

Evaluating the Impact of G-scan 3-Based Hybrid Vehicle Diagnostic Training on Automotive Engineering Students' Learning Outcomes

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ABSTRACT:

The increasing adoption of hybrid and electrified vehicles has created new requirements for automotive engineering education. This study evaluates the effectiveness of a hybrid vehicle diagnostic training program using a Toyota Hybrid platform and the G-scan 3 diagnostic scanner. A total of 62 Automotive Engineering students participated in the study. The training activities included ECU identification, diagnostic trouble code (DTC) reading, data stream analysis, active testing, and hybrid battery monitoring. Training effectiveness was assessed through a pre-test/post-test design, a 10-point grading scale, and a student satisfaction survey. The results showed that the average score increased from 4.90/10 before training to 8.45/10 after training, corresponding to a 72.4% improvement. The average student performance improved from Grade D to Grade B+, while the proportion of students achieving Grade B or higher increased significantly. Survey results also indicated high levels of satisfaction with the training activities. The findings demonstrate that practical diagnostic training using modern equipment can effectively enhance students' technical competence and professional readiness.

KEYWORDS: Automotive engineering education; Hybrid vehicle; G-scan 3; Practical training; Diagnostic systems; Learning outcomes.

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I. INTRODUCTION

The global automotive sector is currently undergoing a significant shift toward electrified mobility solutions. Hybrid electric vehicles (HEVs), plug-in hybrids (PHEVs), and fully battery-powered electric vehicles (BEVs) are gaining widespread acceptance due to their benefits in fuel efficiency, energy conservation, and reduced environmental impact [1]. This evolution has not only reshaped vehicle design and production processes but has also transformed maintenance practices, repair protocols, and the skill sets required for technical personnel. Contemporary hybrid automobiles represent intricate integrations of mechanical, electrical, electronic, and software-driven subsystems. In contrast to traditional internal combustion engine vehicles, hybrids are equipped with specialized components including high-voltage battery packs, motor-generator units, power inverters, regenerative braking mechanisms, and dedicated hybrid system controllers [2]. As a result, modern automotive technicians and engineers must develop a broader range of capabilities, spanning electronic system troubleshooting, data interpretation, and adherence to high-voltage safety protocols.

The growing sophistication of vehicle systems poses new pedagogical hurdles for automotive engineering curricula. As emphasized by UNESCO, engineering education must balance theoretical instruction with applied, industry-relevant practical skills [3]. Consequently, learners are required not only to master conventional automotive elements such as engines, gearboxes, and brake assemblies but also to become proficient in utilizing diagnostic instruments and decoding electronic data from vehicles. Electronic fault diagnosis has emerged as a cornerstone of contemporary automotive service workflows. Today's vehicles rely on numerous electronic control units (ECUs) that continuously monitor operational parameters and log fault-related data when irregularities occur [4]. Diagnostic scanning tools enable service personnel to extract diagnostic trouble codes (DTCs), observe real-time performance metrics, conduct active system tests, and confirm the success of repairs. Hence, competence in operating diagnostic tools has become an essential professional attribute for graduates in automotive engineering.

Hands-on training is indispensable for cultivating these proficiencies. Kolb's experiential learning framework posits that meaningful knowledge acquisition stems from direct engagement and active involvement [5]. In a similar vein, Prince [6] found that active pedagogical strategies tend to yield superior academic results relative to conventional lecture-dominated approaches. In automotive engineering education, practical exercises

allow students to engage directly with real vehicle systems, bridge theoretical concepts with real-world applications, and hone their analytical and troubleshooting skills. Among the array of modern diagnostic devices, the G-scan 3 scanner is extensively adopted in both academic and professional settings, given its broad diagnostic coverage and compatibility with a wide range of vehicle brands [7]. This tool facilitates access to vehicle ECUs, retrieval of fault codes, examination of data streams, and execution of functional tests. These features render G-scan 3 an effective instructional resource for building diagnostic expertise among automotive engineering students.

