



A University and Community College Partnership to Meet Industry Needs for Future Workers in Advanced Automotive Technology

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ABSTRACT

The automotive industry has been one of the largest and most important industries in the United States, employing more than 3.3 million Americans. Today the automotive industry is engaged in a transformational change that incorporates a technological shift from the petroleum-powered engine that drove the transportation economy of the 20th Century to the renewable resource based electric powered motor that will sustain the dynamic global economy and environmental assets of the 21st Century. The primary developments are Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV), Electric Vehicles (EV), Alternative Fuel Vehicles (AFV) including common rail diesels, and Fuel Cell Vehicles (FCV). The impact today and in the long run is an increasing need for trained automotive engineers, engineering technologists and technicians prepared to support every stage of the product life cycle of these new automotive technologies, which requires acquisition of an expanded skill set for each sector of the industry. To keep pace with the demand for new technologies, the university and community college presenting this paper have responded to the changing needs by strengthening communications with industry to clearly define future workforce requirements, and developing and offering technologically progressive training programs. To support the training, the Department of Energy (DOE) has provided funding for developing industry needed vehicle education programs, the Department of Labor (DOL) has provided funding to sponsor training programs, and the State of Michigan Workforce Development Agency (WDA) has collaborated with industry to establish Michigan Academy for Green Mobility Alliance (MAGMA). Through funding from the National Science Foundation (NSF), a Center for Advanced Automotive Technology (CAAT) was established as an Advanced Technological Education (ATE) center to support the partnering work and leading systemic curriculum reform. This paper reviews the education and training programs provided by the University-Community College Partnership in meeting industry needs for future workers in advanced automotive technology.

INTRODUCTION

The automotive industry has been one of the largest and most important industries in the United States, employing more than 3.3 million Americans [1]. Today the automotive industry is engaged in a transformational change that incorporates a technological shift from the petroleum-powered engine that drove the transportation economy of the 20th Century to the renewable resource-based electric powered motor that will sustain the dynamic global economy and environmental assets of the 21st Century. The primary developments are Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV), Electric Vehicles (EV), Alternative Fuel Vehicles (AFV) including common rail diesels, and Fuel Cell Vehicles (FCV). The impact today and in the long run is an increasing need for trained automotive technicians prepared to support every stage of the product life cycle of these new automotive technologies, which requires acquisition of an expanded skill set for each sector of the industry.

The HEV reached the market in 1999 and current projections show that 44 models of hybrid vehicles are available by 2012, and that sales will exceed 870,000 units [2]. A typical long-range forecast shows that 20% of U.S. Cars will be HEVs by 2020 [3]. The automobile manufacturers, and the DOE, as well as a number of vehicle conversion companies are actively involved in electric vehicle development through the Partnership for a New Generation of Vehicles (PNGV) [4]. Electric conversions of gasoline powered vehicles, as well as electric vehicles designed from the ground up, are now available that reach super highway speeds with ranges of 50 to 200 miles between recharging [5]. A PHEV is a HEV with batteries that can be recharged by connecting a plug to an electrical power source. The PHEVs have characteristics of both conventional hybrid electric vehicles and of battery electric vehicles [6]. The longer term trend of automobiles includes fuel cell vehicles. Fuel cell technologies are projected to have increasing demand for new skills in the next ten years and may have the broadest implications for industries beyond auto manufacturing. Alternative fuel and common rail diesels are other two technologies to improve vehicle fuel efficiency.

The undergoing technological transformation to vehicle electrification and other advanced technologies is fundamentally changing the educational requirements for the industry's future workforce. The industry demands highly trained technical workers, of which there is currently a shortage. More than 80% of automotive employers indicate an added need for highly trained technicians and 13% report a severe shortage [7-8]. The 2006-2016 Michigan Green Jobs Projection shows that green-related occupations should produce 12,000 openings each year, of which 40% are in Clean Transportation and Fuels, and those requiring more education background are a major occupational force in this area [9]. Wayne State University (WSU) and Macomb Community College (MCC) have responded to these changing needs by strengthening communications with industry to clearly define future workforce requirements, by developing technologically progressive curricula, and by gathering and disseminating current, innovative educational materials to a broad network of national institutions.

