STEM Consortium's ten partner colleges have generated a wealth of best practices at every stage along the program continuum, from program design and development to student job placement. The following examples of innovative and effective job placement strategies and activities come from partner schools within four NSC pathways.

## Using Social Media

The Electric Vehicle Development Technology (EVDT) certificate program at Macomb Community College (MCC) in Warren, Michigan has made extensive use of Facebook and LinkedIn as recruiting/marketing, instructional, and job placement tools. The EVDT program Navigator launched the program's Facebook page in close collaboration with MCC's Marketing Department, which approved the graphics and content and included it on the college's own Facebook page to ensure maximum visibility. Several times weekly, the Navigator updates the program's page with industry news, job opportunities, information sessions, and special class events, such as a recent trip to the Chevrolet Volt plant. On average, 200 people view such posts on the EVDT program's Facebook page, while 9,000 or more view them on MCC's Facebook page.

The program Navigator discovered that cold calling and emailing industry contacts to discuss the program tended to yield minimal response from employers, and thus created an EVDT program LinkedIn group. Within days, several employers who had ignored previous outreach attempts agreed to meet with program staff to discuss student internships and employment opportunities. The Navigator provides training to students to maximize use of both Facebook and LinkedIn and encourages students to post frequently on the program's pages. Active discussion has ensued on both sites, revolving around recently posted articles, class materials, and upcoming events. Such engagement facilitates interaction with employers, who in turn view students more seriously as potential future hires. This job search strategy can be especially fruitful given that EVDT program alumni—many of them now in positions to hire—are often frequent participants in the LinkedIn group's online discussions. The Navigator also encourages students to extend their networking within the industry by joining related LinkedIn groups, such as Green, EHV, Automotive, and Alternative Energy. The EVDT program itself has been able to use the site to extend its recruiting reach to a much wider constituency by connecting with workforce agencies, industry associations, and other relevant groups.

For the EVDT program's Facebook page, see: https://www.facebook.com/MCCEVCert. For its LinkedIn page, see: http://www.linkedin.com/groups/MCC-Electric-Vehicle-Development-Technology-4842522.

### Tailored Job Search Assistance

During Macomb's Learning Lab (an NSC STEM Readiness component, as noted above), students learn how to build a relevant résumé by using key words specific to the electric vehicle field to describe their skills. Students with significant work histories (who might otherwise appear overqualified) receive instruction in how to focus on the experience most relevant to positions in the new field. Students also learn job search protocols, including phone, email, and business etiquette, job search ethics, and appropriate interview dress. Finally, they receive guidance in formulating job search strategies using social media. For example, they learn how to use the "power trio" (LinkedIn, Twitter, and Facebook); set up a Google profile; "connect," "follow," or "friend" industry group and career professionals; seek mentors and network contacts for motivation and encouragement; share and recommend the work of others ("Pay It Forward"); leverage the latest features of job search engines (e.g., SimplyHired, Indeed); and find a "Social Media Champion" to help leverage social networking in their search.

### Employer Networking

Macomb Community College hosted a well-regarded information and networking event on campus, attended by seventeen students and eight representatives from five companies. During the panel discussion, employers described their companies and made hiring projections six months out. Afterwards, students conducted one-on-one conversations with employers regarding potential internships. Of the five employers, one (General Motors) hired five students through its staffing agency; another hired a permanent employee and three interns; and a third maintained its assigned intern for several consecutive terms as the intern continued his educational studies.

### Reverse Interviews

The South Seattle College (SSC) NSC program has created an effective strategy for sharpening its understanding of local employers' workforce needs and expanding its employer base, while fostering continuous improvement. In a nutshell, program staff remain in contact with program alumni through a system of periodic interviews, not only with alumni, but also the hiring or Human Resources staff at their respective employers. On a monthly basis, program staff contact alumni and conduct a short survey, asking such questions as whether the company currently is hiring and, in light of the graduate's current job duties, whether the program's curriculum omitted any important learning outcomes. Indeed, the information flowing from these contacts has led instructors to make important curricular changes, such as adding embedded safety and math topics into the curriculum and expanding the focus on metrology, semi-precision and precision measurement, and prints and drawing, among other topics.

This scheduled system of call-backs with alumni also helps the program cultivate relationships with HR staff, which often generates useful information for the program, such as alumni retention rates and career paths within particular companies. Moreover, these relationship-building efforts have encouraged many alumni to contact the program when jobs at their companies open up, while some even personally deliver students' résumés to HR staff. As the SSC team lead summed up: "Our students are our ambassadors. They give us an inside knowledge of job postings, provide feedback on skills they are lacking, and connect us to production managers and HR."

