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Digital Data-Based Inclusive Vocational Learning Capital in Injection Motor Maintenance Material for Deaf Students

Naufal Irsan Sani Oktalgifari [1], Iding Tarsidi [2]

[1] Universitas Pendidikan Indonesia, Indonesia; naufalsani@upi.edu
[2] Universitas Pendidikan Indonesia, Indonesia; idingtarsidi4@upi.edu

Abstract	Inequality in access to modern technology in vocational education for deaf students is a major obstacle to developing job skills aligned with current industry needs. This study aims to implement and evaluate the effectiveness of digital technology-based vocational learning in Honda injection motor maintenance for deaf students at Special Schools (SLB). The method used is a descriptive qualitative method, involving 2–4 SMALB students as research subjects. Data collection techniques include observing practical activities, documenting, interviewing vocational teachers, and evaluating student skills. A case study was chosen to describe the contextual application of digital technology-based Honda injection engine maintenance learning using K-Line-based OBD FTDI for deaf students in special education units. The learning stages included introduction to tools, demonstrations, data reading practice, diagnosis result interpretation, visual discussions, and basic corrective actions. The results show that students can understand the tools' functions, read fault codes, and visually identify technical problems. Obstacles in understanding technical terms are overcome through visual media-based learning strategies, illustrated guidebooks, and video tutorials. In terms of affection and participation, this learning increases student motivation, confidence, and active involvement in practice. Vocational teachers play a strategic role in simplifying technical concepts into adaptive visual and procedural forms. New findings from this study indicate that the use of digital automotive diagnostic tools as learning media can help bridge the communication barriers faced by deaf students in technical learning contexts. Thus, this approach is considered effective and feasible for continuous integration into the SLB vocational curriculum.
Keywords	Deaf Students; Digital Technology; Honda Injection System; OBD FTDI K-Line; Vocational Learning

Corresponding Author
Naufal Irsan Sani Oktalgifari
Universitas Pendidikan Indonesia, Indonesia; naufalsani@upi.edu

1. INTRODUCTION

Special Schools (SLB) play a strategic role in ensuring equal and inclusive education rights for students with special needs, including deaf students (Wing et al., 2019; Mulyosari et al., 2023). In practice, SLBs still face various challenges, particularly in vocational learning, which requires an understanding of technical concepts and practical skills (Clark & Mayer, 2022; Apriliani & Aprilia, 2010).

Deaf students tend to experience difficulties understanding material conveyed verbally and abstractly, requiring a learning approach that emphasizes visualization, hands-on practice, and concrete experiences (Erwin et al., 2022). Therefore, the development of a vocational learning model that is adaptive to the learning characteristics of deaf students is an urgent need (Prasojo et al., 2022; Evmenova et al., 2024).

These challenges are even more complex in the automotive field, especially in the subject of injection engine maintenance, which is based on electronic systems and digital data (Amelia & Azizah, 2023) (Felicia, 2025). Motorcycle injection systems require an understanding of the relationship between sensors, actuators, and electronic control units (ECUs), which is difficult to explain through text or lectures alone (Ridhuan et al., 2023; Ayeni & Eden, 2024). This condition has the potential to cause a competency gap between SLB graduates and the needs of the increasingly digitized automotive industry (Budi et al., 2022; Kibrit et al., 2022).

Several previous studies have examined the use of visual and multimodal media in learning for deaf students. Research by (Harapan, 2025) and (Zahroh et al., 2022) shows that visual media such as video tutorials, procedural images, and live demonstrations can improve deaf students' understanding of technical concepts (Hamedani et al., 2025). Other studies also confirm that visual and practice-based approaches are more effective than verbal approaches in vocational learning for students with hearing impairments (Queiroga et al., 2024). However, most of these studies still focus on static learning media and have not integrated real-time digital data from real industrial systems (Almos et al., 2025).

In the international context, (Enríquez et al., 2025) The Rochester Institute of Technology (2020) report indicates that integrating real industrial technology into vocational education can improve deaf students' work-readiness. Nevertheless, these studies emphasize technical skills training and have not specifically developed a structured and contextual digital data-based inclusive vocational learning model for automotive learning in special needs schools (Syam, 2025; Dunan et al., 2025).