THE WSU-MCC PARTNERSHIP

WSU, located in Detroit, Michigan, is a Carnegie Doctoral/Research Extensive university that serves over 35,000 students. MCC, located in Warren, Michigan, is the second largest community college in the state, annually serving 46,000 students, 21,000 of whom are degree-seeking students. The two institutions have a long history of collaboration in serving industry and community. The WSU-MCC partnership described in this paper refers specifically to the collaboration between WSU's Division of Engineering Technology (DET) and MCC's School of Engineering and Advanced Technology.

In 2005, the partnership was awarded a National Science Foundation–Advanced Technological Education (NSF-ATE) grant for the “Development of a Learning Environment for Hybrid Electric Vehicle Technology.” Through this project the partnership developed HEV specific courses and curriculum, and integrated it with the existing Associate of Applied Science program in Automotive Technology, created an HEV specialized laboratory, initiated a pilot program for Automotive Service Excellence (ASE) certification in hybrid vehicles, developed transfer plans and articulation agreement to provide 2+2 education pathway for MCC graduates to continue upper-division education in WSU-DET, developed and delivered short courses on HEV

technology for community college automotive instructors, and conducted a series of seminars and workshops for various groups of audiences, including K-12 teachers, emergency first responders, corporate partners, automotive repair facilities, and general public. The successful completion of this project led to the award of a NSF-ATE Planning Grant for investigating the need for establishing an ATE Center to lead systematic curriculum reform for advanced automotive technology education. In this project, the WSU-MCC partnership conducted a survey in 2008 to research the current state of some key issues related to advanced automotive technology. These issues include automotive workforce needs, automotive educational core competencies, automotive educational curriculum/pedagogy, and advance automotive future trends. The survey showed that engineers, technicians or technologists in advanced powertrain technology will be in high demand over the next 5 years. More than 35% of the manufacturers and suppliers considered the bachelor's degree as the minimum educational level of their desired EV/HEV technicians [10].

In response to the rapid growth in the renewable energy sector, the Michigan WDA also collaborated with automotive manufacturing employers and educational institutions to establish the Michigan Academy for Green Mobility Alliance (MAGMA). Its mission is to provide rapid skill growth in green technology solutions for advanced ground vehicles. Representatives from WSU and MCC, CP Yeh and William Stark, were invited to serve in the Steering Committee for forming the Academy. William Stark was elected by MAGMA members to serve as Vice Chair of the Governance Board, and Committee Chair for Curriculum and Competencies. In 2009, the WSU-MCC partnership, in collaboration with A&D Technology and Ovonic Battery as industrial partners, was selected by MAGMA to offer the first industry requested graduate level course on Advanced Battery Systems for HEV. The course content included 75% in lecture and 25% laboratory experiences, as requested by the employers. WSU provided lectures, covering theories and computer modeling and simulation, MCC provided the laboratory facility, including five different models of HEVs currently available on the market and related testing equipment, for hands-on experiments, and the industry partners provided onsite experiences for battery manufacturing and testing. The collaboration between academia and industry, and between a 4 year university and a community college, has established a model for an industrial-based course for advanced automotive technology. Through these experiences the partnership has established a solid foundation for the development of degree programs in this emerging technology.

In 2009 the DOE announced the funding opportunity under the American Recovery and Reinvestment Act for developing advanced electric drive vehicle education (EVE) programs. WSU, in collaboration with MCC and NextEnergy, a State of Michigan organization to facilitate alternative energy technology development, was awarded a \$5 million grant for developing and implementing degree programs and certificate program at associate degree, bachelor degree, and master degree levels. These programs provide a 2+2+2 education pathway that allows students to transfer from associate degree programs to WSU for the baccalaureate degree program, and advance to the master degree program. To further support green mobility, WSU-DET established the Undergraduate Certificate Program in Advanced Energy Storage Systems (AESS) through the support of a NSF-Course Curriculum and Laboratory Improvement (CCLI) grant awarded to the WSU-MCC partnership.

In 2010 the WSU-MCC partnership was invited by the Michigan WDA to serve as education providers in a proposal to the DOL for green job training. The proposal was awarded a \$6 million State Energy Sector Partnership (SESP) grant for providing training in four green job areas. WSU and MCC are responsible for providing AESS training programs for engineers and technicians, respectively. In addition, the WSU-MCC partnership was awarded the NSF-ATE grant for the establishment of the Center for Advanced Automotive Technology (CAAT). The CAAT office and a branch office have been established at MCC South Campus and WSU-DET, respectively.

