ORIGINAL ARTICLE

DIAGNOSING THROTTLE POSITION SENSOR INTERFERENCE IN ELECTRONIC CONTROL UNITS FOR AUTOMOTIVE VOCATIONAL EDUCATION

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ABSTRACT
Intermittent sensor faults can produce unstable engine behavior while remaining difficult to detect through visual inspection or sparse static measurements. This study examined Throttle Position Sensor (TPS) interference, corrective action, and instructional implications for automotive vocational education. A single-vehicle experimental diagnostic case was conducted on a Daihatsu Xenia 1.0 Non-VVT-i with an EJ-DE engine. The procedure separated original-fault inspection, preliminary connector service, controlled interference replication, and post-repair verification. Original inspection identified resistive-track wear and mild oxidation of the VTA connector terminal. After preliminary connector cleaning and fastener retightening, three static TPS checkpoints remained within specification. Controlled replication then produced intermittent 0.3–4.8 V fluctuations at 45°–55°. During the diagnostic sequence, DTCs P0121, P0122, P0300, and P0171 and irregular TPS live-data behavior were recorded, while idle fluctuation of 550–950 rpm was explicitly observed during the interference simulation. Because the source record did not timestamp every DTC/live-data observation relative to deliberate manipulation, those data are not attributed exclusively to the untouched natural fault. After TPS replacement, connector service, recalibration, and DTC clearing, the three retained verification points returned to specification, idle stabilized at approximately 750 rpm, acceleration normalized, and no DTC recurrence was observed during the recorded test drive. No evidence of persistent ECU malfunction was observed during these functional checks. The case offers a bounded diagnostic sequence for vocational troubleshooting instruction; educational effectiveness and transferability require further validation.

Keywords: Automotive diagnostics, Automotive vocational education, Electronic control unit, Throttle position sensor, Troubleshooting

INTRODUCTION

Modern engine management depends on the continuous interaction of sensors, actuators, and an electronic control unit. As vehicle control architectures become more sensor-dependent, diagnosis increasingly requires technicians to interpret electrical signals and data streams rather than relying only on visible mechanical symptoms. Fault-diagnosis research therefore emphasizes the need to identify abnormal sensor behavior accurately and to select diagnostic procedures that match the operating context of the vehicle (Li et al., 2023). In an electronic fuel-injection system, the Electronic Control Unit (ECU) processes sensor inputs to determine operating commands such as injection duration and ignition timing. The reliability of those commands is consequently conditioned by the integrity, plausibility, and continuity of the input signals received by the ECU. Automotive diagnosis has progressively moved beyond simple threshold checks toward structured residual generation, analytical redundancy, observer-based methods, and combined model/data-driven fault isolation (Gertler et al., 1993; Krishnaswami et al., 1995; Nyberg, 2002; Svärd et al., 2013). Recent vehicle-sensor studies continue this trajectory by addressing sensor fault detection, isolation, estimation, and robustness to partial faults or uncertainty (Huang et al., 2023; Escobar-Jiménez et al., 2025).

The Throttle Position Sensor (TPS) is a particularly important input because it represents throttle opening and is used by the ECU when interpreting driver demand and engine load. In the contact-type potentiometer configuration examined in this study, a wiper moves over a resistive track and produces an analog voltage that should change predictably with throttle position. Long-term mechanical contact can wear the resistive path, while oxidation or contamination at the connector can alter contact resistance. Such degradation is diagnostically challenging because a sensor may remain physically intact and may still produce apparently normal values at a limited number of static checkpoints. The more consequential defect can appear only while the wiper passes through a worn portion of the track or when connector contact becomes intermittent during operation. This makes signal continuity across the operating range more informative than an isolated measurement at idle or wide-open throttle. Research on electronic throttle systems likewise treats reliable throttle-position feedback and health monitoring as important diagnostic and control requirements, including detection of soft or hard anomalies and robustness to parameter variation and aging (Conatser et al., 2004; Pavković et al., 2006).

