Research on Cultivating Innovative Talents in Automobile Maintenance Specialty from the Perspective of Mechatronics

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Abstract. The rapid evolution and advancement of automotive technology have posed considerable instructional challenges for educators in the field of automobile maintenance. In China, this challenge is further accentuated by national advocacy for a comprehensive talent development, aiming to construct a knowledge-driven, skill-oriented, and innovation-focused workforce. Consequently, investigating how to cultivate automobile maintenance professionals capable of not only embracing technological advancements but also demonstrating innovative acumen becomes an imperative research endeavor. In this paper, the main objective is to investigate the cultivation of innovative talents in the field of automobile maintenance. Through the incorporation of numerous detailed teaching cases, we can effectively demonstrate the authenticity and efficacy of our teaching strategies. The study employs statistical analysis and surveys to evaluate the effectiveness of our instructional approach in fostering innovative talents in the specialty of automobile maintenance, yielding commendable educational outcomes.

Keywords: Innovative Talents, Automobile Maintenance Specialty, Mechatronics

1 Introduction

Cultivating innovative capabilities in talents is a challenging and intricately complex endeavor [1-3]. Strictly speaking, innovation finds its origins not only in one's interactions with life but also significantly in one's experiences, reflections, and discoveries within the realm of work [4]. Usually, when we aim to address challenges in our daily lives or work, we frequently encounter limitations due to a lack of technical expertise. Consequently, we aspire for students to acquire a broader range of technical skills, foster design capabilities, and enhance their ability to apply these skills. This, in turn, will enable them to explore greater opportunities for innovation in their future careers [5].

Conversely, by bolstering fundamental skills in technical applications, students can gain a more profound understanding of automotive and automobile maintenance tasks [6]. This will ensure elevated levels of work quality and efficiency within the field of automobile maintenance. In this paper, we will combine our own exploration and practical experience to detail introduction, sharing insights from the perspective of technical teaching within automobile maintenance field.

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1.1 Transformation in automobile maintenance specialty

The study of automobile maintenance involves vehicles as ultimate products. However, adopting a vehicle-centric approach can result in a narrow perspective. This viewpoint, akin to being unable to see the forest for the trees. Coping with immediate learning and application suffices, achieving flexibility in application is not easy, and achieving innovation is even more challenging. Thus, nurturing innovation becomes an arduous endeavor.

Recently, the emergence of new energy vehicles further complicates the landscape [7-9]. These vehicles epitomize intricately integrated electromechanical entities. Their introduction poses substantial challenges for educators, students, and the industry. The conventional emphasis on individual vehicles as the sole topic of educational discourse no longer suffices.

1.2 Challenges of new automotive technologies

The emergence of "new automotive technologies" largely involves the application of mature electromechanical and information technologies to automobiles [10, 11]. For instance, in the case of new energy vehicles, technologies such as electric motor control, the Internet of Things (IoT), battery technology, and more are extensively utilized. As a result, the imperative to shift instructional paradigms and enrich teaching content has become increasingly pressing.

2 Cultivation of innovative in automobile maintenance specialty

Taking automotive circuit course as an example, our conventional objectives include the ability to understand circuit diagrams, identify circuit components, perform circuit testing, and repair faulty components. However, if elevated to the level of designing a basic circuit, considering additional factors is necessary. This would result in an enhanced understanding of circuits and improved maintenance skills among students.

Automobile maintenance serves as the cornerstone of this field, providing students with the essential foundation upon which they can build their careers after graduation. Currently, the combination of specialized teaching and enterprise practice provided by the college is sufficient to meet the job competency requirements of students within the first five years after graduation. In terms of competencies for automobile maintenance positions, the differences in program duration and entry points for students do not manifest significantly in their performance after graduation. This currently stands as our advantage. However, if the teaching content can be adjusted appropriately, enhancing innovation, learning, methods and approaches, as well as written expression and communication abilities, it will enable students to have more diversified development based on their individual characteristics.