### Placing Graduates through Speed Interviewing

The NSC Cyber Technology and Mechatronics programs held a joint speed interviewing event at Anne Arundel Community College in which 25 local companies interviewed graduating students for actual job openings. Similar to speed dating, this technique allows for a quick assessment of the potential match between applicant and hiring company. With program staff keeping time, students rotated to a different employer every six to eight minutes. Staff provided each employer with a bound book of student résumés, arranged alphabetically (the order in which students interviewed). The event took place at the college's CyberCenter, using every classroom and office in the building. In the lounge, where staff provided refreshments for participants, huge screens projected employer contact information, which substituted for employer introductions and thus economized on time. In addition to providing students with valuable interviewing experience and the opportunity to compare a large set of employers, the event showcased the students' technical expertise and professionalism to a range of new employers, who thereby became more vested in the program. See the accompanying folder NSC Electric Vehicles Example Job Placement for speed interviewing materials.

### Systemic Job Development Strategies

One systemic job development strategy involves deepening partnerships with local industry by meeting the full range of employers' education needs. For example, the Roane State Community College Mechatronics program aims to be an education clearinghouse for companies by offering a number of ad-hoc classes to meet incumbent worker training needs. If a particular company does not need Mechatronics Technology certificate classes, the program can still provide on-site training at the company in OSHA 30-hour General Industry certification or similar areas. Such incumbent workforce training is typically less expensive than company-provided training, and thus highly desirable to industry. The program's unofficial motto is "If Mech is not the solution, we'll find what is!"

Another significant, long-term job development strategy involves working with college and local economic development agencies to influence employer location decisions. For example, Roane State helped recruit Ceramica del Conca, a leading Italian manufacturer of ceramic floor and wall tiles, to the region by presenting the Mechatronics program to company leadership. The existence of the program reportedly played a significant role in the company's decision to build a highly automated manufacturing facility within the college's operational area. The company agreed to hold a special job fair with the college for the program's Mechatronics Technology students when its plant was nearing completion.

# Appendix E: Navigating Student Success

Embedded student support services are a linchpin in the National STEM Consortium's effort to promote high rates of program completion, credential attainments, and employment. Each NSC partner college had flexibility to design such services to meet their local needs. Some programs combined all support functions in a single position, typically called a Navigator, while others divided them among several positions, such as student outreach coordinator and internship coordinator. The key was to offer students intensive support and ongoing personal connection throughout the student lifecycle, from initial program recruitment to job placement.

This case study illustrates the work of one Navigator, located at Anne Arundel Community College, in Arnold, Maryland. Responsible for student recruitment, screening, enrollment, retention, and job placement, the Navigator seeks to build a systematic relationship with students through regular one-on-one meetings and an Individual Employment Plan (IEP) assessment tool, which she adapted to meet the needs of her student body.

The IEP addresses personal information, including employment status, any disability, and any criminal background and/or current or previous legal issues; career and educational goals; academics and study strategies; resource needs, including housing, medical, food, clothing, child/family care, credit, and transportation; and activities and services needed. By eliciting this array of information, the Navigator aims to paint a full picture of her students, who are in vastly different positions in their lives: one student makes $10 an hour while another makes twice that amount; one student has a closet full of suits, the other has only a single pair of khakis; one student aspires to attain a master's degree, another needs a place to live.

The Navigator and the student complete the half-hour assessment four times throughout the program: once during each of the program's three terms and the last at program completion. Because much in a student's life can change over the course of a year, she designed four versions of the IEP, each of which corresponds to a different stage of the program. While some questions vary across forms, others remain the same so that she can track student progress from a baseline set of data. See the accompanying folder NSC Mechatronics Example Job Placement for the full set of IEP tools.

At the start of each meeting, the Navigator explains that the form is confidential—shared only with program staff, not instructors—and that students may provide as much or as little information as they feel comfortable doing. She observed that no student has ever declined to answer a question, even those probing basic resource needs: "Sometimes they're dying to talk about these issues. They'll say the next day that they feel so much better having talked about the issue, and now they can focus on school."

Using this tool, the Navigator may learn that a student "couldn't focus in class because they hadn't eaten, or did not do their homework because they did the graveyard shift the previous night. Their house may have been foreclosed on, they have a newborn and can't afford formula, or they had major surgery. You wouldn't recognize this in a regular academic environment; no one asks: 'Did you have dinner last night?'" As a result, she spends much of her time connecting students to a variety of county- and state-level social services and low-cost support options, including food pantries, medical care, mental health counseling, child care, substance or domestic abuse recovery groups, public transportation, veteran resources, unemployment benefits, and emergency and/or temporary housing. Experience in community outreach is thus an important qualification for the position.

Identifying problems at the program's beginning greatly assists students on the employment end. For example, one student came to her concerned that the one suit that he owned no longer fit him properly, which meant that he lacked business attire for an interview scheduled for the following day. As a result, the IEP now asks whether the student has needs related to interview preparation, in part to connect students early on with suitable professional attire.