Earlier research highlights the educational value of experiential and practice-oriented learning in engineering education. Barber [8] showed that practical activities contribute significantly to technical competence and workplace readiness. Likewise, Kolb [5] emphasized learning through direct experience, while Prince [6] reported that active learning approaches improve student engagement and learning outcomes. In automotive engineering education, hands-on interaction with diagnostic equipment helps students better understand vehicle systems and develop troubleshooting skills. The importance of practical training is even greater for hybrid and electrified vehicle technologies. Hybrid vehicles combine internal combustion engines with electric propulsion systems, requiring knowledge of battery management, power electronics, and hybrid-specific diagnostic procedures [9,10]. As the adoption of hybrid and electric vehicles continues to expand globally, the demand for engineers and technicians with advanced diagnostic competencies is expected to increase significantly [1,2]. Therefore, practical experience with modern diagnostic tools is essential for preparing students for future industry requirements.

In Vietnam, numerous universities have upgraded their workshop infrastructure and diagnostic toolkits to elevate the caliber of automotive engineering instruction. Nevertheless, there is a scarcity of quantitative research assessing the efficacy of hybrid vehicle diagnostic training using professional-grade equipment. Much of the extant literature centers on learner perceptions rather than on measurable gains in knowledge or skill. To fill this void, the current investigation evaluates a practical diagnostic curriculum implemented on a Toyota Hybrid vehicle platform using the G-scan 3 scanner, targeting Automotive Engineering undergraduates. The program's impact is gauged through a pre-test/post-test framework alongside a student satisfaction questionnaire. The primary objective is to ascertain whether experiential engagement with state-of-the-art diagnostic tools enhances learners' grasp of hybrid systems, diagnostic protocols, and problem-solving capabilities. This work offers three principal contributions. First, it outlines a systematic, practical teaching framework for hybrid vehicle diagnostics utilizing industry-standard equipment. Second, it provides a quantitative assessment of student performance using a 10-point scoring system and corresponding letter-grade classifications. Third, it furnishes empirical support for the notion that embedding contemporary diagnostic technologies and genuine hybrid vehicle platforms into academic curricula can markedly boost students' technical skills and career preparedness.

II. MATERIALS AND METHODS

2.1. Participants

The study was conducted with 62 students from the Automotive Engineering program at the Faculty of Automotive and Energy Engineering. The participants included 34 third-year students and 28 fourth-year students. These students had previously completed basic courses related to automotive systems, electrical systems, and engine technology. However, most of them had limited experience with hybrid vehicle diagnostics and professional diagnostic scanners. The students were selected because they were participating in a practical training module related to modern automotive diagnostics. Before the training program, students were introduced to the purpose of the study and the evaluation method. The assessment was used only for educational research and training improvement purposes.

2.2. Training Equipment

The practical training system included a Toyota Hybrid vehicle, a G-scan 3 diagnostic scanner, an OBD-II interface, instructional materials, and technical manuals. The Toyota Hybrid vehicle was selected because it represents a common hybrid technology platform and provides multiple electronic control systems suitable for training. The G-scan 3 diagnostic scanner was the primary diagnostic tool. Through the OBD-II interface, the device allowed students to communicate with several vehicle control modules, including the Engine ECU, Hybrid Control ECU, Battery ECU, ABS/VSC ECU, and Air Conditioning ECU. The training equipment allowed students to perform diagnostic procedures under conditions similar to those in real automotive workshops. This helped make the learning process more realistic and professionally relevant.



Figure 1. Students performing diagnostic exercises on a Toyota Hybrid vehicle using the G-scan 3 diagnostic scanner

2.3. Training Program

The training program consisted of three laboratory sessions with a total duration of nine hours. Students were divided into small groups of four to five members to ensure that each student had opportunities to operate the diagnostic scanner and participate in the diagnostic process. In the first session, students learned how to connect the G-scan 3 device to the Toyota Hybrid vehicle through the OBD-II port. They were guided to identify different electronic control units and access basic hybrid system information. This session focused on familiarizing students with the diagnostic interface and vehicle communication systems.

In the second session, students practiced reading diagnostic trouble codes and interpreting their meanings. They also learned how to analyze possible fault causes and clear diagnostic codes after completing inspection procedures. This session helped students understand the relationship between diagnostic codes and vehicle system behavior. In the third session, students practiced monitoring live data streams, performing active tests, and evaluating hybrid battery conditions. They observed parameters such as battery state of charge, battery module voltage, engine operating status, and hybrid system data. This session emphasized data interpretation and diagnostic reasoning.