Based on the aforementioned considerations, it will inject more vitality into our teaching that positioning the cultivation goal of innovative automobile maintenance professionals within the perspective of mechatronics, with an emphasis on automobile maintenance competence as the core, and enabling students to possess a certain level of electromechanical design ability. Accordingly, We have made appropriate adjustments to the traditional curriculum, incorporating specialized courses such as 3D modeling, machinery foundation, and electrical and electronic technology into the automobile maintenance specialty. Additionally, we offer elective courses in computer programming languages, microcontroller programming, and

encourage students to engage in small-scale course and graduation projects. Our course teaching breaks free from conventional methods, adopting task-driven and action-oriented teaching methodologies. Each course serves as a window that opens up broader horizons for students, allowing them to witness more captivating vistas. These practices, in fact, align with the national standards for automobile maintenance technicians, particularly the requirements for skill transformation and innovation. Without the support of these technologies, these requirements also cannot be achieved. In the following sections, we will provide a brief overview of some approaches and the achieved outcomes.

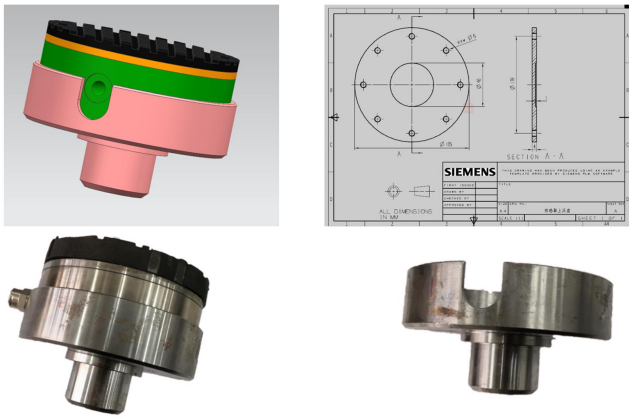

Fig. 1. 3D modeling of basic components, assembly of components, and generation of 2D engineering drawings in UG software

2.1 Case studies in specialized course

An obligatory course titled "UG 3D Design" has been introduced for the automobile maintenance specialty. Through 36 or 72 lessons, students gain proficiency in fundamental UG software application, encompassing the basics of 3D modeling of components, assembly, and 2D engineering drawing generation as shown in Fig. 1. Advanced applications such as sheet metal design, surface modeling, and WAVE can be offered as elective courses for interested students. The course's core intention is to equip students with the ability to transform their ideas for tools or enhancements to mechanical structures into tangible 3D representations in their future carrers. Teaching practice demonstrates that learning 3D modeling is considerably more accessible compared to our prior curriculum involving geometric drawing and planar drafting. This is attributed to its inherent ability to visualize progress at every step, which reduces the complexities associated with spatial imagination.

In the realm of circuit design, within the course "Automotive Electrician Electronic Basis", we have incorporated domestically-developed circuit design software that is user-friendly and easily accessible. With just one lesson, students can effectively create a schematic diagram for a basic circuit, generate a PCB layout, and even proceed to order the designed PCB (Fig. 2). Within a mere three days, students can witness the realization of their own circuit board designs. Abundant free design tutorials are available online, facilitating self-directed learning for students.

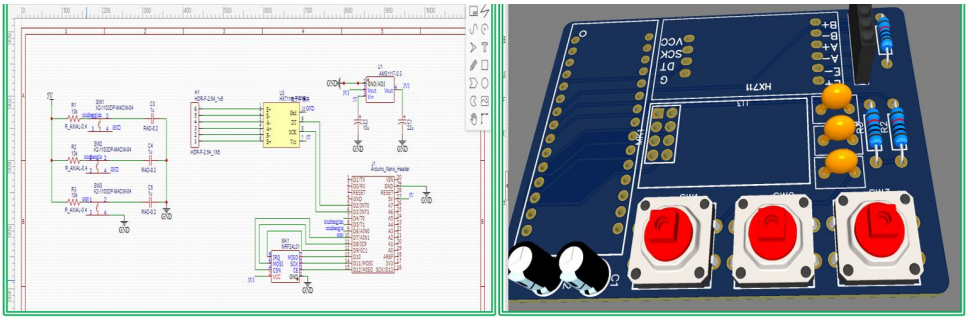

Fig. 2. Realizing the schematic design of a simple circuit and generating PCB

Similarly, within the course "Automotive Electrician Electronic Basis", we have also introduced the Arduino board and the Mixly graphical programming software for immediate application. These programming and control software and hardware resources are widely employed in primary and secondary school information courses. Additionally, another hardware simulation and graphical programming software, Linkboy, provides a more intuitive development experience for microcontroller programming as shown in Fig. 3. These programming tools are remarkably powerful in realizing fundamental control applications, obviating the need for code input. It has circumvented the obstacle of computer language that automobile maintenance students encounter when applying single-chip microcontroller programming.

