Teaching Platform Construction of Automotive Electronic Control System

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Abstract. With the continuous development of electronic science and technology, automotive electronic control technology plays a very important role in the development of the automobile industry. Automotive Electronic Control System (AECS) is a core professional course related to the major of automobile. It not only involves the theoretical knowledge, but also involves the practical activities, such as vehicle wheel sideslip, fault diagnosis, and so on. Based on the constructivism theory, this paper uses the theory and practice of AECS, including the construction of learning situation, cooperative mechanism, mutual communication and deep learning, to integrate the teaching platform. In addition, this paper also proposes the key points of the AECS integration model, which consists of classroom-laboratory, theoretical-experimental teachers, teaching-management, and knowledge assessment and ability examination. An empirical study was implemented, and the study results show that the proposed integrated model outperforms the traditional teaching method.

1. Introduction
Electronic control technology was developed in the late 20th century, and it has become one of the most important automotive key technologies. Word-wide automobile enterprises have increased their investment in the field of electronic control, and gradually have realized their applications in different types of automobiles. The progress of the automotive industry is inextricably linked to the discovery and application of electronic control systems. The electronic control system directly promotes the rapid development of automobile industry, so that the automotive industry has become the most important mode of the industry. The application of computer technology in recent years makes it drive the development of intelligent and automated electronic control technology. Auto parts and assembly technology also adopts the electronic control technology broadly.

With the continuous development of automotive electronic control system, many automotive enterprises and countries have introduced or developed different automotive electronic control systems, so as to pursue better and higher automotive performance. From the perspective of automotive electronic control system, in order to acquire more market share, many automobile enterprises should put forward research on automotive electronic control system to provide technical foundation for the automobile industry development.

2. Automotive Electronic Control System
Electronic Control Unit (ECU) is the core of the electronic control system. The main functions of the ECU software include data acquisition, calculation, output control, system control, and self-diagnosis. The voltage operating range of ECU is generally set at 6.5-16V, working current is set at 0.015-0.1A, and working temperature ranges from minus 40 centigrade to 80 centigrade. It can withstand the
vibration frequency below 1000Hz; therefore the probability of ECU damage is very small. In the ECU, CPU is the core part, and it has the operation and control function. When the engine is running, it collects signals of different sensors. It is also applied for memory (ROM/FLASH/EEPROM, RAM), the input/output interface (I/O), and other external circuit control. Program stored in ROM memory is obtained through calculation and experiments based on the data writing. The results of comparison and calculation are used to control the ignition, air to fuel ratio, idle speed, and waste gas recirculation. The compositions of ECU are shown in Figure 1.

![Figure 1. Formations of ECU](image)

The differential input is used when the battery voltage is detected. Although the voltage of a single cell is not high, the differential input terminal will produce a few hundreds of volts to the end of the test instrument. This voltage is called as a common mode voltage. Most of the data acquisition instruments have no insulation, and the limit of input voltage is always set at 5 volts or 10 volts. In addition, the non-insulation instrument is often easily affected by the grounding loop.

To overcome the high common mode voltage in the fuel cell system, high voltage insulation is required. Although external signal converters or caches can be used, many systems have built-in caching. Automotive bus technology is widely used in modern vehicles. The automotive bus provides a unified data exchange channel for various complex electronic devices, controllers and measuring instruments. The number of components controlled by electronic control unit is increasing, such as electronic fuel injection device, idle speed control, anti-lock braking device, airbag device, electrically controlled door and window device, active suspension, and so on. With the wide application of integrated circuits and single chip in the automotive, the number of electronic control unit in the car is increasing.

When I began to teach this part, I classified the students into several groups and brought them to the lab. I made the detailed demonstration, at the same time, simulated the working conditions of the car. After the above teaching, the students received more knowledge in terms of theory and practice.