2.4. Assessment Design

The effectiveness of the training program was evaluated using a pre-test/post-test design. A 20-question test was administered before and after the training. The test covered five main content areas: hybrid vehicle system knowledge, high-voltage safety, G-scan 3 operation, diagnostic trouble code interpretation, and data stream analysis. Each test was converted to a 10-point scale. Student performance was also classified according to the university grading system:

Score Range	Grade
8.5–10.0	A
8.0–8.4	B ⁺
7.0–7.9	B
6.5–6.9	C ⁺
5.5–6.4	C
5.0–5.4	D ⁺
4.0–4.9	D
Below 4.0	F

In addition to test scores, student satisfaction was evaluated using a five-point Likert scale. The survey included criteria related to understanding hybrid systems, ability to use G-scan 3, reading DTCs, data stream analysis, fault diagnosis capability, teamwork, learning motivation, and confidence during practical work.

III. RESULTS AND DISCUSSION

3.1. Pre-Test and Post-Test Results

Table 1 summarizes the students' performance before and after the hybrid vehicle diagnostic training program. The average score increased from 4.90/10 in the pre-test to 8.45/10 in the post-test, representing an improvement of 72.4%. According to the university grading system, the average student performance improved from Grade D to Grade B⁺.

Before the training, many students demonstrated limited knowledge of hybrid vehicle systems and diagnostic procedures, as reflected by the relatively low mean score and the high proportion of students in the D and F grade categories. Following the training program, students showed substantial improvements in their understanding of diagnostic processes, interpretation of hybrid system data, and operation of the G-scan 3 diagnostic scanner. The results indicate that practical exposure to modern diagnostic equipment can significantly enhance students' technical knowledge and diagnostic competence.

Table 1.Pre-test and post-test results

Indicator	Pre-test	Post-test
Mean score (/10)	4.9	8.45
Standard deviation	1.2	0.95
Highest score	7.5	10
Lowest score	2	6
Pass rate (≥ 5.0)	58%	96%
Excellent performance (≥ 8.0)	12%	82%

3.2. Grade Distribution

Table 2 presents the distribution of student grades before and after the hybrid vehicle diagnostic training program. A substantial shift toward higher performance levels was observed following the training. Before the training, only 12% of students achieved Grade B+ or higher. After completing the training program, this proportion increased to 62%, with 24% of students achieving Grade A. Moreover, no students remained in the D or F grade categories after the intervention.

Table 2. Grade distribution before and after training

Grade	Before Training	After Training
A	0%	24%
B+	3%	38%
B	9%	25%
C+	12%	8%
C	21%	3%
D+	28%	2%
D	19%	0%
F	8%	0%

These findings indicate that the training program was effective not only in improving the average score but also in reducing the proportion of low-performing students. The observed improvement can be attributed to hands-on learning activities that enabled students to apply theoretical knowledge in real diagnostic situations. Through direct interaction with the Toyota Hybrid vehicle and the G-scan 3 diagnostic scanner, students developed a better understanding of hybrid vehicle systems, diagnostic procedures, and fault analysis techniques.

3.3. Improvement by Skill Area

The improvement in student performance can be further explained by considering different skill areas. The largest improvements were observed in G-scan 3 operation, DTC interpretation, and data stream analysis. These are skills that require direct practice and cannot be fully developed through lectures alone. During the first session, students became familiar with the diagnostic scanner and learned how to access vehicle systems. This helped improve their confidence in using the device. During the second and third sessions, students practiced analyzing diagnostic information and connecting electronic data with physical vehicle conditions. This process helped them develop a more systematic diagnostic approach. The improvement in high-voltage safety awareness was also important. Hybrid vehicles involve potential electrical hazards, so students must understand basic safety precautions before performing diagnostic work. The training helped students recognize high-voltage components and understand safe working procedures.

3.4. Student Satisfaction Survey

Table 3 summarizes the results of the student satisfaction survey conducted after the training program. Among the evaluated criteria, learning motivation received the highest average score (4.57/5), indicating that the use of a real Toyota Hybrid vehicle and the G-scan 3 diagnostic scanner created an engaging and motivating learning environment. The ability to use G-scan 3 was also highly rated, with an average score of 4.48/5, suggesting that students considered the diagnostic tool effective for understanding vehicle systems and performing diagnostic procedures.

