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Addressing New Skills Needed for the Automotive Industry through a Motorsports Educational Pathway

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Abstract

The automotive industry has higher-skilled positions available that need engineers and engineering technologists qualified and capable to work in a high-paced, advanced manufacturing sector. Various educational programs across the country offer programs related to the motorsports area at the Associate of Science level. There are also various articulation agreements that enable students to continue their education to the baccalaureate level. These programs try to fill in the gap related to the skills shortage in systems and new design methods and processes. The main strength of such educational pathways is that students, who are trained to work as technicians with an associate's degree in automotive and motorsports areas and then continue onto complete their four-year undergraduate degree, have specific skills highly sought by the automotive industry. In this paper, the authors present an example of such an educational pathway, with an emphasis on motorsports.

Introduction

In the beginning, motorsport competitions started as testing venues for the performance and reliability of engines and automotive vehicles [1]. *La Petit Journal* organized the first car race in France in 1894. This was a competition in which companies, such as those of inventors Karl Benz and Gottlieb Daimler, had their vehicles competing with one another. The first race competition in the U.S. was held in Evanston, Illinois, in 1895 [2] (see Figure 1). The main goal of this race was to showcase the "horseless carriage" as "an admitted mechanical achievement, highly adapted to some of the most urgent needs of our civilization."

Various studies have shown an impact of the motorsports industry to manufacturing sectors in the U.S. and across the globe [3]. For example, in the state of Indiana, it contributes to more than 23,000 jobs directly and 421,000 jobs indirectly with annual wages around $63,000, which is well above the state average, as stated in a report by Purdue University researchers: "Race to the Future: The Statewide Impact of Motorsports Industry in Indiana" [3].

Figure 1. The First Car Race in the U.S. Held in Evanston, Illinois [2]

Few career paths for science, technology, engineering, and math (STEM) areas are as dynamic, exciting, and engaging to prospective students as motorsports [4]. The speed and color of the sport engages students in thinking about how cars are designed and made in a very different way than almost any other industry.

Skills Shortage in the Automotive Sector

Skill shortages in the automotive sector are not just related to traditional causes such as high levels of separation from the trades, low take-up of apprentices, or low levels of stock of skills in the work force [5]. They are also related to rapid changes in technology. Typical problems reported were related to recruiting skilled labor, especially maintenance engineers, electrical engineers, and production cell managers [6]. Many of the jobs in the automotive sector that require qualifications between a high school diploma and a bachelor's degree are also hard to fill, since many of the current skilled workers are close to their retirement [4, 6-8].

There is a need in the industry for skilled workers to perform multi-faceted jobs (e.g., someone with electrical and welding knowledge), and some companies report that they

are facing downtime in their production systems in part because of the skills shortage [7]. Expensive CNC machines can be idle in manufacturing systems due to the lack of skilled operators. Various initiatives across the country are focused on addressing these skill shortages. Some of them are focused on a development of new certificate programs, such as the Career Pathways initiative in Oregon, which created 300 flexible certificate programs [8]. Such certificates led to a job placement of 44.5% of participants, many of whom earned more than $15 per hour. Another initiative in Virginia established a Board of Workforce Development to facilitate collaboration between relevant agencies in order to address the skills shortage.

Automotive Technology Skills

The National Automotive Technical Education Foundation has identified a set of needed industry-driven skills related to automotive technology [9]. These standards are divided into the following groups: engine repair, automatic transmission, manual drivetrain and axles, suspension and steering, brakes, electrical/electronic systems, heating and air conditioning, engine performance, and alternative fuels and vehicles. These skills are then assessed by the National Institute for Automotive Service Excellence. The other section is related to the employability and possible transferability of acquired skills because of the nature of the current industrial environment, where many people are switching from one job to another [10].

Motorsports Technology Skills

Various universities around the world are offering courses related to motorsports technology, some even offering degrees in Automotive Performance Engineering and Motorsports Technology [11-12]. Others are using motorsports themes for their senior design projects [12].

Technical Skills: Motorsports programs and student competitions allow students to stay current with the technology and develop skills needed for the workforce of the future through various courses in an engineering curriculum. Motorsports projects engage students in problem-based learning with many different multidisciplinary challenges.

Project and Team Skills: Students involved in motorsports projects learn engineering concepts through hands-on experience and teamwork, leadership, and critical thinking skills that are applicable to real-life situations [7]. Another engineering management skill that might be beneficial is related to the mechanics and production crews engaging in planning, setting up, and running a motorsports event, such as a monster truck show [9].

Re-Profiling of Skills in the Automotive Sector

The automotive sector includes technologies transferable to other industries, such as defense, aerospace, energy, and transport [10]. Innovation is a key asset of a successful motorsport team. One such skill is welding, which can be transferred to a wide array of industrial jobs in various sectors [11]. Race teams spend a significant amount of time in the research and development of high-end engineering systems, while adopting new technologies under strict deadlines. Examples of new technology developed for motorsports applications, which are transferred over to the defense sector, include the development of more efficient engine-cooling systems, radiators, and filter systems for armored vehicles that need to work in very hot and dusty conditions in Afghanistan [10]. Aside from these systems, other transferable skills include aerodynamics, lightweight structures, electronics, embedded systems, and general onboard car systems.

