PRACTICAL TRAINING IN AUTOMOTIVE ELECTRONICS

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The increase in complexity of modern cars also increases the demands placed on diagnostics, maintenance and repair. The paper outlines the design and implementation of blended learning course for training in Automotive electronics and OBD diagnostic. Developed practical exercises with emphasis on engine performance test and OBDII diagnostic are discussed. Topics with increased complexity dedicated to training in three professional levels are considered. Teaching aims and results of conducted pilots with car mechanics and employers from car garages are also outlined.

Keywords: automotive electronics, OBD diagnostic, practical training

1. INTRODUCTION

Modern cars need networked measurement, control and communications systems to meet the growing demands for complex features, including increased safety (brake systems, airbag system, Electronic Stability Program - ESP), driver assistance systems (cruise control, navigation, night vision, blind spot detection) or to comply with legal requirements (reducing the emission of pollutants by intelligent engine control). On-board diagnostics (OBD) check the operation of almost every electrical/ electronic part in every major vehicle system. A vehicle's Engine Control Unit (ECU) monitors the operations of the fuel injectors, ignition coils, fuel pump, emissions system part, and other major components that affect vehicle performance and emission control.

All of the changes to the various systems of an automobile and the integration of those systems has made becoming a successful technician more challenging than ever before [1]. As a result of the growing technical complexity of cars a continuous need to upgrade the technical competencies of car mechanics and employees is emerging. Technicians must have an understanding of electronics and good diagnostics skills to be able to diagnose and service electronic systems in modern cars.

To prepare car technicians to those challenges an innovative blended learning approach for training in automotive electronics and OBD diagnostics, tailored to the needs of small and medium sizes car garages and car mechanics was introduced. It combines Web based interactive e-learning, simulations and practical exercises with measurement instruments and scan tool for engine performance test. The paper discusses developed practical exercised for training in automotive electronics with emphasis on OBD diagnostic. Results of conducted pilot course with employers in car garages are also outlined.

2. AUTOTRONICS COURSE

The curricula and structure the Autotronics (AUTOmotive+ElecTRONICS) course is considered in [2]. The course contains a comprehensive suite of e-learning modules dedicated to three professional levels [3] in combination with sophisticated classroom training specifically designed to meet the needs of car garages and car mechanics.

The e-learning courses are divided into small units, allowing each learner to complete courses based on his speed of learning and individual time budget. All course modules are provided to users via the Moodle Learning Management System and can be accessed online, allowing self-guided learning to be completed at any time from any location.

After passing e-learning modules with many interactive practical tasks, simulations and virtual laboratories, moreover, the classroom courses provide the possibility to deepen the theoretical knowledge being acquired during the e-learning courses. Practical training for all levels is performed in learning centre equipped with computers, necessary measurement instruments and appropriate workbenches.

3. AUTOTRONICS PRACTICAL TRAINING

The methodology used to develop the classroom practical modules consisted of following steps:

- plan the time distribution for the classroom practical sessions over the duration of the practical training per module
- plan the timing structure of each classroom learning course
- cross-examine the adjusted curriculum with the eLearning content to specify the needed classroom course modules
- create a specification for the requirements towards the classroom course modules with all details needed for their development
- develop the classroom course modules

In the process of the development of the specification, the following constraints were taken into consideration:

- the determined duration of the practical training sessions per level and the number of modules per day
- the determined duration of a module, as per the module structure and schedule
- the adjusted curriculum and syllabi of the service
- the existing eLearning course material for each level of the service

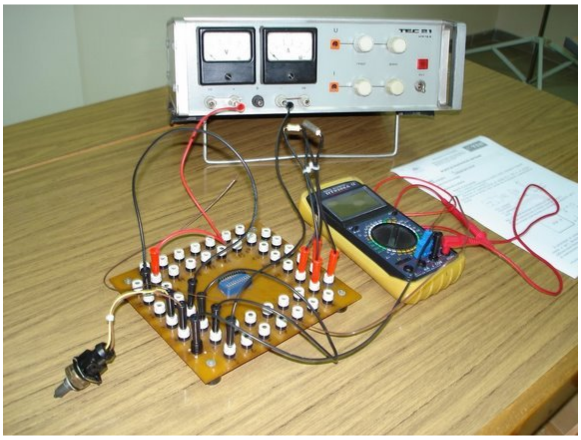
Main focus in the development of the specification was to identify the needed practical training that is to take place within the classroom training sessions that will lead to the development and consolidation of the needed practical skills in the trainees. This included also the identification of material that is not covered or can not be covered by the e-Learnnig component of the service.

Different topics with increased complexity are dedicated to training in three professional levels. They cover general electrical system diagnosis and services (for level 1), sensors' and actuators' diagnosis and service for level 2 and emission control and OBDII diagnosis for level 3. The thematic areas of practical sessions in each professional level are given in Table 1.