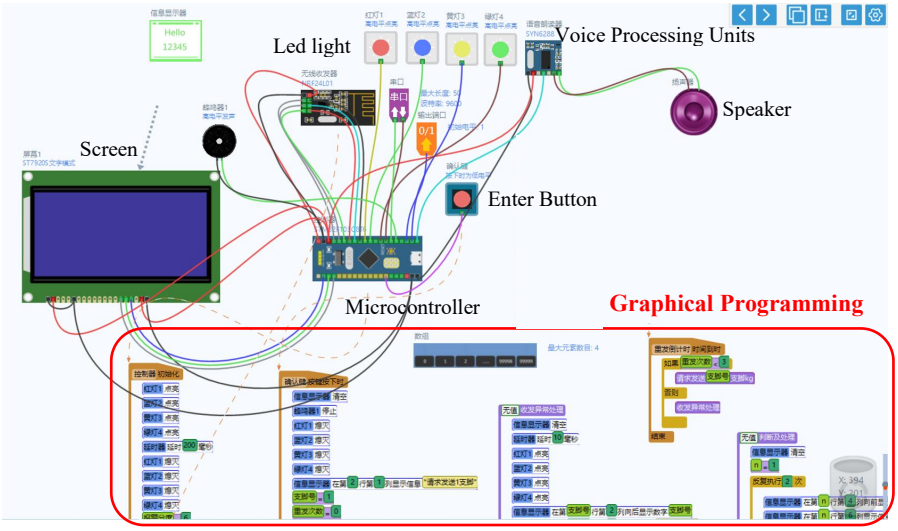

Fig. 3. The microcontroller hardware simulation and graphical programming software

The study of electrical and electronic technology is not an instantaneous achievement; rather, it involves learning through practical engagement. Steadfast commitment leads to the breakthrough of bottlenecks, initiating a beneficial cycle of self-guided learning. To facilitate this, we have opted for the "Breadboard 130" kit and accompanying materials, which students

can carry with them for convenient learning. We require students to install circuit simulation apps on their smartphones, enabling them to engage in circuit simulation. Through simulation, students gain an intuitive understanding of the intricacies of circuit operation. Combined with practical experimentation using the electronic component kit, students proficiently grasp circuit knowledge and application methods.

2.2 Comprehensive course project and graduation design

We have previously attempted to complete a mini greenhouse design and fabrication project within four lessons an shown in Fig. 4. This project achieved the monitoring of air and soil temperature and humidity, as well as the control of heating and watering systems. Moreover, it automatically turns on lights at night to extend the photosynthesis period for plants.

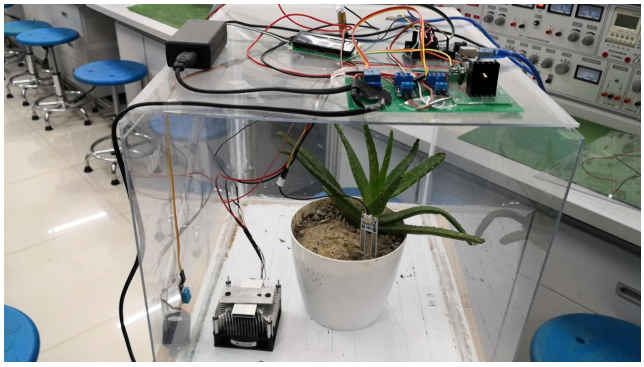

Fig. 4. Design and construction of a mini greenhouse

In the latter part of the first-year course " Automotive Electrician Electronic Basis," students are required to work in groups of up to four under the guidance of the instructor. They undertake a small-scale course project, which involves creating a tangible product, producing a demonstration video, and crafting a concise presentation.

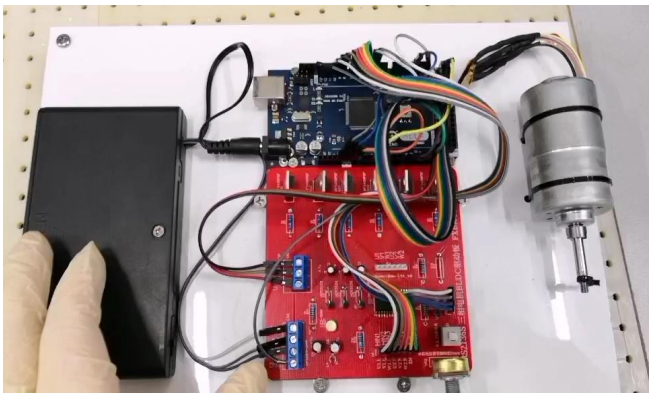

Fig. 5. Brushless motor control system design project

In the field of New Energy Vehicles, a topic concerning the design of a brushless motor control system has been developed (Fig. 5). Students are required to accomplish the entire process, including circuit board design and program coding, under the supervision of their instructor. Presently, this topic is also incorporated into the training for teachers in the New Energy Vehicles field. Students are expected to complete this project as part of their graduation design before they graduate.

