Reform and Practice of Vocational Undergraduate Curriculum Based on the OBE Concept

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Abstract: The intelligent connected vehicle industry is growing fast, but vocational undergraduate courses on in-vehicle networks have not kept pace. Practical training still revolves around fault inspection and maintenance, while the work that graduates actually do on the job, such as multi-bus application and database development, is rarely covered. This paper reports a reform of the course In-Vehicle Network and Communication Technology carried out under the outcome-based education (OBE) concept. The course objectives were redesigned across three dimensions, namely knowledge, ability, and quality, and the content was reorganized into six modular projects covering network fundamentals, CAN, LIN, automotive Ethernet, bus simulation, and calibration and diagnosis, by drawing on post requirements, the 1+X certificate assessment, and skill competition standards. A real enterprise task in in-vehicle network database development was adapted into an eight-hour practical training case. The reform also brought in blended online-offline teaching, a set of digital resources, and a combined process-and-outcome evaluation system, with ideological and political education embedded in the training process. The experience may serve as a reference for similar courses in vocational undergraduate programs.

Keywords: Vocational Undergraduate Education; In-Vehicle Network and Communication Technology; OBE Concept; Curriculum Reform

1. Introduction

As intelligent connected vehicles evolve, demand keeps rising for engineers who can test in-vehicle multi-bus systems and develop communication databases. Vocational undergraduate programs are expected to produce high-level technical talent able to solve complex engineering problems, which sets them apart from higher vocational programs that put more weight on vehicle fault diagnosis and repair. Teaching reform of in-vehicle network courses is not new, but several problems persist: content updates lag behind industry practice, teaching modes remain rigid, and digital resources are scarce. The practical training offered in most programs is still built around fault inspection and maintenance, while mainstream enterprise work such as DBC/LDF database development and joint commissioning of in-vehicle networks is barely touched. Graduates therefore often fall short of what these posts actually require.

This paper describes a reform of In-Vehicle Network and Communication Technology, a core course in the vocational undergraduate major of Intelligent Connected Vehicle Engineering Technology. Starting from real enterprise development tasks and following the OBE principle of working backward from intended learning outcomes, we rebuilt the course objectives around knowledge, ability, and quality, reorganized the teaching content and its implementation, developed supporting digital resources, and revised the evaluation mechanism, with ideological and political elements woven into the training process. The experience reported here may be useful to teachers of similar courses.

2. Overall Design of Course Construction

2.1 Course Orientation and Analysis of Learning Conditions

In-Vehicle Network and Communication Technology is a compulsory core course for the vocational undergraduate major of Intelligent Connected Vehicle Engineering Technology. It carries 48 class hours, sits in the intelligent vehicle trial-manufacture and testing post module, and is taught in a blended online-offline mode. Students came to the course with a basic understanding of automotive electronic control and in-vehicle networks and learned best through

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hands-on practice [1].What they usually lack is hands-on contact with real engineering: most have never worked on a multi-bus project, and few have touched CAN FD, LIN, or automotive Ethernet applications, let alone DBC/LDF database development, bus simulation, or calibration, testing, and diagnosis. Closing this gap in engineering operation and project handling is the starting point of the reform.

2.2 Designing Three-Dimensional Course Objectives under OBE

With OBE in the driver's seat, the course starts at the end and walks itself back: lock in what students should have in hand when they graduate, then reverse-map every course component from there [2]. The learning objectives fall into three groups, drawn up against the competency standards for intelligent connected vehicle roles; Figure 1 shows how the three relate to each other. For in-vehicle networks, students need to build a solid foundation and work their way through the core protocols: CAN/CAN FD, LIN, and automotive Ethernet. Students should also be able to make sense of DBC/LDF database specifications and have a rough idea of what each bus type is commonly used for. The course is shaped so that students will be able to handle tough on-site engineering jobs down the road, and that is exactly why it spends most of its effort on practical skills: bus signal analysis, fault diagnosis, DBC/LDF file creation and checking, automotive Ethernet link troubleshooting, bus simulation, plus ECU calibration, testing, and diagnostic flashing. Once students are actually doing the work, they pick up the knack of following standard procedures, working side by side with teammates, and gradually figuring out their own solutions. The course sharpens technical skills but also takes professional ethics seriously, steering students to work by the book and stay on the right side of ethical boundaries