3. Constructivism Theory

The earliest proponents of Constructivism can be traced back to Piaget in Switzerland. He is the most influential psychologist in the field of cognitive development. The school he founded on the development of children's cognitive development is called as the Geneva school. Piaget's theory persists in studying the cognitive development of children from the perspective of the interaction of internal and external factors. He believes that children are gradually building up knowledge about the external world in the process of interacting with the surrounding environment, so that their cognitive structure can be developed. From the constructivism theory, the cognitive development is closely related to the process of individual learning, therefore, the use of Constructivism can better explain the cognitive rules of the learning process, which can be used to explain how the concept of how learning takes place and the formation of the ideal learning environment. Generally, under the guidance of Constructivism, we can form a new set of effective cognitive learning theories, and achieve an ideal constructivist learning environment. Constructivism holds that knowledge is not acquired by teachers, but by learners in social and cultural background. Because learning is conducted in a social and
cultural background, with other people's help, namely, through interpersonal collaboration activities to achieve the meaning construction process. The situation in the learning environment must be helpful for the students to construct the meaning of the content they have learned. This is the teaching design new requirements proses in the constructivist learning environment. The teaching design should not only consider the analysis of teaching objectives, but also consider the creation of problem situations for students, and the situation should be considered as the most important content of teaching design.

4. Construction Method of Automotive Electronic Control System

4.1. Construction method of learning situation
In constructivist teaching design, it is the most important link or aspect to create a situation which is beneficial to the constructivist of the learners. We can construct the learning situation through the interesting guidance of the course teaching, and then guide the students to build the meaning of the content they have learned. For example, operation research courses originated from military practice. Especially after World War II, all branches of operation research developed rapidly, and became a practical discipline for practical problems, analysis and solving problems, which covered every aspect of our life, such as the management of planning, production, transportation, storage, market management, marketing personnel, equipment procurement, equipment update and maintenance, capital investment.

We explain the case story continuously and pleasantly, but also inspire the students’ interests to try to solve the problem step by step. The construction method of learning situation can help the students to better understand operational research and knowledge while students construct their own background knowledge of the learning situation. It can exercise the students’ thinking and problem-solving ability, and is easy to realize the meaning construction of learning content by interest guiding. Guided by the working needs of the engine and brake system, we take automotive sensor and actuator knowledge, detection methods, failure analysis, judgement and exclusion as the teaching core content. The skill traction teaching model makes the students master the diagnosis and elimination of the component level faults and the system level faults of the electronic control system.

4.2. Construction method of collaboration mechanism
The construction of cooperative learning mechanism is through the whole process of learning, including the collaboration between teachers and students. On the course of learning, through the course of learning materials, especially the analysis of related cases in practice, such as the selection of existing transfer station transportation problem and shortest network routing problem of campus network, case analysis, and construction of model research. The teachers and students put forward the hypothesis and verify it to realize the self-feedback and the evaluation results in the learning process to promote the final construction of the learning significance. In addition, collaboration includes self-negotiation and mutual consultation. We can achieve deliberation, discussion, and even debate within the learning unit through the establishment of a research group or a learning team. Especially for group collaborative learning based on case analysis, it can better integrate theory into practice, combine theory with practice, put forward analysis problems to solve problems, connect smoothly and coherently to achieve better integration of theory and practice. The content of this course is only the three most important and basic sub-systems of the automotive electronic control system, and these three systems are also upgrading and developing constantly. Therefore, it is also an important part of the teaching effect to follow up the mainstream of current technology, and find the direction of future development in real time. Therefore, the teacher must seize the classic models, the main system, and the main components because the main content and teaching focus on new systems and new technology to improve the effectiveness of knowledge and students' learning enthusiasm.

4.3. Construction method of mutual communication
Communication and interaction construction is the most basic way or link in the process of collaboration. In the learning of automotive electronic control system, teachers actively guide learners to discuss how to complete the specified learning tasks and how to get more guidance and help from teachers or others to achieve the goal of meaning construction. The students should incorporate experiential knowledge and constructive understanding into specific problem discussions and collaborative learning. In fact, the process of collaborative learning is the process of communication and interaction. In this process, the ideas of each learner are shared by the whole learning group. Communication is crucial to promote the learning process of each learner. The mutual communication should combine emphasis and demonstration with the independent practice.

The main communication and interaction points of the automotive electronic control system are shown as follows. First, the gasoline engine is the main body of the engine electronic control. It has a very important foundation and template role for the later diesel engine learning. Second, the direct explanation of the diesel engine on the basis of the electronic control of the gasoline engine helps to improve the teaching efficiency and study efficiency, which is conducive to strengthen the firmness of the knowledge. Third, it is useful to further review and consolidate the structure and principle of gasoline engine and diesel engine, and to diagnose and eliminate the overall fault of the engine.