Previous TPS studies have frequently concentrated on performance differences between standard and racing or aftermarket sensors. Batutah et al. (2024), for example, compared standard and racing TPS configurations under different fuels and evaluated engine-performance indicators, while Apriyanti and K N (2025) compared standard and racing TPS use on a Honda CB150R. These studies are useful for understanding how TPS characteristics can influence engine response, but their principal emphasis is component variation and performance rather than degradation-induced intermittent faults. Other work has focused on diagnostic infrastructure. Setiyawan (2022) demonstrated OBD-II-based wireless engine monitoring, and Echsony and Nurfaizin (2018) described ECU monitoring through a personal-computer interface. More generally, fault-diagnosis studies show that sensor variables in an internal-combustion engine are dynamically coupled, so a fault in one sensor can influence other measured or calculated variables and may generate a pattern of symptoms that is not uniquely attributable from a trouble code alone (Cervantes-Bobadilla et al., 2023). Experimental automotive research has also used online sensor fault accommodation and analytical redundancy (Capriglione et al., 2003; Gutiérrez León et al., 2018), signal- and process-model-based diagnosis under real operating conditions (Kimmich et al., 2005; Nyberg & Stutte, 2004), and multivariate statistical methods that exploit correlations among engine variables (Wang et al., 2008).

The educational significance of this diagnostic problem is also relevant. Automotive vocational learners must do more than memorize component functions; they need to develop a structured diagnostic strategy that connects symptoms, hypotheses, measurements, interpretation, fault isolation, corrective action, and verification. Meier et al. (2022) emphasize the importance of diagnostic strategies in car-mechatronics training and show that diagnostic knowledge and transfer to practical problem solving should be treated as related but distinct learning outcomes. In another vocational context, Maksum et al. (2024) reported that problem-oriented automotive learning can support problem-solving and communication skills. Practical TPS training devices have likewise been developed to help learners understand sensor operation and output characteristics (Pahlevi et al., 2024). In car mechatronics, diagnostic success has been linked to how learners represent information and test hypotheses (Abele, 2018), while recent automotive-apprentice research shows that video-based modeling examples can strengthen diagnostic knowledge and scaffolded diagnostic skills (Meier et al., 2024). More broadly, authentic problem-based learning tasks and simulation have been reported as useful designs for vocational learning when they are deliberately structured around realistic decision making (Monks, 2010; Rush et al., 2010). These studies support the instructional value of authentic diagnostic processes, but they do not justify assuming that any single workshop case automatically produces measurable learning gains.

Against this background, the research gap addressed here is narrower than a general claim that TPS faults are unknown. What remains insufficiently documented in the literature used for this manuscript is a case-based sequence that links naturally observed TPS degradation, physical evidence, signal discontinuity, OBD-II and live-data interpretation, corrective action, and verification within one diagnostic narrative, while explicitly translating that sequence into bounded implications for automotive vocational instruction. The present manuscript therefore treats the tested vehicle as a diagnostic case, not as a representative sample of all four-wheeled vehicles. It also distinguishes the original vehicle condition from a subsequent controlled interference replication so that naturally occurring evidence is not conflated with experimentally induced behavior.

The study had three objectives. First, it sought to characterize the TPS-related fault observed on a Daihatsu Xenia 1.0 Non-VVT-i and to examine how physical degradation and unstable sensor signaling were associated with ECU diagnostic information and engine behavior. Second, it evaluated corrective actions through post-repair functional verification. Third, it formulated instructional implications from the diagnostic sequence for automotive vocational education without claiming educational effectiveness, because no student learning outcomes were measured. The scholarly contribution is therefore the integration and transparent ordering of diagnostic evidence in a single case, together with explicit boundary conditions for causal interpretation and transferability.

METHOD

This study used a single-vehicle experimental diagnostic case design. The design was selected to document a real workshop fault, replicate the signal-interruption mechanism in a controlled manner, and verify whether corrective action was followed by functional normalization. The case was conducted at a specialist workshop for automotive electrical and fuel-injection systems in Manado, Indonesia. The test object was one Daihatsu Xenia 1.0 Non-VVT-i equipped with an EJ-DE engine and a three-pin, contact-type potentiometer TPS. Because only one vehicle and one TPS architecture were examined, the design supports detailed mechanism-oriented diagnosis rather than statistical generalization.