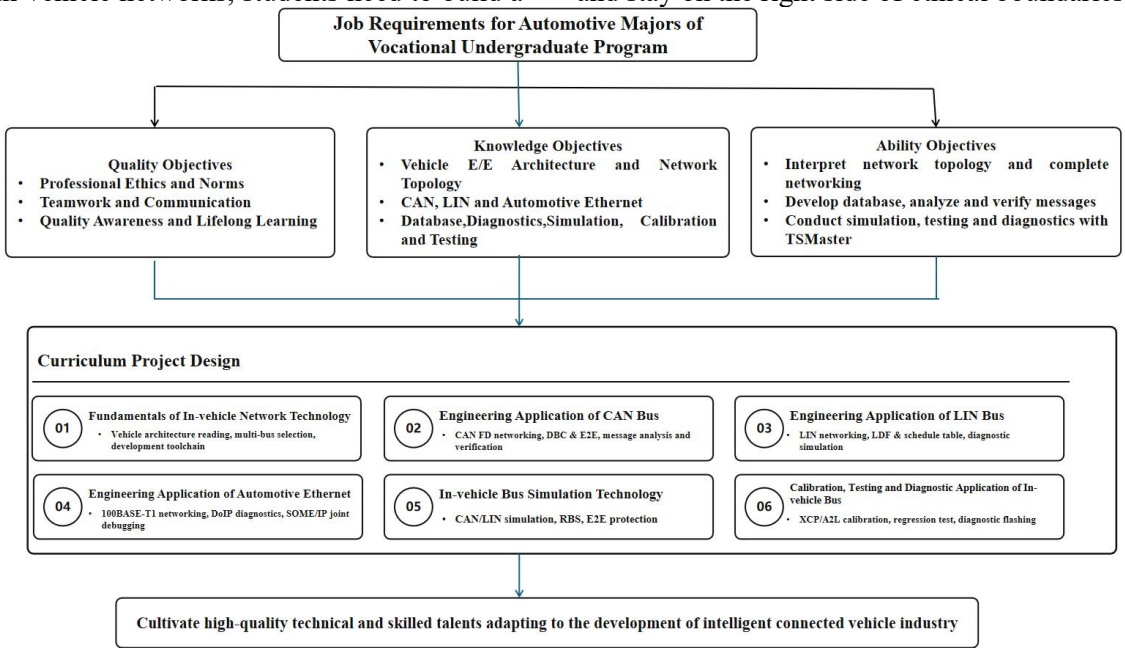

Figure 1. Logical Framework of Three-Dimensional Objectives: Quality, Ability, and Knowledge for the Course

2.3 Rebuilding Modular Course Content around Post-Course-Competition-Certificate Integration

The course content is reshaped around what real jobs demand, with the aim of weaving classroom learning, skills contests, and professional certs into one connected whole instead of leaving them to operate separately. We lay the course out in six linked projects, each one a bit harder than the last, as laid out in Table 1.The projects are built so as to line up with three things: workplace requirements for in-vehicle bus development, the "1+X" assessment standards, and competition regulations [3]. We stage the learning path so that students begin by getting in-vehicle network architecture and the development toolchain under their belt, then move into the bus technologies, and cap it off with hands-on integrated training. The project tasks are not hypothetical but are drawn directly from real-world industry scenarios, encompassing database development, Ethernet integration and commissioning, bus simulation, calibration, and diagnostics. The

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course goes modular on purpose just to catch protocol development up; in the old way of doing practical training, it often got shelved, and now we want it to carry the same weight as troubleshooting. We lay the projects out on the same tracks that enterprises actually use, sewing certificate and competition assessment points right into classroom work [4], so the teaching content hits the mark on both occupational standards and what vocational undergraduate education is out to cultivate.