### 4.4 Construction Method of Deep Learning

The last aspect is the meaning construction of deep learning. This is the goal of the teaching process, and it refers to the law of the nature of things and the internal relations between things. Regarding to the research learning, constructive significance is to help the students to learn the current research content or knowledge which reflected the intrinsic link between the nature of things and the law of things, to achieve a more profound understanding of the reality, such as investment in dynamic programming and the understanding of the problem at the beginning. Students can realize the goal of maximizing the ultimate income in different investment projects according to their own experience and knowledge. But when solving the problems, the students need to think how to make use of the understanding in practice. The integration of knowledge theory and practice needs deep meaning construction. The construction of theoretical learning will further enhance the learning effect and integrate theoretical knowledge with practical problem solving, to achieve the goal of deep learning of curriculum knowledge. The teaching mode of the skill traction is to improve the students' skills as the traction and the goal. The core of any teaching work is to develop the skills of the students.

Based on the curriculum characteristics of automotive electronic control system and the characteristics of students, we consider how to transform knowledge into students' job skills. In order to improve the quality of teaching, we carry out this teaching model by three ways, i.e., the theory visualization, the field practice, and the theory-practice integration.

### 5. Teaching Platform Construction of Automotive Electronic Control System

#### 5.1. Combination of Classroom and Laboratory

As shown in Figure 2, the teaching environment is designed as a teaching factory model to create a good professional atmosphere and environment. We integrate classroom, training, experiment and examination into an organic whole, which has many functions, such as multimedia teaching, physical presentation, drill training, experiment, and training. Automotive electronic control system is an interdisciplinary course, and it is the application of engineering technology courses in the fields of power engineering, vehicle engineering, computer engineering, automation engineering. They will be applied to the engine structure, internal combustion engine, engine repair, automotive electronics, computer theory, sensor technology and automatic control technology curriculum knowledge. The curriculum integrates the theory and practice of engineering, and its applicability and universality also exist at the same time; it is both a challenge and an opportunity. We compare the electronically controlled gasoline engine with the diesel engine. A gasoline engine is the main engine, has a very important foundation and the template effect of diesel engine on learning of the latter; the two is based
on electronic controlled gasoline engine on diesel engine direct explanation helps to improve teaching efficiency and learning efficiency, is conducive to strengthen the knowledge firmly; three is the structure and principle of knowledge further review and the consolidation of gasoline engine and diesel engine, the whole engine fault diagnosis and elimination is very useful. By the control course overview, vehicle sensors, electronic control system of petrol engine and diesel engine electronic control fuel injection system and vehicle anti-lock braking system, through industry cognition, parts knowledge and system knowledge, industry into cognitive ability, analysis ability, parts detection ability, comprehensive analysis ability, comprehensive ability and comprehensive detection the ability to rule out, and ultimately the formation of comprehensive qualities by using the basic knowledge of automotive electronics and automotive related knowledge to detect and eliminate the fault analysis.

5.2. Combination of theoretical and experimental teachers
As shown in Figure 3, professional theory teachers are integrated with experimental and trainee teachers. They should have a solid foundation of professional theory, high level of operation skills and rich practical teaching experience. In the classroom is a teacher, in the experiment, training is a technician, not only teaching theory, but also the operation of demonstration skills, but also to solve the field technical problems. After training and self-study, teachers have both solid theoretical knowledge and high level of operation skills. The integration of theory and practice teaching mode requires teachers not only have rich professional knowledge and professional teaching theory, skilled production practice skills, but also have recognition requirements and heavy and difficult, familiar with teaching equipment, teaching ability of writing subject. During teaching, effective teaching methods are adopted with the consideration of the teaching content and the students’ actual situation. The integration of theory and practice requires higher teachers, and the workload of teachers is large. These pressures help teachers study hard, practice skills and improve teaching level.
5.3. Combination of teaching and management