The diagnostic equipment reported in the original study record consisted of a digital multimeter, standard workshop tools, an ELM327 OBD-II scanner, a replacement TPS unit, connector-service materials, and the vehicle service manual. The original record states that test equipment was prepared and calibrated before use; however, a calibration certificate, measurement uncertainty statement, and detailed calibration trace were not retained in the manuscript record. For transparency, the measurements in this paper are therefore interpreted as workshop diagnostic measurements referenced to the service-manual ranges rather than metrological validation data.

The procedure was organized into three analytically distinct phases. Phase 1 documented the naturally occurring complaint and physical condition before deliberate interference was introduced. The vehicle presented with unstable idle, hesitation during initial acceleration, and an illuminated Check Engine indicator. The TPS housing, connector, resistive path, throttle shaft, and fastening condition were inspected. The source record then states that the connector terminal was cleaned and the loose fastening bolt was retightened before the three-point voltage measurement at idle, half opening, and wide-open throttle (WOT). Therefore, those three values are reported as post-preliminary-service checkpoints rather than as an untouched voltage trace of the original fault. They are also limited checkpoints and are not treated as proof that the sensor was normal throughout its entire sweep.

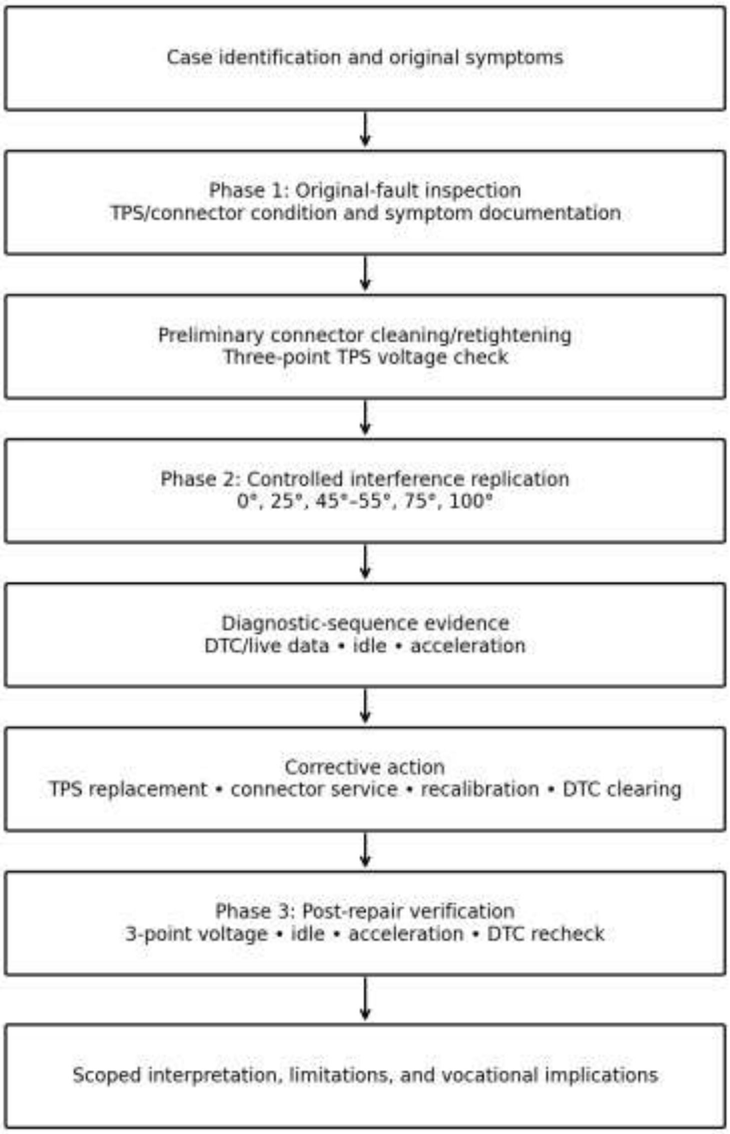

Figure 1. Revised diagnostic workflow distinguishing natural-fault documentation from controlled interference replication and post-repair verification