Table 1. Design of Modular Teaching Projects for the Course

Teaching Project	Main Theoretical Content	Practical Training Task	Corresponding Core Competency Objective
Project 1: Fundamentals of In-Vehicle Network Technology	E/E architecture, network topology, topology design, protocol selection, multi-bus technology and toolchain	Interpret the network architecture and topology; get started with TSMaster	Use development tools
Project 2: Engineering Application of CAN Bus	CAN/CAN FD, DBC, E2E protection	CAN FD verification, DBC creation, message analysis	Build a CAN network and complete communication verification
Project 3: Engineering Application of LIN Bus	LIN protocol, frame check, LDF and schedule table	LIN networking, LDF creation, slave node simulation	Configure a LIN network and verify diagnostic communication
Project 4: Engineering Application of Automotive Ethernet	100BASE-T1, DoIP, SOME/IP	Ethernet networking, DoIP diagnostics, SOME/IP joint commissioning	Complete automotive Ethernet networking and service integration
Project 5: In-Vehicle Bus Simulation Technology	RBS, counter and checksum, E2E protection	CAN/LIN simulation, protection verification, signal injection	Configure multi-bus simulation and verify protection mechanisms
Project 6: Calibration, Testing, and Diagnostic Application of In-Vehicle Bus	XCP/A2L, regression testing, UDS flashing	ECU calibration, automated testing, diagnostic flashing	Complete virtual ECU calibration, testing, and flashing

3. Design of an Engineering Practical Training Case for CAN FD DBC Creation

3.1 Case Source and Analysis of Teaching Value

The case comes from a real assignment of the ECU communication database development post at an automotive OEM, rebuilt around the TSMaster tool in accordance with the CAN FD protocol and the DBC specification [5]. A DBC file records the nodes, messages, and signals of a CAN FD network; it is the working basis of bus testing and development and is used daily in ECU communication debugging [6]. The LIN project involves similar work with LDF files, including signal and schedule table configuration, so the case supports that part of the course as well. The way practical training used to run, it mostly circled back to message parsing and fault detection, leaving students next to no room to piece together an entire database from scratch themselves. We set out to fill this gap by grabbing real tasks from the shop floor, giving them a good rework, and making them genuinely usable in the classroom. Any engineering condition beyond the classroom's reach gets stripped away piece by piece, and the industry tasks only need a light tweak before they're fit for the classroom. Students still have to make their way through every single step of the core workflow—from getting the requirements straight and nailing down messages and signals, to validating the DBC database, setting up E2E protection, and running a check on communication. Driven by real industry tasks, students move past rote menu clicking and instead take charge of designing signal schemes, tuning parameters, and running communication verification on their own. Students cut their teeth on the most basic software menu operations and climb the ladder until they can run an entire task start to finish by themselves.

3.2 Adapting Practical Training Tasks for the Classroom

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On the shop floor, cobbling a database together means haggling back and forth across multiple controllers, and running through one message tweak after another during vehicle testing. Getting the full process to play out in class is an uphill battle—too many steps crisscrossing each other, too much back-and-forth linkage, and it just drinks up time. We trim the classroom version by slicing off anything that lies beyond the syllabus—whole-vehicle debugging, cross-department coordination, and the like. Lining the core activities up along the workflow, they fall into five units, adding up to eight class hours altogether. Armed with what they've picked up about automotive electrical and electronic systems, vehicle structure, and in-vehicle networks, students pair up and take on the tasks themselves using TSMaster's DBC editor. To kick off, students go ahead and build the nodes and messages the way industry does. They first walk through the message name, ID, DLC, message type, and CAN FD BRS bit one by one, then yank signals into the data field and tick off exactly which byte slot each signal sits in. The engine status message's parameters and signal arrangement are all laid out in Figure 2. By the end, each team turns in its DBC file, completed worksheets, and a troubleshooting log. By the time they've run through all these tasks, students have gotten comfortable with industry development workflows and started reading problems through a bus development engineer's eyes.