In Indonesia, studies on automotive vocational learning for deaf students are still very limited, especially those that link learning with the use of digital diagnostic tools that represent real-time engine conditions (Harsi & Utami, 2024). The use of digital data-based OBD scanners is generally still used for mechanical practice purposes, not as a pedagogical medium designed to support the conceptual understanding of deaf students (Herviani et al., 2025; Saad et al., 2023). Thus, there is a research gap regarding how digital data from injection systems can be systematically integrated into inclusive vocational learning models in SLBs.

Based on this gap, this study focuses on developing an inclusive vocational learning model grounded in digital data, using motorcycle injection system data visualization as a learning medium for deaf students. The focus of this study is not on developing diagnostic tools, but rather on the design and implementation of learning that transforms digital engine data into concrete visual aids for understanding injection engine maintenance concepts.

Based on the background above, this study aims to describe the application of an inclusive, data-driven vocational learning model in injection engine maintenance materials for deaf students and to analyze its impact on deaf students' understanding of concepts and engagement in learning.

The novelty of this research lies in the development of an inclusive vocational learning model that integrates real-time digital diagnostic data as a visual-pedagogical medium rather than merely as a technical practice tool. This model offers a learning approach that bridges the limitations of deaf students' verbal communication with the demands of digital literacy in the modern automotive industry. The results of this study are expected to provide theoretical and practical contributions to the development of inclusive vocational learning in special schools, as well as serve as a reference for the development of micro-curricula and teacher training grounded in digital technology.

2. METHODS

This study uses a qualitative descriptive case study design with limited instructional development. This design was chosen based on the limited characteristics of the research subjects and the research objective, which focuses on an in-depth description of the learning process and implementation rather than on generalizing the results. A case study was chosen to describe the contextual application of Honda injection motor maintenance learning based on digital technology using K-Line-based OBD FTDI for deaf students in special education units. The limited instructional development approach was used because the study did not aim to develop a new learning model broadly, but rather to adapt and implement digital technology-based learning strategies tailored to the needs and characteristics of deaf students, particularly in the context of automotive vocational learning.

Research Subjects and Setting

The research subjects were a limited number of deaf students enrolled in vocational automotive education at a special needs school, as well as one teacher of motorcycle injection maintenance. The research setting was the school's practice workshop, which was equipped with Honda injection motorcycles, K-Line-based OBD FTDI devices, and computer-based data analysis applications (Muwaniki et al., 2025; Putri, 2024).

Learning Procedures

Learning was carried out gradually and systematically, adopting the principles of learning by doing, visual-based learning, and total communication tailored to the characteristics of deaf students. The learning procedure included the following stages:

a. Introduction to Tools: The teacher introduced the K-Line-based OBD FTDI tool, including its physical form, functions, and parts. Explanations are provided through visual media, such as pictures, presentations, and live demonstrations, to reinforce students' understanding.

b. Demonstration of Use: The teacher demonstrates how to connect the OBD tool to a Honda injection motorcycle and open and run the diagnostic analysis application. This stage emphasizes visual observation and clear modeling of work steps.

c. Practice Reading Data: students directly practice reading data from the application screen, such as sensor parameters and injection system conditions. The teacher provides assistance using visual guides and sign language.

d. Diagnostic Result Interpretation: Students are guided to read and interpret error codes with the help of injection system diagrams, pictures, and color tables. This stage aims to connect digital data with the engine's technical condition.

e. Discussion and Corrective Action: The diagnostic results are discussed visually using sign language and student worksheets. Students then carry out simple corrective actions according to the analysis results until the engine condition returns to near operational standards.

In addition to these main stages, the learning process also includes an introduction to injection system components such as sensors, connector cables, and throttle bodies. At the end of the activity, students compile a report on the analysis results as a form of reflection and reinforcement of their understanding.

Data Collection Techniques

Research data is collected through direct observation, to observe the learning process, student engagement, and teacher-student interaction, semi-structured interviews with teachers to obtain information related to learning planning, implementation, and evaluation, ocumentation in the form of photos of activities, learning notes, student work, and diagnostic reports, student performance

evaluation to assess their ability to read data, interpret diagnostic results, and make simple improvements.

Data Analysis Techniques

Data analysis was conducted using descriptive qualitative methods across several systematic stages, namely data reduction, which involved selecting and focusing on data relevant to the research objectives. Data presentation in the form of narrative descriptions and tables facilitates understanding of the relationships between data. Drawing conclusions and verification, by interpreting the findings to assess the effectiveness of digital technology-based learning and identifying factors that support and hinder implementation. These stages of analysis are carried out repeatedly (iteratively) during the research process so that the results obtained accurately reflect the conditions in the field.