In 2011 the partnership was invited by Macomb/St. Clair Workforce Development Board to serve as education providers in a DOL proposal for the New Obama Administration Initiative to Spur Job Creation and Accelerate Economic Growth. The proposed “Southeast Michigan-Advanced Energy Storage Systems Initiative” was one of the 20 funded projects nationwide. MAGMA also endorsed the professional development short courses on HEV/PHEV technology and advanced battery systems developed by WSU-DET. The following sections of this paper provide more details about MAGMA and WSU-MCC partnership’s joint efforts in meeting industry needs for future workers in advanced automotive technology, including the NSF sponsored CAAT and the DOE sponsored EVE degree and certificate programs.

THE MICHIGAN ACADEMY FOR GREEN MOBILITY ALLIANCE

MAGMA was established in 2008, in conjunction with Michigan's Green Jobs Initiative, to ensure the automotive industry has the trained workers necessary to grow and prosper in the emerging green economy. Its members are from industry, educational institutions, government agencies, workforce development, professional societies and non-profit organizations. Through election by members, MAGMA has established a Governance Board consisting of six employer representatives, four education/training providers, and three members from government agencies, workforce development and professional societies. In addition, MAGMA has formed five subcommittees to manage key areas of focus, including Competencies/Skills/Curriculum, Evaluation, Funding, Communication/Marketing, and Job Placement.

To provide rapid skill growth in green technology solutions for advanced mobility to meet industry needs, MAGMA has set the following objectives for the Academy:

- Prepare individuals for emerging technologies in vehicle propulsion and vehicle component design, manufacturing, and maintenance through rapid/accelerated training and re-training.
- Target the training to displaced and incumbent engineers, engineering students, displaced and incumbent technicians, and technician program students.
- Seek and provide funding to help employers or individuals access the training.

In response to industry's requirements, education and training institutions support MAGMA by developing learning opportunities that are targeted, innovative, flexible, and have a strong focus on hands-on practical experience. Education and training providers for the Academy are selected through competitively based requests for proposals. Currently three Michigan universities offering graduate certificate programs are approved by MAGMA, including

- Michigan Technological University: Hybrid Vehicle Engineering Certificate
- University of Detroit Mercy: Advanced Electric Vehicles Graduate Certificate

- Wayne State University: Graduate Certificate in Electric Drive Vehicle Engineering

In addition, MAGMA also endorses the following non-credit professional development courses:

- Wayne State University: Fundamentals of Electric Drive Vehicles, Battery Systems, Motor Drives and Power Electronics for HEV/PHEV/BEV Applications, Automotive Direct Injection Engines
- Society of Automotive Engineers (SAE) International: Introduction to Hybrid and Electric Vehicle Battery Systems, Safe Handling of High Voltage Battery Systems, Selective Catalytic Reduction for Diesel Engines, Gasoline Direct Injection Engines, Hybrid Vehicle Systems Integration, Hybrid and Electric Vehicle Engineering Academy
- A & D Technology: Advanced Energy Storage Fundamentals of Battery Systems
- Hybrid Electric Vehicle Technology Center: Hybrid Electric Vehicles Systems

Since 2009, MAGMA has trained more than 300 individuals through endorsed programs and leveraged \$3 million in state and federal training dollars to do so. In addition, MAGMA has approved the proposal for an Electric Vehicle Technician Certificate by MCC.

THE CENTER FOR ADVANCED AUTOMOTIVE TECHNOLOGY

CAAT is a National Science Foundation funded regional center for Advanced Technological Education. As a regional center, CAAT focuses on Michigan, Indiana, Ohio and Wisconsin and will expand its reach within the Great Lakes region. The mission is to provide leadership for a regional alliance of two-year colleges, school districts, and universities, working in collaboration with industry, professional associations and government agencies, to prepare a 21st century technical workforce for the design, development, manufacturing, service and recycling sectors of the advanced automotive industry.

As a model for educating automotive technicians and technologists, CAAT provides leadership and coordination for curricular reform of automotive technician education programs, integrates advanced automotive technology skills, and emphasizes Science, Technology, Engineering and Math (STEM) education at the secondary and postsecondary levels in the region and other areas in the U.S. with similar needs for newly skilled automotive technicians in a transformed automotive industry. CAAT also serves as a clearinghouse of educational materials and methods related to advanced automotive technology for partners and other interested institutions and individuals.