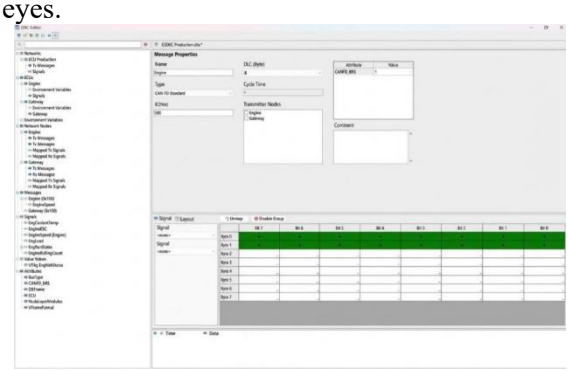

Figure 2. Engine Message Configuration and Signal Layout in DBC Editor

3.3 Implementation Flow and Assessment Criteria of Practical Training

The training is split into three steps, the first being an easy opener: students work through the online materials on their own before class. As soon as class begins, each group is expected to take the wheel on database design, parameter configuration, and communication verification, instead of simply copying the teacher's demo move by move. See Table 2 for the assessment criteria. Once class is over, students work through the training worksheets to firm up what they've learned. The assessment weighs both the path students take to do the work and the finished results they walk away with. We pull four threads together when grading: whether the DBC and LDF databases cut the mustard, how smoothly they run in communication tests, the quality of the training worksheets, and whether the fault analysis actually nails the core issue. When you roll engineering design, sticking to procedures, and problem analysis into one exam and grade them as a whole, the practical training results get pulled along for the better.

Table 2. Assessment Indicators of CAN FD DBC Creation Practical Training

Assessment Dimension	Assessment Content	Weight (%)
Completeness of Engineering Deliverables	Network nodes, messages, and signal configuration are complete; the DBC file can be loaded and parsed normally	40
Engineering Standardization	Signal scaling factor, offset, byte order, and transmitting/receiving node relationships are configured accurately without errors	35
Troubleshooting Capability	Able to identify and correct typical DBC configuration faults such as signal bit overlap	20
Practical Training Documentation	Training worksheets and records of fault phenomena and troubleshooting analysis are complete and standardized	5

4. Course Teaching Implementation and Supporting Construction

4.1 Organization and Delivery of Blended Online-Offline Instruction

Pre-class online prep and post-class online review complement the hands-on practice done in class, with our homegrown digital resources holding up all three stages of the course the whole way through [7].Prior to class, students go through micro-lectures and animations that focus closely on network protocols and DBC/LDF file structures, getting ready for the tasks ahead, as shown in Figure 3. By mixing hands-on work, group discussions, and case studies, students work their way through everything from multi-bus communication and database development to simulation testing, calibration, and diagnostics. Whenever students bog down in design, parameter configuration, or fault analysis, teachers move in close and hand out targeted tips.

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After class, students turn in the training worksheets, their project work, and learning reflections online; the teacher reviews them and clears up whatever questions come up.

The training drives proper procedures and quality standards home at every single step, so over time students' vocational skills sharpen up and their professional values settle in.

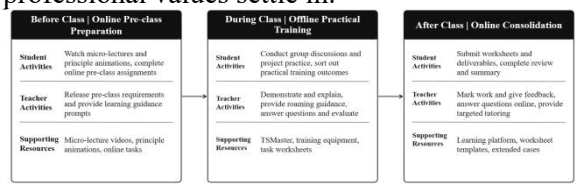

Figure 3. Diagram of Teaching Implementation

4.2 Building and Putting Digital Teaching Resources to Work

The course's modular setup rests on a complete digital resource kit—short video lessons, animations that break key principles down for you, bus simulation stuff, and standardized worksheets. Theory class hands the teaching of protocol principles, message transmission, and DBC/LDF file structure over to animations and short videos, which students can open up before class for a first look and pull back up afterward to review [8]. After virtual simulation environments go live, hardware needs for practical training ease up, and students can crack them open whenever they want to build databases, lay out signals, check communication, run bus sims, calibrate, and troubleshoot, on demand. For every project, the training worksheets spell out exactly how the operating procedures go, what to jot down, and which angles to zero in on when walking back through problems. These resources string theory and practice together, walk students through the training one step at a time, and leave them doing engineering work with a sharper eye for detail and a more methodical head.