Data Validity

To ensure data validity, this study uses method triangulation and source triangulation. Method triangulation is carried out by comparing data from observations, interviews, documentation, and student evaluations. Source triangulation is carried out by comparing information from teachers, students, and learning documentation. The application of triangulation aims to increase the credibility, validity, and reliability of the research results, so that the findings obtained can be scientifically accounted for.

Learning Procedures

The learning procedures in this study were designed to be gradual, systematic, and oriented towards the learning characteristics of deaf students, adopting the principles of learning by doing and visual-digital-based learning (Husein et al., 2026). These procedures aimed to transform diagnostic data on injection systems into concrete learning experiences that were easy to observe and visually interpretable by students (Maspupah & Basit, 2025). Learning is carried out through five interconnected main stages. Each stage is designed to minimize dependence on verbal communication and strengthen conceptual understanding through demonstrations, hands-on practice, and visual reflection (Tadeu & Paiva, 2015).

Stages of the Learning Procedure

a. Introduction to Learning Media and Context: In the initial stage, the teacher introduces learning media in the form of digital data-based diagnostic tools as a means of understanding motorcycle injection systems. The introduction focuses on the general functions of the tools, their visual appearance, and their relationship to the injection system, without emphasizing complex technical aspects. This stage aims to build students' initial understanding and readiness to learn.

b. Guided Visual Demonstration: The teacher demonstrates how to connect the learning media to the motorcycle and displays the injection system data through software. The demonstration is conducted slowly, accompanied by explanations in sign language, gestures, and visual pointers. Students are directed to observe the relationship between the engine condition and the data that appears on the screen.

c. Practice Reading and Observing Digital Data: Students practice reading the displayed digital data in groups or individually. This activity emphasizes students' ability to recognize symbols, numbers, and visual indicators that represent the condition of the injection system. The teacher serves as a facilitator, providing visual guidance and corrections when necessary.

d. Visual Interpretation and Simple Analysis: At this stage, students are directed to interpret the results of diagnostic data readings with the help of injection system diagrams, component images, and color tables. Interpretation focuses on recognizing simple types of disturbances or abnormal conditions so that students can relate digital data to the physical components of a motorcycle.

e. Visual Discussion and Basic Corrective Actions: The final stage consists of a visual-based discussion using sign language and supporting media. Students and teachers discuss the results of data interpretation and determine basic maintenance or repair actions. Students then perform simple maintenance practices as directed, followed by a brief reflection on the learning outcomes.

In addition to these five main stages, the learning process also includes an introduction to injection system components such as sensors, connector cables, and throttle bodies through a visual and manipulative approach. Students are directed to compile a simple report, based on images or symbols, detailing the results of their analysis and the maintenance actions they have taken. This process is designed to increase learning independence and strengthen the connection between digital data and the engine's actual condition.

Table 1. Learning Stages in the Digital Data-Based Inclusive Vocational Learning Model

No.	Learning Stages	Activity Description	Learning Media	Expected Output
1	Introduction to Media	Introduction to the functions and appearance of diagnostic media as a visual aid for learning about injection systems.	Digital diagnostic media, visual presentations	Students recognize media and understand its general functions.
2	Visual Demonstration	The teacher demonstrates the use of the media and displays real-time injection system data.	Video tutorials, live demonstrations	Students understand the flow of media usage.
3	Practice Reading Data	Students read and observe digital data with visual guidance.	Illustrated guidebooks, computers/laptops	Students can recognize data indicators and symbols.
4	Visual Interpretation	Students interpret data using diagrams and color tables.	Injection system diagrams, visual tables	Students can identify simple system conditions.
5	Discussion and Corrective Action	Visual discussion and basic maintenance practice based on the results of the interpretation.	Sign language, student worksheets	Students can conclude and perform basic maintenance tasks.

Data Analysis

Data obtained through observation, interviews, documentation, and student performance evaluations were analyzed using descriptive qualitative methods. The analysis was conducted using source triangulation and other techniques to ensure data credibility and validity. The analysis process focused on patterns of involvement and learning responses of deaf students during learning, students' ability to understand and interpret visual-digital data, and factors supporting and hindering the implementation of the learning model. The results of the analysis were used to reflect on the effectiveness of the learning procedures and to refine the developed data-driven, inclusive vocational learning model.