High ratings were also observed for DTC reading (4.40/5), teamwork skills (4.35/5), and understanding of hybrid vehicle systems (4.31/5). These results indicate that the training activities not only improved technical knowledge but also fostered collaborative and problem-solving skills. The lowest-rated criterion was fault diagnosis capability, with an average score of 4.12/5. Although this value still reflects a positive evaluation, it suggests that diagnostic reasoning remains one of the most challenging competencies for students. Effective fault diagnosis requires integrating theoretical knowledge, practical experience, and exposure to diverse fault scenarios. Therefore, additional training sessions involving more complex diagnostic cases may further enhance students' diagnostic competence and confidence in real-world applications.

Table 3. Student satisfaction results

Criterion	Mean Score
Understanding hybrid systems	4.31
Ability to use G-scan 3	4.48
Reading DTCs	4.4
Data stream analysis	4.21
Fault diagnosis capability	4.12
Teamwork skills	4.35
Learning motivation	4.57
Confidence during practical work	4.29

3.5. Discussion

The findings confirm that practical diagnostic training using modern equipment can significantly enhance automotive students' learning outcomes. The improvement from 4.90/10 to 8.45/10 demonstrates that students gained substantial knowledge and skills after only three structured laboratory sessions. One of the main reasons for this improvement is the use of real equipment. When students work directly with a Toyota Hybrid vehicle and a G-scan 3 scanner, they can observe real system responses rather than only studying diagrams or theoretical descriptions. This creates a stronger connection between classroom knowledge and practical application. Another important factor is the structure of the training program. The training was organized from basic to advanced tasks. Students first learned how to connect the diagnostic tool and identify ECUs. They then practiced reading DTCs and analyzing data streams. Finally, they performed active tests and evaluated hybrid battery conditions. This progressive structure helped students build confidence step by step. The results also show that diagnostic training supports teamwork and communication. Since students worked in small groups, they had to discuss diagnostic procedures, share observations, and make decisions together. These activities reflect real workshop conditions where technicians often collaborate to solve technical problems.

The study also has implications for curriculum development. Automotive engineering programs should include more practical modules related to hybrid and electric vehicle diagnostics. As the automotive industry continues to shift toward electrified vehicles, graduates must be prepared to work with high-voltage systems, electronic control units, and diagnostic data. However, this study also has some limitations. The sample comprised 62 students from one faculty. The training lasted only 9 hours, which may not be sufficient to develop advanced diagnostic expertise. In addition, the assessment focused mainly on short-term learning outcomes immediately after training. Future studies should include larger samples, longer training periods, and follow-up assessments to evaluate long-term retention of knowledge and skills. Despite these limitations, the study provides useful evidence that the use of G-scan 3 and Toyota Hybrid platforms can improve the quality of automotive diagnostic education. The approach can be applied to other training modules, including electric vehicle systems, advanced driver assistance systems, and intelligent vehicle technologies.

V. CONCLUSION

This study evaluated the effectiveness of a practical hybrid vehicle diagnostic training program using the G-scan 3 diagnostic scanner and a Toyota Hybrid vehicle platform for Automotive Engineering students. The main findings are as follows. First, the average student score increased from 4.90/10 before training to 8.45/10 after training, corresponding to a 72.4% improvement. Second, according to the university grading system, the average student performance improved from Grade D to Grade B⁺. Third, the proportion of students achieving Grade B or higher increased significantly after training, while the proportion of low-performing students decreased. Fourth, students reported high satisfaction with the training program, especially regarding learning motivation, the ability to use G-scan 3, and confidence during practical work.

These results demonstrate that integrating modern diagnostic equipment and real hybrid vehicle platforms into automotive engineering education can effectively improve students' knowledge, practical skills, and professional readiness. The proposed training model can be expanded to other modern vehicle technologies, including battery electric vehicles, ADAS systems, and intelligent mobility systems. Future research should

focus on developing more comprehensive diagnostic training modules, increasing the number of practical fault scenarios, and evaluating long-term skill retention. In addition, cooperation with automotive service centers and manufacturers may further improve the relevance of university-based practical training.

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