Table 1. Table title. Table captions should always be positioned *above* the tables

	2019	2020	2021	2022
Teaching Satisfaction	88%	89.70%	91.50%	92.70%
Relevance of Major to Work	36%	48%	54%	61.50%
Alumni Recommendation Rate	56%	58.70%	60.30%	61.90%

To ensure the smooth implementation of the aforementioned courses, we have gradually established teaching resources aligned with task-driven and action-oriented approaches. This includes an electronic component library, electrical and electronic experimentation and fabrication workstations, and computers. With the advantage of affordable electronic component prices and convenient procurement channels, we have achieved remarkable results in teaching with minimal investment.

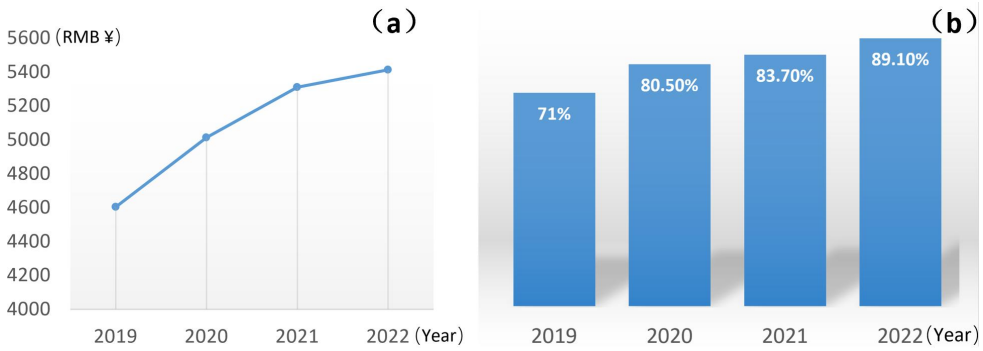

Fig. 6. (a) Trend in monthly income changes (b) Trend in employment satisfaction

In order to achieve favorable outcomes within the limitations of available class hours, We adopt a combination of required courses and elective courses, providing students with opportunities for choice and allowing them to leverage the strengths of the instructors. This approach encourages students to pursue their areas of expertise. We also organize student seminars, offering each student the chance to present their accomplishments or reflections in a particular field to their peers within the class or at the institutional level. Furthermore, we conduct initiatives to foster excellence and motivate learning, using outstanding student achievements as inspiration for their peers. This cultivates a culture of mutual support and academic excellence among students, which in turn serves to inspire instructors and enhance the substance and quality of teaching.

3 Result of Statistics and Surveys

According to our statistics and surveys in graduate students as show in Fig. 6, in this innovative-focused teaching practice, the monthly income level of four graduating classes (2019-2022) has continued to rise (Fig. 6a), indicating an enhanced competitiveness of graduates in the job market. In terms of employment matching, graduates' work relevance to their major has been consistently increasing (Table 1), and the job satisfaction rate for the past three graduating classes has remained above 80% (Fig. 6b), to some extent reflecting the favorable outcomes in terms of employment quality and achievement of professional training goals. Additionally, the overall satisfaction and recommendation rates of the past four cohorts of graduates towards the college's teaching have shown an upward trend, indicating a gradual enhancement of our teaching effectiveness (Table 1).

4 Conclusion

This paper shares some insights and practices regarding the cultivation of innovative abilities among students majoring in automobile maintenance. The primary viewpoint is to enhance the automobile maintenance curriculum by incorporating relevant electromechanical foundational courses from the perspective of mechatronics. The courses include 3D modeling, single-chip microcontroller programming, and circuit design. The objective is to equip students with basic electromechanical design skills, aiming to empower them to transform their innovative ideas into reality in their future careers. The work competence in automobile maintenance remains our foundation. Essentially, these electromechanical foundational courses are not contradictory to our fundamental principles. Balancing the relationship between the them can actually promote mutual enhancement.

Acknowledgments

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