Phase 2 was a controlled interference replication conducted after the initial inspection and preliminary service. The original manuscript describes partially loosening the TPS connector and introducing additional resistance or obstruction in the signal path to reproduce intermittent signal behavior. During this phase, TPS output was observed across a wider set of throttle positions: 0°, 25°, 45°–55°, 75°, and 100° (WOT). This phase was used to demonstrate a plausible electrical mechanism by which intermittent contact could produce a large signal spike or dropout. The readings generated during this deliberate manipulation are explicitly identified as simulated or replicated interference and are not presented as direct measurements of the naturally degraded resistive track under untouched conditions. OBD-II DTCs and ECU live-data observations are reported in the source results after the controlled-interference table, but the available notes do not timestamp each of those observations sufficiently to determine whether every code or live-data anomaly preceded, arose during, or persisted after the deliberate manipulation. The revised analysis therefore treats them as diagnostic-sequence evidence rather than attributing all of them exclusively to the natural fault.

Phase 3 consisted of corrective action and post-repair verification. Corrective actions recorded in the source study were cleaning the TPS connector terminal, replacing the TPS unit, tightening the TPS fastening hardware, carrying out TPS/ECU recalibration through the reset procedure, clearing stored DTCs, and retesting the vehicle. Post-repair voltage values were retained at three positions only: idle, half opening, and WOT. The vehicle was then rechecked using OBD-II and driven for a functional test. The record reports no newly recurring DTC during that test drive, an idle speed of approximately 750 rpm, and normalized acceleration response. The duration of the test drive and the number of complete operating cycles were not documented; consequently, the verification is described as short-term functional confirmation rather than evidence of permanent restoration.

Data analysis was descriptive and based on evidence triangulation. Measured voltages were compared with the service-manual reference ranges, while physical inspection findings, DTCs, live-data behavior, idle-speed changes, and acceleration response were examined for technical coherence. No inferential statistics were applied because the unit of investigation was a single vehicle and repeated independent experimental trials were not reported. The manuscript also avoids treating DTCs P0300 and P0171 as unique proof of a TPS fault. The original workshop record states that no apparent ignition-system or injector damage was found; however, itemized exclusion tests and their quantitative results were not retained. These statements are therefore treated as supporting workshop observations rather than definitive exclusion of every alternative cause.

The study did not recruit human participants and did not collect personal participant data; accordingly, human-subject ethics review was not applicable to the reported vehicle diagnostic procedure. The manuscript contains no personally identifying information. Separate written workshop authorization, a formal safety checklist, and a data-governance protocol were not included in the original record. Their absence is acknowledged rather than reconstructed retrospectively. Live-engine and electrical diagnostic work inherently requires appropriate workshop safety controls, and future replications should document authorization, equipment calibration, electrical precautions, and test-drive conditions prospectively to improve governance and reproducibility.

RESULTS AND DISCUSSION

Vehicle and Initial Diagnostic Evidence

Table 1. Unit specifications

Specification	Recorded value
Make/model	Daihatsu Xenia 1.0 Non-VVT-i
Engine code	EJ-DE
Control system	Electronic Control Unit (ECU)
Displacement	989 cc
Configuration	3-cylinder inline, SOHC, Non-VVT-i
Maximum power	63 PS at 6,000 rpm
Maximum torque	86.5 Nm at 3,600 rpm
Transmission	5-speed manual
Throttle sensor type	Throttle Position Sensor (potentiometer, contact type)

Specification	Recorded value
TPS supply voltage	5 V reference from ECU
TPS output reference	Approximately 0.5 V (idle) to 4.5 V (WOT)
Connector pins	3 pins (VC, VTA, E2)

The vehicle was a Daihatsu Xenia 1.0 Non-VVT-i with an EJ-DE, 989 cc, three-cylinder inline SOHC engine and a five-speed manual transmission. The reported TPS was a three-pin contact-type potentiometer supplied by a 5 V ECU reference. The original complaint consisted of unstable idle, hesitation during initial acceleration, and a continuously illuminated Check Engine indicator. Table 1 summarizes the vehicle and sensor specifications used to contextualize the diagnostic case.