The design of vehicles for motorsports includes engineering design principles and the use of computer-aided design. Various material options and alternatives can be analyzed in a digital model so that engineering decisions could be made as early as the design stage, before the realization phase begins. In this way, successful collaboration with people not located in one company is enabled, and skills gained during work in virtual teams could be used in any other industry.

Educational Pathway for Automotive Sector

The first bachelor's degree in Motorsports Engineering and Motorsports Engineering Technology in the U.S. was offered at Indiana University-Purdue University Indianapolis [12]. In addition, various summer camps and pre-engineering curriculum modules were developed to enable the pipeline to this educational pathway. Examples of such modules are related to concepts of a working modern race-car. Examples of educational materials related to motorsports are safety design concepts such as safety structure design and investigations of previous crashes and the development of design improvements based on them. These materials have had a positive effect on high school students and their teachers. In Great Britain, similar initiatives are taking place to engage the younger populations in activities related to motorsports to spark their interests in STEM careers, including four-day intensive courses in motorsports. For example, the Formula Student initiative focuses on teamwork, management, and marketing skills to bring more students into the motorsports educational pipeline [13]. An-

other example is the study of engineering concepts through an analysis of monster truck competitions [9].

Students' motorsports education continues at the university through their participation in Formula SAE teams and use of the ODU facility, the Virginia Institute for Performance Engineering and Research (VIPER) lab, which is a facility for teaching and hands-on experience, as well as a commercial race facility. Old Dominion University in Norfolk, NASA Langley Research Center in Hampton, and Virginia Tech in Blacksburg collaborated to offer a graduate degree in motorsports engineering and consulting services to automakers and racecar teams [14].

Old Dominion University (ODU), Norfolk, Virginia, and Patrick Henry Community College (PHCC), Martinsville, Virginia, have undergraduate motorsports pathway programs (see Figure 2). In these programs, they are providing educational training for future technicians, engineering technologists, and engineers interested in this technical area. The programs are designed as Associate of Applied Sciences programs that build into a Bachelor of Science degree. As a first step, students enroll in the motorsports program at PHCC. Those students wanting to continue working towards their bachelor's degree have to complete one year at the community college or at a university to take all the necessary requirements for transfer. After that, they enroll in the Mechanical Engineering Technology (MET) program at ODU. The MET program has an option for them to choose Motorsports as their minor. ODU and the New College Institute have partnered to offer Motorsports Engineering Education in Martinsville for students, professionals, and companies involved in motorsports [15].

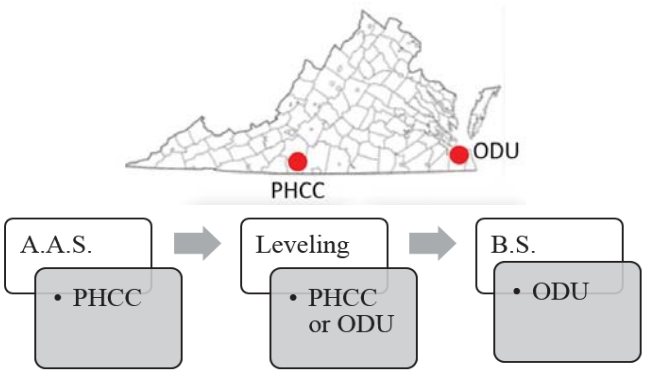

Figure 2. Locations of Two Institutions and Motorsports Educational Pathways

ODU offers a minor in motorsports engineering for mechanical engineering and engineering technology students [15]. Students are introduced to important engineering concepts related to aerodynamics, chassis dynamics, piston engines, and racecar performance. These areas are important for working with high-performance racecars. Graduates with this minor are qualified to work in entry-level positions in motorsports or the automobile sector. A motorsports minor is available to ODU students who have completed lower-division credit requirements in education and a group of technical-based credits that stress subjects related to motorsports. Students may complete general education credits at a local community college, but not many programs can provide technical courses directly related to motorsports.

Table 1 lists courses for the motorsports minor that are available to ODU students in Mechanical Engineering Technology or Mechanical and Aerospace Engineering programs. Students must take four of these courses to satisfy requirements for the minor.

Table 1. Motorsports Minor Courses Available at ODU

Code	Course Name	Credits
MAE 407	Ground Vehicle Aerodynamics	3
MAE 457	Motorsports Vehicle Dynamics	3
MAE 467	Racecar Performance	3
MET 480 / MAE 477	High Performance Piston Engines	3
MET 427 / MAE 427	Mechatronics System Design	3

High Performance Piston Engines is one example of the available courses. This course uses the motorsports lab, which includes a Briggs and Stratton animal racing engine connected to a land and sea dyno and a flow bench to study the air intake process. The students study the ideal internal combustion four-stroke cycle and work their way up through the complete fuel-air cycle. Students study chemical reactions and combustion. After a thorough study of the thermodynamics of the cycle, they complete this part of the course with comparisons to the actual cycles and spend time in the lab running the animal engine on the dyno (see Figure 3).