The WSU-MCC partnership is the leader of CAAT. Other key partners include the Workforce Innovation Network (WIN), the Macomb Intermediate School District (MISD), MAGMA, the Center for Automotive Research (CAR), and the SAE International. WIN includes a consortium of nine community colleges in Southeast Michigan, encompassing the Southeast Michigan Community College Consortium, that have joined forces with Workforce Development Agencies to expand the capability of each to deliver shared programs; MISD is CAAT's key partner in reform of the K-12 curriculum, and a state leader in reform efforts for career technical education; CAR is the nation's leading provider of economic research for the auto industry; SAE International is a global association of automotive engineers and related technical experts, having life-long learning as its core competency. In order to promote awareness of advanced automotive technologies to diverse audiences, CAAT also includes Excel Institute in Washington

DC in the program, and collaborates with the NSF funded Louis Stokes Alliance for Minority Participation (LSAMP) program and the state funded *King-Chavez-Parks Initiative* University Bound Program. The major CAAT activities include:

1. Collecting and evaluating existing courses, curricula, educational tools and training programs to create easily-accessible course and curriculum database.
2. Coordinating systematic curriculum reform in the region by providing “seed funding” for course and curriculum improvement, facilitating course and curriculum adoption, and promoting inter-college collaboration.
3. Integrating advanced automotive technology skills at the secondary level by adapting and integrating curricula, aligning new and emerging advanced automotive technologies to national curriculum requirements that emphasize STEM disciplines.
4. Developing transfer plans and articulation agreements to provide seamless educational pathways connecting K-12, two year colleges and baccalaureate programs.
5. Supporting faculty professional development for community college instructors and K-12 STEM teachers by providing summer short courses and workshops in EVE and AES technologies.
6. Conducting outreach activities to promote the concept of green transportation, including annual conference for promoting CAAT activities, Summer Academies for introducing advanced automotive technologies to K-12 students, University Bound program for encouraging community colleges students transferring to four year universities, and workshops and seminars for exposing the technologies and related impacts to key groups, including first responders, industry professionals, and the general public.
7. Coordinating educational and industry partners to promote internship and undergraduate research opportunities of students as gateways to full time employment.
8. Conducting core competence survey and market assessment, including industry expectations of educational institutions, technical worker demand, and demand in growing sectors of the industry.

Providing “seed funding” for course and curriculum improvement is a unique approach taken by CAAT for promoting systematic curriculum reform in the region. Examples of the seed grant projects are:

- “Modify Automotive Service Excellence Certification classes to include Hybrid EVs,” Lewis & Clark Community College
- “Battery manufacturing job training curriculum,” Grand Rapids Community College
- “EV modules for community delivery,” Lansing Community College
- “Development of innovative “Off Grid” Energy Center to educate students in renewable energies, smart grid integration, installation/maintenance of EV charging stations,” Ivy Tech Community College
- “Hybrid EV based Modules for Mechatronics courses” Lawrence Tech University

ELECTRIC DRIVE VEHICLE DEGREE AND CERTIFICATE PROGRAMS

In 2009, the DOE awarded \$39.1 million to nine universities and colleges and a professional association, through the American Recovery and Reinvestment Act, for development and implementation of Advanced Electric Drive Vehicle education programs. WSU, in partner with MCC and NextEnergy, was funded a \$5 million grant to develop a comprehensive set of

advanced educational programs, including a Master's Degree and a Graduate Certificate Program in Electric-drive Vehicle Engineering (MS-EVE and GC-EVE), a Bachelor's Degree in Electrical Transportation Technology (BS-ETT), and Associate of Applied Science (AAS) Degrees in Automotive Technology and Electronic Engineering Technology, with emphasis on Electric Drive Vehicles, that include certificates with Electric Vehicle Technology courses. The goal of these integrated programs is to provide a 2+2+2 educational pathway for students seeking degrees and certificates, whether they are fresh out of high school or have already obtained a degree from a traditional engineering or applied technology discipline and have been working. In addition, WSU and MCC also deliver a set of workshops, seminars, and short courses for emergency first responders, high school and middle school teachers, and corporate partners.

Master of Science in Electric Drive Vehicle Engineering

The MS-EVE program is designed to admit students with Bachelor's degrees in engineering or engineering technology, or with mathematics-based science degrees in exceptional cases or equivalent. Students will receive the master's degree after completing 32 credits of formal courses, directed studies, research, or thesis. The program offers a thesis and a non-thesis option, both of which have a group of required core courses, supplemented by elective courses.