The Navigator identifies students who are struggling in order to intervene before they veer too far off track. By asking how each course is progressing, she can ascertain whether the problem lies in the speed of the class or the student's study habits. If the latter, she can connect the student with tutoring services or help the student find a study group to join. The assessment also solicits student feedback on each class, allowing the instructor to adjust the curriculum as needed and conveying to students that the program truly does value their opinions and suggestions, not just at program completion, but at its beginning.

The IEP tool prompts students to think about their career and educational goals. A student may express an interest in creating a business, in which case the Navigator might suggest possible entrepreneurship training opportunities or services. The question whether the student wishes to pursue further certification or degrees may lead to a discussion about additional educational options. For instance, the Navigator may help a student who holds only a GED to determine the classes required to complete an associate's degree. She noted that holding a conversation around what the college can offer students if they enroll in future programs is "good for student retention, as well as for the college."

# Appendix F: Student Success Stories

## Timothy Masters

Before enrolling in Macomb Community College's Electric Vehicle Development Technology (EVDT) program, Timothy Masters was working extremely long hours installing restaurant equipment. Although he had no prior college or work experience in an electrical or automotive-related field, he had "worked on cars since [he] could walk" and was constantly tinkering with electronics. Once enrolled, he became interested in the subject of alternative energy, but did not consider a career in the area, believing that it required mastery of chemistry. A program instructor, however, introduced him to the idea of electrochemistry, which changed his focus and ultimately led to his current full-time work as an engineering technician at Energy Power Systems, a company that promotes renewable energy by advancing energy storage technology. Timothy said that he loves his current work, which involves assisting engineers who build and test battery systems prototypes, and plans to pursue future studies in electrical engineering.

Exemplifying the critical problem-solving skills that the EVDT certificate program seeks to foster, Timothy recently designed and implemented, on his own initiative, a testing system for adhesives. As he was having difficulty sealing a particular battery, Timothy researched the issue and, finding that there was no standard method for testing the material, decided to devise his own. He retrieved the scraps from the battery cases that he had just cut to size, re-cut and drilled holes in two of the scraps, glued them together, and placed them in a pull tester (a device measuring the amount of force needed to pull apart an object). He then put some of the glue in sulfuric acid and conducted a retest with the remaining glue. After two weeks, he tested the glue in the acid to identify any drop in its weight that would signify vulnerability to an acid attack. Measuring the glue, which weighed merely hundredths of a gram, required the use of a precision scale reaching to four decimals.

Now a permanent employee at the company, Tim continues to help develop and test new battery-related products. For example, he recently designed and built the hardware to test the durability of a case for a new type of battery that a company engineer had created. This involved assembling the circuit board, valves, solenoids, and an air pressure regulator (among other parts). He also programmed the software for the microcontroller that ran the stress test, determining how long and how frequently to inflate and deflate the battery case, and at what pressure.

Tim said that he especially enjoys using the data acquisition equipment to measure such information as voltage, temperature, and hydrogen content, and has become the go-to technician around the company whenever data needs to be measured.

### Jonathan Burt

Jonathan Burt enrolled in Macomb Community College’s Electric Vehicle Development Technology (EVDT) program to get “back to his roots.” A tinkerer who enjoys breaking things in order to fix them, Jonathan worked for years as a skilled tradesperson at BASF, then moved into the field of postsecondary education as an instructor, eventually becoming a director of education. The introduction of the Toyota Prius, Chevy Volt, Nissan Leaf, and Ford hybrid vehicles piqued his interest in cutting-edge technology and kindled his idealism: helping to reduce our carbon footprint would be his “donation to the world.” He also missed working with power tools and hand tools like volt multi-meters. He realized that, after more than a decade away from hands-on work, he needed a refresher program in the electro-mechanical field in order to change careers.

Jonathan lauds the EVDT program’s focus on detailed troubleshooting, noting that it requires students to fully grasp the fundamentals underlying such questions as what drives motors, why they continue turning, and what causes them to run away. In fact, Jonathan credits the hands-on and problem-solving orientation of the program with preparing him for his current job as a technical training instructor at FANUC Robotics. Although his previous work experience in robotics familiarized him with the specific content of this work, the problem-solving and critical thinking skills that he gained in the EVDT certificate program “were exactly what FANUC needed.” Among other skills, this includes the ability to adeptly field questions from participants during FANUC training sessions, which Jonathan says the program strengthened.

# Notes

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[11]Hamilton, James. September 2011. *Careers in Electric Vehicles*. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics. http://www.bls.gov/green/electric_vehicles/
[12]For Automotive Engineering Technicians, see http://www.onetonline.org/link/summary/17-3027.01. For Automotive Service Technicians and Mechanics, see http://www.onetonline.org/link/summary/49-3023.00.
[13] By contrast, students enrolled in the Electric Vehicle Service Technology program at Ivy Tech Community College dedicate each Friday of the program's last eight-week session to the internship.
[14] For example, program staff at one NSC partner college worked closely with the local workforce agency to create a combined application process that greatly reduced time and paperwork for program applicants.