The next major portion of the course involves air, fuel, and exhaust flow. Topics for discussion include valves, valve timing, intake, and exhaust flow modeling (followed by flow bench experiments). Students then spend course time discussing the tuning of the manifold using CFD, Helmholtz resonators, and a simple acoustic method, as well as turbocharging and supercharging. Students also study the thermodynamic and mechanical aspects of engine design and learn how to read compressor and turbine performance

maps to understand how they are created and how to use them. After this, friction and heat transfer is discussed. Many of the students in the course are also involved in the Formula or Baja motorsports teams, so they can apply what they learn right away. The following experiments are conducted during this class: torque calibration; manual dynamometer test with water brake dynamometer; sweep test for different throttle positions; air flow, air/fuel ratio, and fuel flow measurement; exhaust gas analysis; and, injector versus carburetor.

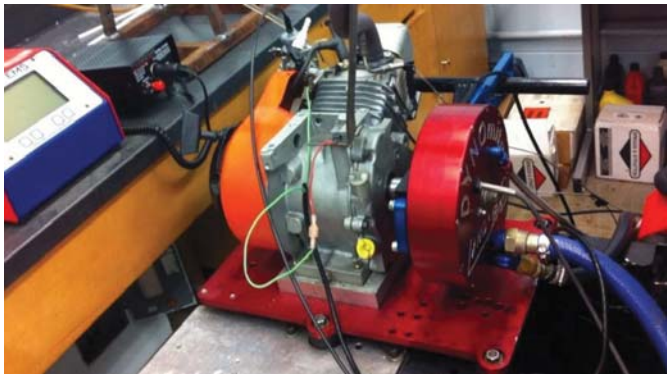

Figure 3. Motorsports Engine Testing Lab at ODU

Facilities Used in the Motorsports Program

VIPER Lab: This facility is located at PHCC, a 12,000-square-foot building next to the Virginia International Raceway, where teams can bring their racecars and simulate track conditions on a seven-post "shaker" rig [14]. The facility is designed to support hands-on teaching of undergraduate and graduate motorsports engineering courses at ODU and the New College Institute, along with PHCC. It is also used to conduct engine and drivetrain research, while operating as a commercial entity. This program was established through support from NASA, Virginia Tech, and the Virginia Tobacco Commission. The engine and drivetrain lab has three main areas of commercial concentration that complement research and teaching aspects: engine diagnosis and performance testing, engine performance optimization (tuning), and vehicle data acquisition and analysis [15].

The engine and drivetrain lab serves commercial applications during race events. Maintenance crews measure horsepower output, and various other measurements related to the race vehicle's drive and chassis. Aside from the weekend events, the lab is used by students for learning [16]. Its main applications are engine diagnostics, performance testing, performance optimization, and data acquisition and analysis. The VIPER vehicle has a 250 HP, 1.4 liter Suzuki motorcycle engine, heavily modified to produce 250 HP. The vehicle's chassis is a lightweight carbon fiber body [17].

Various other facilities are available to students in this minor at ODU: wind tunnel, engine dynamometers, and labs at Virginia International Raceway, which include a modified Formula Mazda and advanced data acquisition system. All junior- and senior-level courses in the motorsports minor are delivered both on campus and through the distance learning program. Motorsports courses are delivered by ODU at the New College Institute in Martinsville, Virginia. Facilities at PHCC include a driving simulator, vehicle dynamics rig, and chassis dynamometer. In addition, students have access to the engine instrumentation lab and Virginia International Raceway.

Motorsports Student Senior Design Teams at ODU

ODU has participated in the Formula Society of Automotive Engineers (SAE) competitions since 1998. Each year, the team has requirements to design, build the vehicle, and participate in the competition with a formula-style racecar (see Figure 4). In addition to the design and build requirements, the team has to be involved in project management tasks to plan, coordinate, and verify the robust design of all car components, subassemblies, and assemblies. Main subassemblies are chassis, drivetrain, engine, suspensions, aerodynamic components, and controls. Components are designed to the manufacturing specifications, built, assembled, and integrated. Before the race, they are tested for durability and reliability [18].

Figure 4. ODU Motorsports Fleet

Conclusions

Automotive and motorsports industries have faced rapid expansion in recent years. Various car manufacturers are participating in motorsport competitions to research and

develop various innovations related to vehicle design and performance. In addition, modern high-performance vehicles are now redesigned to run on more environmentally friendly fuels such as electric, ethanol, and diesel, or in a hybrid mode. Working on their design, testing, and maintenance requires very specific skills, many of which can be translated to the automotive sector. The motorsports minor at ODU complements mechanical engineering/technology and aerospace programs. It adds a more specialized focus to prepare students for various jobs. Through work on automotive/motorsports-based themes in the stream of courses, students receive problem-based, lab-oriented, in-depth knowledge of complex engineering principles.

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Biographies

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