With an emphasis in integrated learning by reinforcing theoretical comprehension with computer simulations, hands-on learning in the laboratory, and capstone design projects, the MS-EVE curriculum covers fundamentals, physical laboratories, computer simulations, technical areas, and capstone design. In terms of technical areas, this covers advanced energy storage, EV/HEV modeling and simulation, thermal management, power electronics and electric machines, control and optimization, onboard communication, and product development and infrastructure. Most courses involve multiple departments and instructors to maximize the multi-disciplinary nature of the proposed program. Laboratories, computer simulations, and/or design and case study projects all have both stand-alone courses as well as being an integrated part of all lecture-dominant courses.

Bachelor of Science in Electric Transportation Technology

The BS-ETT program is offered by WSU-DET as an upper division program. The degree requires a total of 128 semester credit hours, including 72 credits for technical courses, of which 30 credits are lower division technical courses transferred from community college. The program is offered in a 2+2 format with the expectation that students enter with an associate degree from community colleges or equivalent education. To further encourage community college transfer, WSU and MCC has signed the articulation agreement that allows Macomb graduates with an AAS in Electrical Engineering Technology degree or AAS in Automated Systems Technology - Mechatronics degrees to apply up to 80 transfer credits toward the BS-ETT degree.

The upper division technical core courses required in the BS-ETT curriculum include both electrical/electronic fundamental courses and electric transportation specialized courses, including Automotive Electric and Electronic Systems, Electric Machine Design and Application for Automotive, Fundamentals of Hybrid and Electric Vehicles, Control Systems for

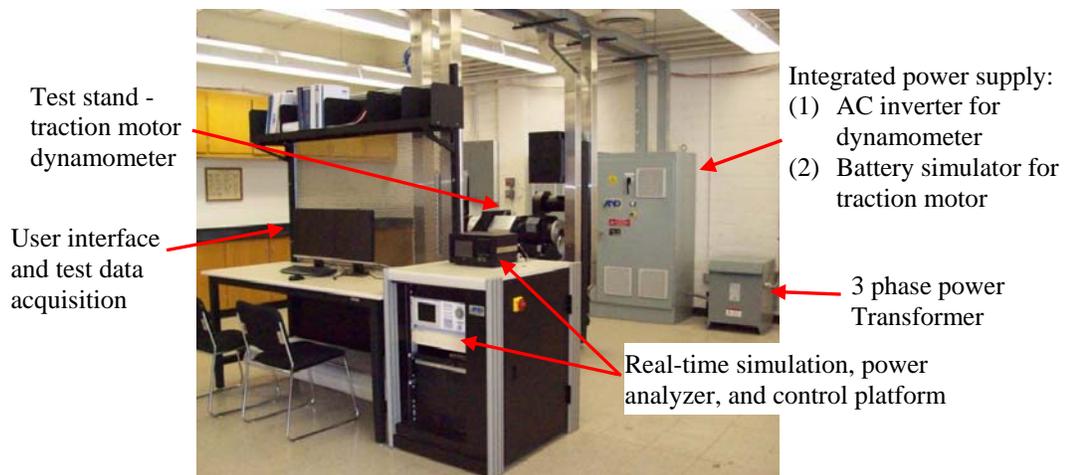
EV/HEV, Energy Storage Systems for EV/HEV, Power Electronics and Charging Infrastructure for EV/HEV, and In-Vehicle Networking and Embedded Systems. Students are also required to take an Engineering Project Management course and complete a Senior Project to earn the BS-ETT degree.

To support both teaching and research for the EVE and ETT programs, WSU has established two industrial-standard laboratories as shown in Fig. 1 through the support of the DOE grant:

- The Energy Storage Lab, located in the Danto Engineering Development Center, provides for the testing of energy storage devices and systems with a focus on batteries and fuel cells at the cell, module, and pack system level.
- The Electric Propulsion and Integration Laboratory, located the Engineering Technology Building, provides for the testing of different types of power electronic converters and electric machines and machine drives/controllers for electric drive applications.