4.3 Building the Course Evaluation System and Weaving in Ideological and Political Education

We blend in-class quizzes and the final result into one overall grade, keeping students' progress in view along the way rather than betting the whole semester on a single test. We grade process and product side by side: on the process end, we look at online study records, classroom participation, how smoothly groups click, and the quality of the training worksheets; on the product end, the DBC/LDF databases and how communication verification, simulation, calibration, and diagnostics pan out [9]. The summative assessment evaluates both students' theoretical knowledge and practical skills, including troubleshooting, database development, system integration and commissioning, simulation, and calibration. The course doesn't stick ideological and political education on as its own thing; it grinds it fine and mixes it into the practical training, so it moves along with the hands-on work. As students walk database development the rulebook way, it seeps in, and they slowly pick up a careful, organized way of working. The moment students start using the domestically built TSMaster, they see firsthand whether the tool is steady in real engineering work, and their faith in our own tech shoots up [10]. This practical training drills hands-on skills and instills professional attitude, with craftsmanship in its marrow.

5. Expected Outcomes and Optimization Paths of Course Construction

5.1 Expected Outcomes of Course Construction

Once the reform is in place, students come away with three kinds of learning gains that differ from one another. In line with what companies expect when they hire, students need to work comfortably with in-vehicle multi-bus applications, DBC/LDF database development, bus simulation, calibration, testing and diagnosis, and be ready to handle real in-vehicle network engineering work. This course will be supported by a full set of digital resources—micro-lectures, animations, simulation materials, and worksheets in place for each of the six projects—while the curriculum standards and teaching cases keep getting fine-tuned through actual use. In the next stage, we will apply for recognition as a university-level quality course and an online quality course, and we hope the experience proves useful to similar vocational undergraduate programs.

5.2 Existing Limitations of Course Construction

Several shortcomings remain. The current training hardware is insufficient for large-scale group work on multi-bus communication and database development. The school-enterprise cooperation mechanism is not yet mature, and enterprise engineers take part in course co-

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construction only to a limited degree. Full-time teachers, for their part, still need more engineering practice experience in in-vehicle bus database development [11].

5.3 Paths for Subsequent Optimization and Improvement

There are still a few things left unfinished, and we'll chip away at them later. Down the road, school-enterprise cooperation will go a layer deeper: enterprise technicians come on board to refine cases and sit in on teaching reviews, while full-time teachers head into companies to dive into real projects and come away with genuine command of in-vehicle bus systems. We'll stack up training gear piece by piece, and once it's in place, small groups can hunker down and get to work on multi-bus projects for real. In closing, cases and content must fall in step with the forward march of intelligent connected vehicle technology, so that the course doesn't pull away from what shop-floor positions actually require.

6. Conclusion

This paper has reported an OBE-based reform of In-Vehicle Network and Communication Technology for the vocational undergraduate major in intelligent connected vehicles. By linking posts, courses, competitions, and certificates, the content was reorganized into six projects that run from network fundamentals through CAN, LIN, and automotive Ethernet to bus simulation and calibration, testing, and diagnosis. A real enterprise database development task was adapted into a stepwise training case, supported by blended online-offline teaching, digital resources, and a multi-dimensional evaluation scheme. The reform shifts practical training away from its traditional focus on fault inspection and maintenance and toward the engineering abilities that vocational undergraduate education is meant to build, and it is offered as a reference for teachers of similar courses. In future work, school-enterprise cooperation, training conditions, and content updating will continue to be improved.

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