The conventional teaching mode of automotive electronic control system mainly uses the text and picture to present the knowledge, however, both the text and picture are always abstract, theoretical, difficult to understand. One of the most important skills of traction teaching method teaching mode is the theory of image, as much as possible to transform the expression elements, using text, graphics, animation, physical model, and the fault reappearance of modern high-tech elements, to improve teaching diversity and incentive. We change the previous experimental practice, and should carry on the field practice, try to reach the work scene as close as possible, and create the scene atmosphere. For example, the analysis of the fault waveform of electric control, using OBD II technology, through the serial port communication, the signal waveform is collected to PC machine to achieve waveform display and analysis, which is the same as the actual decoder detection waveform. Through the control technology, the engine fault is designed into a controllable failure element, and the fault scene is reproduced at any time, and the fault presentation and the on-site fault diagnosis are carried out. At the same time, the same fault of the same engine is detected at the same time in the whole classroom. Using network technology and remote desktop, we can also share experimental systems in many classrooms. Through the theory of visualization, and practice of integration of theory and practice of the three ways to implement this teaching mode, improve teaching quality, shorten teaching time; improve the professional education of the pertinence and validity; lower admission threshold, reduce the difficulty of teaching teachers; improve the teaching level and promote teaching the software and hardware construction.

5.4. Combination of teaching and management

The ability assessment pays attention to the normal assessment, the process control and the grade evaluation system. Specific assessment methods are flexible, students can reflect the workpiece or debugging, some skills of maintenance, fault diagnosis, and solve the related theoretical problems and skills assessment and necessary calculation, assessment for technical problems appearing in the independent solution or propose specific solutions, can also put forward the improvement suggestions processing method of the examinations of the workpiece, tool and workpiece itself, so as to reflect students' comprehensive ability. Practice has proved that adopting the theoretical and practical skills 50% of the assessment method is more reasonable, which not only tests students' professional theory level, but also reflects students' practical operation ability. According to the elements of vocational ability, we integrate experiments and school practice into different courses, synchronize theoretical teaching and practical teaching into teaching modules, to achieve the same level of cognition and practice. For the basic skills module, the practice teaching method is adopted, the experimental teaching method is adopted for the professional basic modules, and the theory and practice integrated
teaching method is applied to the professional skills modules, according to the sequence of structure principle repair inspection.

6. Empirical Study
According to the above-mentioned teaching framework, a teaching practice has been implemented on the undergraduate students of the Tianjin University of Technology and Education in 2017. We revised the syllabus and teaching plan. We have revised the curriculum syllabus and teaching programs. We have changed the previous teaching model of simple classroom + experiment, and integrated case teaching, experiment practice teaching and after-school discussion. We arranged a practical teaching every two theoretical studies. The subject of practice teaching is basically agreed by teachers and students, and a weekly discussion is arranged. The basic idea is to take the case as the guide and carry out the integrated teaching of the theory and practice. In addition, we selected the second semester examination results of the year of 2016, to carry on the comparative research and obtain the comparison of implementation result. The indexes of the achievement statistics are shown in Table 1.

Table 1. Implementation comparison using the ordinary and integrated teaching method

|                  | integrated teaching method | ordinary teaching method |
|------------------|----------------------------|--------------------------|
| Mean             | 82.93                      | 75.71                    |
| Standard deviation | 6.55                      | 9.34                    |
| Median           | 80                         | 73.5                     |
| Mode             | 78                         | 71                       |
| Maximum value    | 93                         | 91                       |
| Minimum value    | 62                         | 48                       |
| Kurtosis         | -0.78                      | 0.09                     |
| Skewness         | -0.38                      | -0.62                    |

According to the data analysis and comparison, the relative teaching achievement of the integrated teaching is higher and the teaching effect is relatively good. The influential mechanism needs to be further discussed. At least, it has enhanced the confidence of the integrated teaching platform and the courage to continue the implementation of teaching reform to further improve the foundation of the research.

7. Conclusions
The proposed integrated teaching model is in line with the characteristics of the education of the automotive profession, which is beneficial to the promotion of students' knowledge and abilities. Conclusions are shown as follows.

(1) Constructivism is the basis of integration of theory and practice teaching platform. It can be applied to the construction of the integrated teaching platform.

(2) The construction methods of integrated teaching platform of theory and practice of Automotive Electronic Control System based on constructivism mainly include the construction methods of learning situation, collaboration mechanism, mutual communication and deep learning.

(3) In the process of building the integrated teaching platform of Automobile Electronic Control System of theory and practice, we should focus on the combinations of classroom and laboratory, theoretical and experimental teachers, teaching and management, and knowledge assessment and ability examination.

(4) The practice has showed that the teaching achievement of the integrated model is higher than the teaching achievement that does not adopt the integrated model.
In the future, we will further refine the construction methods and key points of the teaching model to improve the teaching achievement.

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