Figure 2. Daihatsu Xenia 1.0 Non-VVT-i engine used in the diagnostic case

Physical inspection found no crack or obvious damage to the TPS housing. Mild oxidation was present on the VTA terminal and the terminal surface was slightly darkened. Inspection of the resistive track identified wear or scratching along the wiper-arm trajectory, while the throttle shaft itself moved smoothly without noticeable drag. The original narrative also recorded one TPS fastening bolt as slightly loose. These observations were relevant because they provided a physical basis for considering intermittent electrical contact, although none of the findings by itself establishes the complete causal chain between TPS degradation and all observed engine symptoms.

Table 2. Physical inspection of the Throttle Position Sensor

Inspection component	Recorded observation
TPS body	No cracks or visible damage to the sensor housing

Inspection component	Recorded observation
TPS connector	Mild oxidation/corrosion on the VTA terminal; terminal surface slightly darkened
Resistive track (carbon track)	Wear/scratching at one point along the wiper-arm trajectory
Throttle shaft	Movement remained smooth; no drag observed
TPS fastening	One fastening bolt was recorded as slightly loose

Figure 3. Throttle Position Sensor (TPS) documented during inspection

The TPS photograph retained from the diagnostic case is shown in Figure 3. The figure is used as component documentation rather than as proof of the microscopic electrical behavior of the resistive track; the latter requires electrical measurement. This distinction responds to the practical problem motivating the study: external appearance may be insufficient for diagnosing a contact-related fault that appears only over a particular portion of sensor travel.

Original Fault, Preliminary Service, and Controlled Interference Replication

After the physical inspection, the source record states that the connector terminal was cleaned and the slightly loose fastening bolt was retightened before the first three-point voltage check. At idle, half opening, and WOT, the measured values were 0.52 V, 1.98 V, and 4.31 V, respectively, all within the reported reference ranges (Table 3). The provenance of these data is therefore important: they represent limited checkpoints after preliminary connector service but before the deliberate interference replication and before TPS replacement. Their normal appearance shows why a sparse static test can fail to capture an intermittent defect, but it cannot be used as an untouched baseline trace of the original complaint. The broader discontinuity evidence is consequently separated into the controlled replication reported in Table 4.

Table 3. Three-point TPS voltage measurements after preliminary connector service and before controlled interference replication

Throttle condition	Reference voltage (V)	Measured voltage (V)	Interpretation
Idle	0.4–0.7	0.52	Within reference range
Half opening	1.5–2.5	1.98	Within reference range
Wide-open throttle (WOT)	4.0–4.5	4.31	Within reference range

During the controlled interference replication, the signal matched the reference values at 0°, 25°, 75°, and 100° but fluctuated from 0.3 V to 4.8 V with dropout at 45°–55°, instead of the expected 2.5–3.0 V range (Table 4). This demonstrates a plausible intermittent-contact mechanism that sparse idle/WOT checks could miss. Because the signal path was deliberately disturbed in Phase 2, these readings provide mechanistic support and are not a duplicate measurement of untouched natural degradation.

Table 4. TPS output during controlled interference replication

Throttle opening angle	Reference voltage	Measured voltage
0° (idle)	0.5 V	0.5 V
25°	1.7 V	1.7 V
45°–55°	2.5–3.0 V	Unstable, 0.3–4.8 V with dropout
75°	3.8 V	3.8 V
100° (WOT)	4.5 V	4.5 V