Autotronics professional *Level 1*	*Autotronics professional* *Level 2*	*Autotronics professional* *Level 3*
- Wiring diagrams and basic DC measurements - AC circuits measurement - Testing electronic components - Troubleshooting in a car electrical installation	- Computer System Diagnosis and Service - Reading of car electrical diagrams - Temperature sensor - Hall-effect sensor and inductive sensor - Fuel Pump Motor - Exhaust Gas Recirculation (EGR) Valve	- On Board Diagnosis (OBD) - OBD Data Retrieval - O2 Sensors Check - DTC Diagnosis - Real-time scan data analysis

Table 1. Topics of practical sessions according professional level

For every professional level developed classroom materials for practical training include: general introduction that covers specific topics needed for practical sessions and that to be used by the trainees for preparation before starting practical work; module guides with step by step instructions for trainees to conduct each exercise; presentation materials (where needed as power point presentations for teachers) that covered topics non existing in e-learning content; and workbenches for conducting practical training.



a) Temperature sensor experimental board

b) Troubleshooting experiment

Fig.1 Practical training with experimental board and measurement instruments

Reconfigurable experimental boards (Fig.1) are used in most practical sessions, which can be customized for conducting different practical tasks just by changing interconnections. This approach stimulates trainee's ability to read and analyze wiring diagrams, to recognize serial and parallel wiring and to implement circuit from the wiring diagrams.

Teaching aims for level 1 include ability to measure basic parameters of DC and AC signals – voltage, current, resistance, period, frequency, peak to peak, average and RMS value, ability to interpret multimeter and oscilloscope readings and determine needed repair; ability to inspect and test basic electrical/ electronic components – diodes, transistors, fuses, capacitors, relays, inductors and determine needed replacement. Troubleshooting tasks are dedicated to find shorts, grounds, opens, and resistance problems in electrical/electronic circuit and to relate fault in a circuit and reason that cause it.

Teaching aims at level 2 include ability to choose and apply different testing methods of engine sensor and actuators; ability to read and interpret automotive manual data; ability to identify components of the engine control system, input signals from sensors to ECU and output signals from ECU to actuators; ability to test and diagnose different automotive sensors and actuators and their circuits; ability to relate troubles with engine behavior.

3.1. Training in OBD

On Board Diagnostic standards (OBD II in the USA and EOBD in Europe) define mandatory diagnostic processes for all emission related systems and components.

The car computer is programmed to detect abnormal operating conditions. During day-to-day vehicle operation, the ECU periodically runs test OBD programs. It actually scans its input and output circuits to detect an incorrect voltage, resistance, or current, but also checks the messages to and from the others vehicle's computers. If the on-board computer finds any abnormal values, it will store a diagnostic trouble code (DTC) and light a malfunction indicator light (MIL) on the instrument panel. This will inform the driver and the technician that something is wrong and must be fixed. It is very important car mechanics to know how to use this troubleshooting aid.

Practical Training for the Level 3 covers OBD diagnosis exercises with simulations and live experiments with OBDII scan tool. The emphasis of the module is on those things learners need to know about the OBDII diagnosis and how to perform corresponding engine tests. Various typical engine performance and diagnosis tasks are considered. A developed web based, OBD-II scan tool [4] is used throughout the exercises.

Teaching aims at level 3 include ability to define terms associated with OBD II diagnostics; ability to explain the basic format of OBD II DTCs and to identify the cause of illuminated MIL. To conduct preliminary checks on an OBD II system, to perform a scan tester diagnosis on a car, to use the scan tool software and hardware to read data from a EOBD compliant car, to analyze real-time scan data and to use a symptom chart to set up a strategic approach to troubleshooting a problem are main goals for training in diagnostics.

The first step is learner to be informed about different OBD functions concerning engine subsystems: what are the pre-required conditions for the specific monitoring; which components are monitored during the various tests; what is a bad or plausible signal; when does OBD system switch MIL lamp on; how to interpret OBD data using scan tool, how to generate diagnosis schedules and how to validate the diagnosis process.