(a) Electric energy storage laboratory



(b) Electric propulsion and integration laboratory

Figure 1. Industrial-standard laboratories for ETT and EVE programs

Associate of Applied Science and Certificate Programs

MCC has an Alternative Fuels Certificate for the Automotive AAS degree, and a Renewable Energy Certificate for AAS degrees in Electronic Engineering Technology and Automated Systems to complement the Automotive Technology program. MCC also offers six EV/HEV/PHEV exclusive courses: Introduction to EV Propulsion Systems; Motors & Controls for EVs and Industrial Applications; EV Data Acquisition, Sensors & Control Systems; Capstone Project-EV Build; Electric Line & Smart Grid Design; and Advanced Energy Storage. These courses are designed to be transferable to the SU BS-ETT degree described above.

Outreach Programs

To promote green transportation and alternative energy technologies, and to increase the awareness of the technologies by the general public, WSU and MCC jointly offer a variety of workshops and seminars to various groups with a stake in learning more about HEV technology:

- **Summer Academy for EV/HEV Technology:** To encourage transferring from community colleges to four year universities, the program recruits 30 community college students each year to participate in the WSU Summer Academy for EV/HEV Technology. The program provides room and board for community college students to receive a “university experience” by spending four days at the WSU main campus. WSU engineering and engineering technology faculty serve as mentors to introduce the technology and the programs to the participants. Figure 2 shows the WSU Summer Academy held in May 2012.



Figure 2. WSU 2012 Summer Academy for EV/HEV Technology

- **Faculty Development Program:** WSU offers a two-day short course each summer for community college instructors, high school STEM teachers, and automotive related professionals. The course consists of four modules: Electric Drive Vehicle Fundamentals, Power Electronics and Charging Systems, Advanced Energy Storage, In-Vehicle CAN

Embedded Systems. The photos shown in Fig. 3 is the 2012 program held in Ivy Tech Community College in Lafayette, Indiana. WSU faculty was responsible for lectures, and Ivy Tech provided five different kinds for hybrid electric vehicles for laboratory experiments.

- Professional Development Short Courses: In responding to industry request, WSU has also developed four professional development short courses for incumbent automotive engineers, including Fundamentals of Electric Drive Vehicles, Battery Systems for Electric Drive Vehicles, Motor Drives and Power Electronics for EV/HEV/PHEV, and Automotive Direct Injection Engines. Each course includes 14 hours for lectures and 4 hours for laboratory experiences. All of the four courses are endorsed by the state initiated Michigan Academy for Green Mobility Alliance.
- Workshops for K-12 Automotive Teachers: MCC is a founding member of the Southeast Michigan Automotive Teacher Association, which represents 40 secondary schools and approximately 120 teachers and provides a forum for this project to educate teachers.
- Informational seminar for automotive repair facilities and other corporate partners: This seminar introduces the technology and safety of Electric Vehicles and the supporting infrastructure.
- Summer Academies for K-12 Students: These academies will be offered to encourage the learning of the EV technology and the advantages of these vehicles to the future of young people in terms of costs, environmental advantages, and future national and personal prosperity.