The diagnostic sequence recorded four active OBD-II codes: P0122 (TPS circuit low input), P0121 (TPS range/performance problem), P0300 (random/multiple cylinder misfire), and P0171 (system too lean, Bank 1). In the source results these codes are presented after the controlled-interference measurements, and the available record does not establish a separate timestamp for each code relative to the deliberate manipulation. They are therefore reported here as diagnostic-sequence evidence rather than as unequivocal proof that every code was present in the untouched natural condition. The two TPS-related codes indicate throttle-signal plausibility or low-input concerns, whereas the misfire and lean codes are compatible with broader engine-control disturbance but are not uniquely diagnostic of TPS failure. This caution is consistent with fault-diagnosis literature showing that internal-combustion-engine sensor variables are coupled and that a failure in one sensor can propagate into other measured or calculated quantities (Cervantes-Bobadilla et al., 2023). Accordingly, Table 5 reports system and status but removes the unvalidated severity labels used in the original draft.

Table 5. Diagnostic Trouble Codes recorded before repair

DTC	Description	System	Status
P0122	Throttle Position Sensor Circuit Low Input	Sensor input	Active
P0121	Throttle Position Sensor Range/Performance Problem	Sensor input	Active
P0300	Random/Multiple Cylinder Misfire	Ignition	Active
P0171	System Too Lean (Bank 1)	Fuel	Active

Table 6. Provenance and evidentiary boundary of diagnostic-sequence observations

Evidence source	Operating condition	Recorded observation	Interpretation boundary
Physical inspection	TPS and connector	Resistive-track wear and mild VTA-terminal oxidation	Supports degradation hypothesis; not sufficient alone
Multimeter, three points	After preliminary connector cleaning/retightening	0.52, 1.98, and 4.31 V; within reference ranges	Not an untouched natural-fault trace; sparse checkpoints
Controlled replication	45°–55° opening	0.3–4.8 V fluctuation with dropout	Demonstrates plausible interruption mechanism; deliberately induced
OBD-II DTCs	Diagnostic sequence; exact timing vs. simulation not retained	P0121, P0122, P0300, P0171 active	Consistent with disturbance; provenance does not prove all preceded simulation
ECU live data	Diagnostic sequence; middle opening range	TPS percentage spikes reported as out of sync with throttle position	Qualitative; full trace and exact timing vs. simulation not retained
Engine behavior	Controlled interference / original symptom context	Idle fluctuation approximately 550–950 rpm during simulation; hesitation reported	Simulation-specific numeric idle range; single-case observation

ECU live-data observation provided additional qualitative evidence. The displayed TPS percentage reportedly spiked in the middle opening range and became visibly inconsistent with the actual throttle position. The source explicitly states that the 550–950 rpm idle fluctuation was observed during the interference simulation; acceleration hesitation was also part of the vehicle symptom pattern. A complete time-series export, repeated live-data trace, or retained screenshot set was not available, and the timing of every live-data observation relative to the deliberate manipulation was not separately timestamped. These observations are therefore summarized as diagnostic-sequence behavior rather than presented as a quantitative natural-fault time series. Table 6 makes the provenance and evidentiary boundary explicit.

Corrective Action and Post-Repair Verification

Corrective action combined sensor replacement and connector service: the TPS unit was replaced, the connector terminal was cleaned, fastening hardware was tightened, TPS/ECU recalibration was performed through the reset procedure, and DTC memory was cleared before verification. After repair, the three retained voltage checkpoints were 0.55 V at idle, 2.02 V at half opening, and 4.35 V at WOT (Table 7), all within the reported service-manual ranges. Because post-repair data were retained only at these three points, the revised manuscript does not claim that a complete continuous voltage trace over every throttle angle was recorded after repair.

Table 7. TPS voltage measurements after corrective action

Throttle condition	Reference voltage (V)	Post-repair voltage (V)	Interpretation
Idle	0.4–0.7	0.55	Within reference range
Half opening	1.5–2.5	2.02	Within reference range
Wide-open throttle (WOT)	4.0–4.5	4.35	Within reference range

Functional verification also showed an idle speed of approximately 750 rpm and normal, proportional acceleration response. The OBD-II recheck performed after DTC clearing and the recorded test drive showed no newly recurring code. Taken together, the post-repair observations support the practical diagnosis that the TPS/connector condition was materially involved in the malfunction. However, the follow-up period was not documented beyond the recorded test drive, so the evidence supports restoration during post-repair verification rather than a claim of permanent restoration.