3. FINDINGS AND DISCUSSIONS

The results of this study were obtained through observation of learning activities, in-depth interviews with vocational teachers, field documentation, and assessment of student performance in learning about Honda motorcycle injection system maintenance using digital technology. The presentation of results focused on the description of the process, student responses, and the pedagogical meaning of learning implementation, in accordance with the characteristics of qualitative case study

research.

Results of Student Activity Observations

Observations were conducted on four deaf students at the SMALB level during practical learning using an FTDI-KLine OBD scanner connected to a laptop and the Analysis Pro version 5.0 application. Observations used a qualitative observation sheet with descriptive ratings, including indicators of student engagement, independence, understanding of procedures, and ability to read diagnostic results. The rating scale used a range of 1–5 as descriptive categories (1 = very poor, 5 = very good), not as a quantitative statistical analysis.

The results showed that most students were in the good-to-very good category. The descriptive average score of 4.3 was used solely as an indicator of the activity's quality, not as an inferential quantitative finding. Qualitatively, students were able to actively and relatively independently follow the learning stages. They were able to recognize the scanner's functions, connect the device to a motorcycle, read the sensor parameter display, and identify error codes through the application's visual display.

In addition to technical aspects, observations also showed changes in learning behavior. Students appeared more focused, were not easily distracted, and showed initiative by asking questions in sign language when they noticed differences in the data on the screen. Visual discussion and pair work activities arose naturally during the practice. These findings show that the use of real digital tools functions not only as a technical medium but also as a trigger for meaningful learning engagement for deaf students.

Results of Interviews with Vocational Teachers

Semi-structured interviews were conducted with one automotive vocational teacher at the SLB who was directly involved in implementing the learning process. The interview results are presented as direct quotations (verbatim) combined with thematic interpretations to strengthen the validity of the qualitative data.

Table 2. Vocational Teacher Interview Excerpts and Thematic Interpretation

No.	Researcher Questions	Teacher's Response (Verbatim)	Code / Initial Theme	Researcher Interpretation
1	How do deaf students respond to the use of FTDI-KLine OBD scanners in learning?	"Usually, when it is just theory or pictures on the board, children get bored quickly. However, when using this scanner, they focus on the screen and want to know what the data means."	Visual appeal	Data-visual-based digital media increases deaf students' focus and engagement in learning.
2	Does this diagnostic tool help explain the concept of injection systems?	"The data in the application becomes a common language. I do not need to say much, just show them the numbers and colors, and they immediately understand where the problem is."	Visuals as a language	Digital data serves as an alternative communication medium that replaces the limitations of verbal language.
3	How does this learning affect students' work attitudes?	"The children become more organized, more careful, and follow the work sequence. They feel like they are working like real mechanics."	Professional work ethic	The use of real industrial tools fosters more professional, structured work behavior.
4	Are there any	"When they successfully read the	Self-confidence	The success of

No.	Researcher Questions	Teacher's Response (Verbatim)	Code / Initial Theme	Researcher Interpretation
	noticeable changes in student motivation and confidence?	data themselves, they look proud. Usually, they immediately ask to try again without being told."		independent practice increases students' self-efficacy and intrinsic motivation.
5	What are the most common obstacles that arise during learning?	"Technical terms are the most difficult. Not all of them have sign language, so we have to use pictures and direct examples."	Technical language barriers	Linguistic barriers require visual and demonstrative adaptations in automotive learning.
6	How do teachers overcome these obstacles?	"I repeat the steps, use videos, and point directly to the motor. Eventually, they memorize the process."	Repeated demonstrations	The learning-by-doing approach and visual repetition are effective for building procedural understanding.

Barriers to Learning Implementation

Although learning was effective, several barriers were encountered during implementation. The main barrier was the limited number of technical automotive terms in sign language, which required teachers to use additional visual strategies, such as symbols, colors, and repeated demonstrations (Rohmah et al., 2024). In addition, students needed more time to adapt to developing a consistent work sequence, especially at the stage of interpreting fault codes. Another limitation is the limited number of devices, which means that learning must be done in turns. This condition can reduce individual practice time if not managed properly.