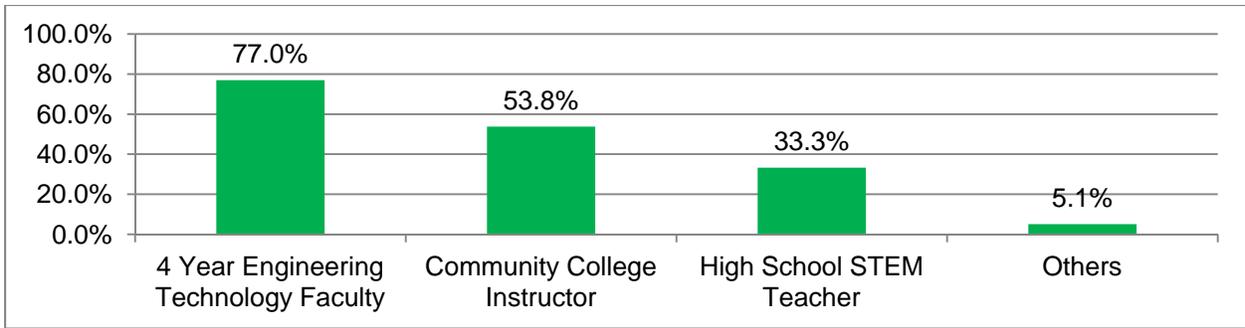


Figure 3. 2012 Faculty Development Program held in Ivy Tech Community College

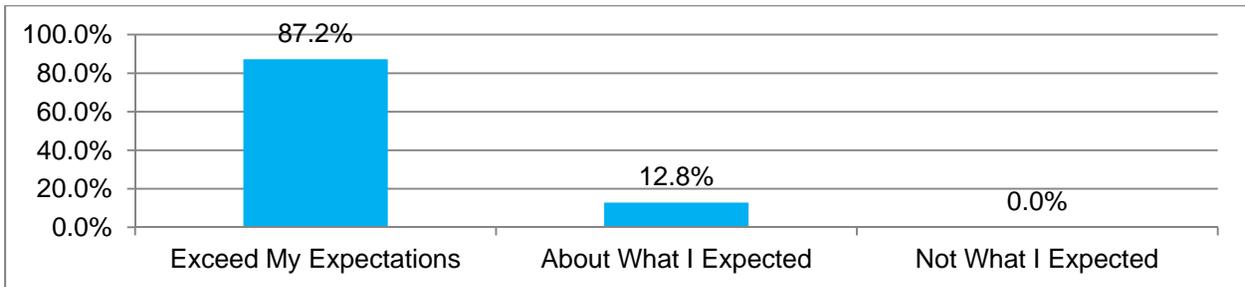
Program Outcome

To measure the effectiveness of these training programs, participants survey was conducted at the end of each summer short courses. The results of the 2012 survey is shown below as an example:

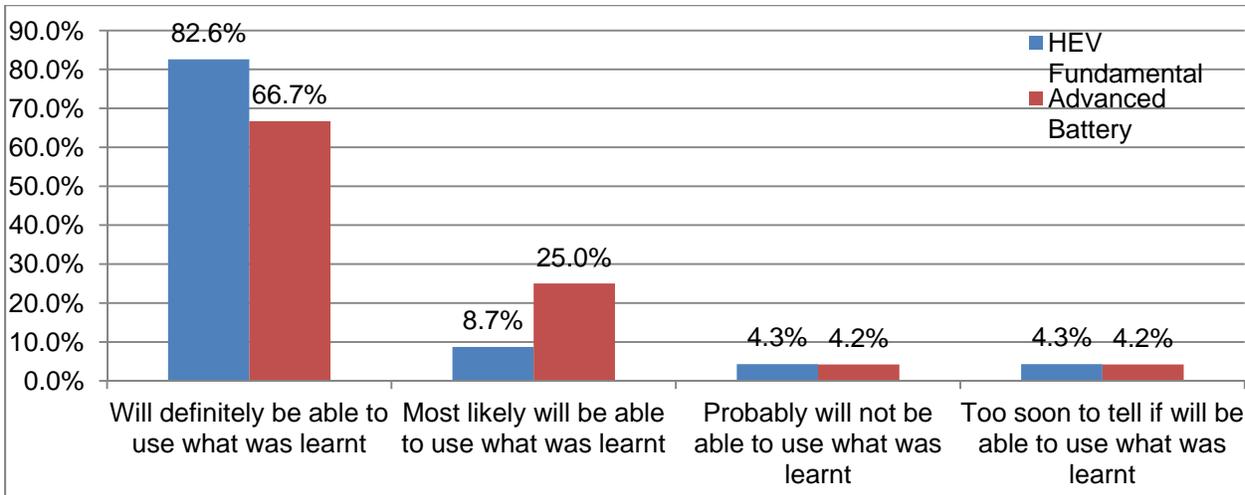
1. Which best describe your position?



2. Did this workshop meet your expectations?



3. Usefulness of this workshop experience for your work:



SUMMARY

Wayne State University and Macomb Community College have partnered to develop educational programs to support the automobile businesses with product and manufacturing development facilities in Michigan. The partnership was engaged by NSF to survey industry to establish educational requirements for technicians, engineering technologists, and engineers involved in vehicle electrification. To strengthen communication with industry, government agencies, and

professional associations, WSU and MCC are participating, and hold leadership positions, in Michigan Academy for Green Mobility Alliance. The two schools also developed, with DOE support, new certification and degree programs in vehicle electrification. The partnership was awarded an NSF-ATE grant to establish the Center for Advanced Automotive Technology. Through the Center, the WSU-MCC partnership is leading a systematic curriculum reform for automotive technology educational in the region. The WSU-MCC partnership is having considerable impact in preparing the future ground vehicles workforce to meet the needs of a transforming industry.

ACKNOWLEDGEMENT

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