The same evidentiary boundary applies to statements about the ECU. No internal ECU inspection, bench test, or dedicated ECU-integrity test was reported. It is therefore not possible to demonstrate from the available data that permanent internal ECU damage was categorically absent. A more defensible conclusion is that no evidence of persistent ECU malfunction was observed during the functional checks: once the TPS and connector-related corrective actions were completed, the ECU no longer displayed the recorded DTC pattern and engine behavior returned to normal during the observed verification period.

Comparison With Previous Studies and Scholarly Contribution

The present case extends the emphasis of earlier TPS studies in a specific direction. Batutah et al. (2024) and Apriyanti and K N (2025) examined performance differences associated with standard and racing or aftermarket TPS configurations. Their work demonstrates that TPS characteristics can influence torque, power, fueling-related variables, or response, but it does not center on naturally degraded contact paths and intermittent signal continuity. In contrast, the principal contribution of this case is diagnostic integration: physical evidence of wear and connector oxidation is considered together with sparse static measurements, a controlled signal-interruption replication, OBD-II codes, live-data behavior, corrective action, and post-repair verification. From a fault-diagnosis standpoint, this integrated sequence also resembles the logic of analytical-redundancy and model-based studies that combine multiple residuals or hypotheses rather than relying on a single measurement (Gertler et al., 1995; Nyberg, 2002).

The findings also align with the broader principle that engine sensor faults should not be diagnosed from a single code or variable. Cervantes-Bobadilla et al. (2023) describe the challenge created by dynamic coupling among engine variables and show why one sensor fault can influence other sensor or control responses. Li et al. (2023) similarly emphasize that fault-diagnosis methods should be selected in relation to the system and operational context. In the present case, this means P0300 and P0171 should be interpreted as part of an evidence pattern rather than as standalone confirmation of TPS causality. OBD-II and ECU monitoring tools, such as those described by Setiyawan (2022) and Echsony and Nurfaizin (2018), are valuable because they expose data beyond the visible symptom, but scan-tool output still requires engineering interpretation and corroboration. Studies using online accommodation, signal/process models, adaptive thresholds, and data-driven residual evaluation similarly demonstrate that reliable engine diagnosis benefits from corroborating information across signals and operating conditions (Capriglione et al., 2003; Kimmich et al., 2005; Nyberg & Stutte, 2004; Svärd et al., 2013). Observer-based supervision and multivariate methods further underscore the value of analytical redundancy and cross-variable consistency checks (Gutiérrez León et al., 2018; Wang et al., 2008).

The novelty of the study should therefore be understood as a bounded case contribution rather than discovery of a new sensor principle. The paper documents how a workshop diagnosis can be organized into an explicit sequence of original-fault documentation, controlled mechanism replication, multi-source interpretation, repair, and verification. That structure increases transparency and makes the case easier to reproduce pedagogically. At the same time, the case cannot establish population-level failure rates, universal voltage behavior, or generalized causal effects across all electronic throttle architectures.

Implications for Automotive Vocational Education

For automotive vocational education, the most useful contribution is the diagnostic sequence rather than the numerical values alone. The case can be converted into an authentic troubleshooting activity in which learners begin with symptoms, formulate competing hypotheses, choose measurements, compare measurements with technical specifications, interpret DTCs and live data, isolate a probable fault, propose corrective action, and verify the result. This progression parallels the structured diagnostic reasoning emphasized in car-mechatronics education, where learners need to develop and execute test strategies and evaluate evidence rather than simply name a faulty component (Meier et al., 2022). It is also consistent with Abele's (2018) process-oriented account of professional diagnostic problem solving and with evidence that modeling examples can support the acquisition of diagnostic knowledge and scaffolded problem-solving skills among automotive apprentices (Meier et al., 2024).