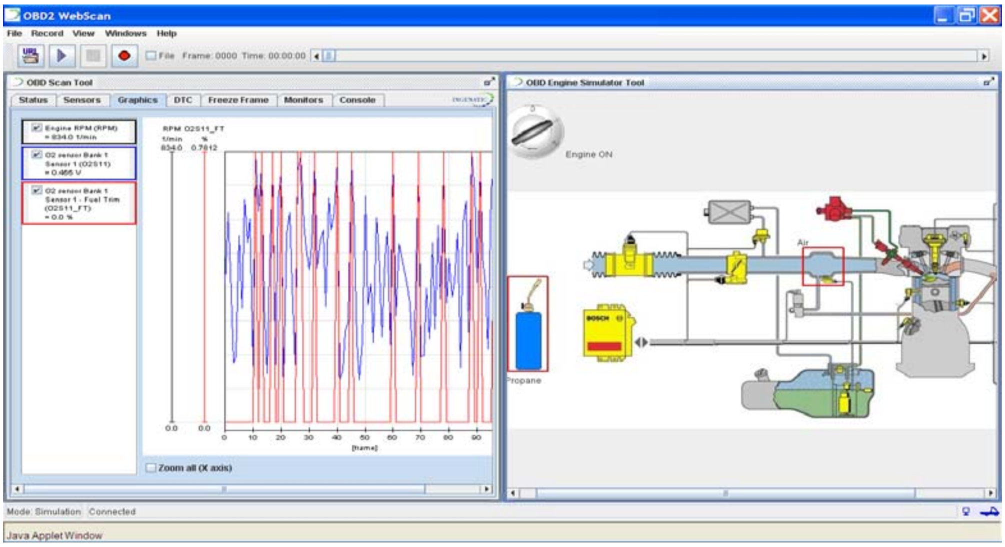
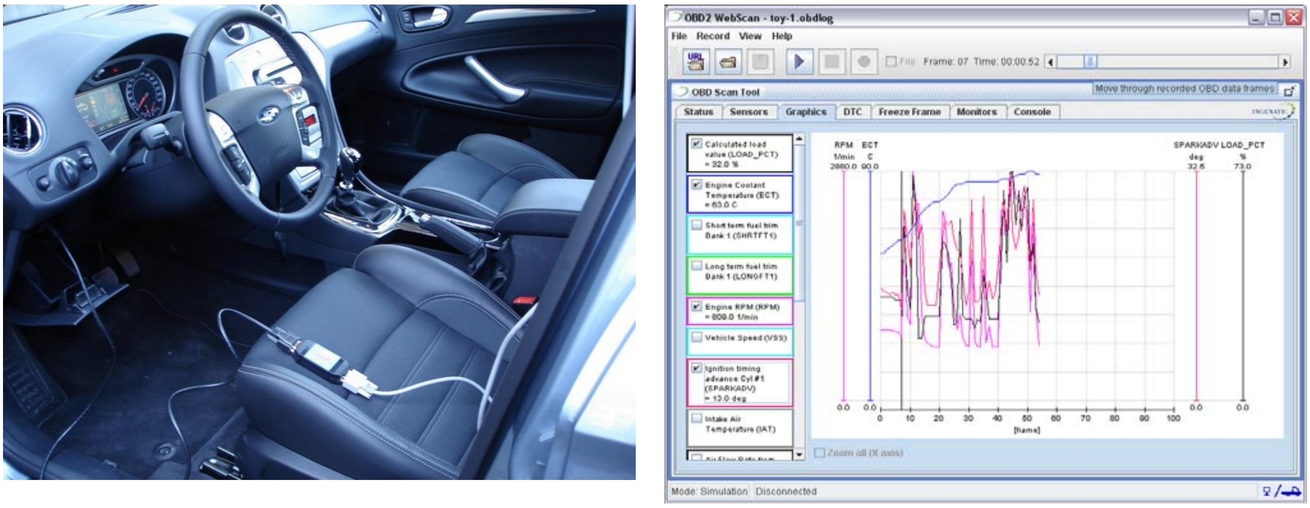


Figure 2. Simulation result of checking lambda sensor

The next stage of the OBD learning process covers such topics as typical failures of the components, how the engine ECU interprets bad sensor signals, and how the engine reacts to the failure sensors or actuators. An engine simulator in OBD scan tool is used for this purpose, which allows faults diagnosis that are difficult to reproduce or potentially dangerous if attempted on a real car. Different sensors in specific fault conditions (engine coolant temperature sensor – ECT, intake air temperature sensor – IAT, manifold air pressure sensor – MAP, lambda sensor – O2S, crank or cam position sensors – CPS) are included in the simulator. Results from the simulator are presented by the instruments of the developed OBD II scan tool, as illustrated in Fig.2 in case of checking lambda sensor – O2S.



a) OBDII interface in All New Ford Mondeo b) live data monitor of the Scan tool

Figure 3. OBD II scan tool use in "real live" experiment

The next step of the OBD learning process is dedicated to the trainee ability to analyze scan tool data and understand the meaning of the various generic OBD parameters. It utilizes the possibilities of the OBD scan tool to store data from previous "live" experiments. The data is captured, saved, and can be retrieved in frames format. This format is very useful for data analysis especially in cases of

DTCs (Diagnostic Trouble Codes) generation. Parameters related to the emission control, O2S signal, short and long term fuel trims are also available.

The last step of the OBD learning process accentuates upon OBD data retrieval and DTC diagnosis by using live experiments with OBDII scan tool (Fig.3). Different DTCs are artificially logged in the engine ECU by disconnecting appropriate sensors or actuators during several subsequent driving cycles. The All New Ford Mondeo and Land Rover Freelander II were used in the OBD diagnostic experiments. By generating false DTC codes and using real data flight recorder the participants were gone through the diagnostic process to the source of the faults.

The three level pilot courses with employers from car garages – car mechanics, car diagnosis specialists, service managers, garage managers and garage owners were conducted. Most interesting for participants were trouble shooting experiments and real life OBD diagnosis on EOBDII compliant vehicles.

4. CONCLUSIONS

The increase in the complexity of modern cars also increases the demands placed on diagnostics, maintenance and repair. Currently there is a great shortage of qualified automotive technicians with good diagnostics skills. Vehicles will continue to become more complex; therefore, the need for good technicians will continue to grow.

The paper discusses practical training in automotive electronics with emphasis on OBD diagnostic. Topics with increased complexity dedicated to training in three professional levels are considered. Results of conducted pilots with employers from car garages are also outlined.

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