The case is also suitable for problem-based or teaching-factory learning because the observed fault is ambiguous at first: three static voltage checkpoints appear normal even though the vehicle exhibits hesitation and unstable idle. Learners can therefore be asked why a normal idle/WOT reading does not necessarily invalidate an intermittent TPS hypothesis, what additional measurements would improve confidence, and how DTCs should be interpreted when multiple engine systems are implicated. This type of problem structure is consistent with the emphasis on authentic problem solving in automotive vocational education reported by Maksum et al. (2024). A dedicated TPS trainer such as that developed by Pahlevi et al. (2024) could further allow learners to practice angle-versus-voltage interpretation before confronting a real vehicle. Framing the same case as a guided problem-based or simulation task is also compatible with vocational research emphasizing the value of authenticity, reflection, and realistic decision making in apprentice learning (Monks, 2010; Rush et al., 2010).

These educational statements are instructional implications, not evidence of instructional effectiveness. The present study did not involve students, did not administer a learning assessment, and did not compare teaching strategies. Consequently, it cannot demonstrate improvement in troubleshooting competence, transfer, retention, or achievement. Future educational research could use the revised diagnostic sequence as a learning task and evaluate outcomes with pre/post measures, performance-based diagnosis rubrics, transfer cases involving different sensor technologies, and observation of learners' diagnostic reasoning.

Limitations and Transferability

Several limitations define the boundary of the findings. First, the evidence comes from one Daihatsu Xenia 1.0 Non-VVT-i with an EJ-DE engine and a contact-type potentiometer TPS in one specialist workshop. Replication is required before extending the findings to other vehicle models, drive-by-wire systems, non-contact position sensors, or ECU strategies with different plausibility and fail-safe logic. Second, Phase 2 deliberately disturbed the connector/signal path; therefore, its 0.3–4.8 V behavior demonstrates a plausible interruption mechanism but should not be treated as an untouched recording of natural resistive-track degradation. Third, the study did not retain oscilloscope traces, a complete ECU live-data time series, repeated independent trials, calibration uncertainty, or a full-angle post-repair signal trace.

Fourth, the itemized diagnostic tests used to exclude alternative ignition or injector faults were not retained, and the recorded test-drive duration and number of operating cycles were not reported. These limitations reduce the strength of claims about unique causality and long-term repair permanence. Fifth, the original record does not contain prospective documentation of written workshop authorization or a formal safety checklist. Finally, no vocational students or instructors were studied, so transfer to educational settings remains conceptual. These constraints do not eliminate the value of the case; rather, they clarify that its strongest contribution is a transparent, technically coherent diagnostic sequence that can be tested in broader engineering and educational studies.

CONCLUSION

This single-vehicle diagnostic case identified wear on the TPS resistive track and mild oxidation at the VTA connector terminal in a Daihatsu Xenia 1.0 Non-VVT-i that exhibited unstable idle, acceleration hesitation, and an illuminated Check Engine indicator. After preliminary connector cleaning and fastener retightening, three static checkpoints remained within specification; a subsequent controlled interference replication across additional throttle positions produced intermittent 0.3–4.8 V fluctuations at 45°–55°, demonstrating how a contact disturbance can escape sparse static testing. The diagnostic sequence recorded P0121, P0122, P0300, and P0171 and qualitative TPS live-data spikes, while the 550–950 rpm numeric idle fluctuation was explicitly observed during the controlled-interference simulation. Because the source record does not timestamp every DTC/live-data observation relative to the deliberate manipulation, these findings are not presented as if all arose exclusively from the untouched natural fault. After TPS replacement, connector service, recalibration, and DTC clearing, the three retained post-repair voltage checkpoints were within specification, idle stabilized at approximately 750 rpm, acceleration response normalized, and no DTC recurrence was observed during the recorded test drive. These findings support TPS/connector involvement in the observed malfunction, while no evidence of persistent ECU malfunction was observed during the functional checks; the study did not perform an internal ECU integrity test or long-term follow-up. For automotive vocational education, the case provides a structured sequence from symptom recognition through measurement, interpretation, fault isolation, repair, and verification, but its educational effectiveness was not measured. Replication across other vehicles, sensor technologies, diagnostic instruments, operating cycles, and vocational learning environments is required before broader generalization.

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