Learning Solution and Adaptation Strategies

To overcome these obstacles, teachers implemented several adaptive strategies, including the use of visual tutorial videos, illustrated guidebooks, and repeated demonstrations based on learning by doing (Prasetya et al., 2025). These strategies allow students to repeat their understanding without relying on verbal explanations and strengthen procedural memory through direct experience. This approach shows that learning success is not determined solely by the sophistication of the tools but also by the pedagogical methods used to mediate them in line with the characteristics of deaf students (Afifi et al., 2025).

To overcome barriers to learning, several adaptive strategies were implemented. First, visual tutorial videos were created to guide students through the steps for using the scanner and the Analysis Pro application in a systematic, sequential manner. Second, an illustrated guidebook was developed containing illustrations of connectors, sensor diagrams, and examples of frequently occurring damage codes. Third, a demonstrative approach and repetitive demonstrations were used, based on the principle of learning by doing, guiding students from the initial stages to the point where they could practice independently. This strategy proved to be effective and in line with the results of (Mustika et al., 2025) Research has shown that a multi-sensory, participatory approach is highly beneficial for students with communication barriers. In addition, research by (Sinjai, 2023) emphasized that illustrated media and videos tailored to the characteristics of students with special needs significantly improve the absorption of technical information. Similar findings were also reported by (Irsan et al., 2025), who showed that interactive, procedurally based multimedia can strengthen deaf students' understanding of complex material in a more concrete, systematic, and visually appealing way.

Impact on Motivation, Self-Confidence, and Work Attitude

The increase in students' motivation, self-confidence, and professional work attitude was identified through a combination of behavioral observations (engagement, independence, perseverance) and

teacher interviews, rather than through psychometric quantitative instruments. Students showed pride when they were able to read the data themselves and perform simple corrective actions (Rijal, 2024). The experience of using real industrial tools fostered a perception of themselves as prospective workers, not just SLB students (Rimadani et al., n.d.).

The main impact of digital tool-based learning is increased motivation, confidence, and a professional work attitude among deaf students, who feel valued when given access to real industrial tools, such as FTDI-KLine OBD scanners. This type of learning encourages the development of soft skills such as cooperation, decision-making, and student independence in practice, in line with research by (Rahmi et al., 2025) which shows that active engagement through technology can build confidence and increase interest in learning. This is reinforced by the findings of (Yanti et al., 2025) who state that a visual technology-based approach in deaf education contributes to social skills and independence. In addition, the Rochester Institute of Technology (2020) emphasizes that the use of real industrial equipment in vocational education for deaf students can strengthen overall work readiness and social engagement (Khikmah et al., 2024; Bariyyah & Tarsidi, 2025).

Discussion and Uniqueness of the Study

Unlike previous studies that generally emphasize the use of static visual media or simulations, this study shows that integrating real industrial automotive diagnostic tools can serve as an inclusive pedagogical medium for deaf students. The uniqueness of this study lies in the use of OBD FTDI-KLine as a learning interface that converts technical data into visual representations that are accessible to students with hearing impairments.

4. CONCLUSION

Based on the research conducted, it can be concluded that digital technology-based vocational learning using FTDI K-Line OBD scanners and the Analisis Pro application is effectively applied to deaf students at the SMALB level in the context of Honda motorcycle injection system maintenance. Through a concrete, visual, and step-by-step learning process that includes tool introduction, demonstration, diagnostic practice, data interpretation, and basic corrective actions, students can understand the tools' functions, read and analyze fault codes, and perform simple repair procedures independently. Observations and interviews with teachers confirmed that the hands-on and digital media-based approach improved focus, participation, and skill retention. Support strategies such as video tutorials, illustrated guidebooks, and repeated demonstrations proved helpful in overcoming technical language barriers and communication limitations commonly experienced by deaf students. By improving cognitive and psychomotor skills, this learning model positively impacts students' motivation, confidence, and professional attitude. Access to real industrial tools makes students more engaged, confident, and feel valued as prospective vocational workers. These findings confirm that digital technology can bridge the communication gap in technical learning for deaf students while strengthening their readiness to meet the demands of Industry 4.0. Thus, this learning model should be developed as a micro-vocational curriculum in special schools through the standardization of teaching modules, technology-based teacher training, and policy support to ensure its sustainability in the national inclusive education system.

However, this study has limitations, including a small sample size and a single-case study design, so the findings are not intended for broad generalization. In addition, the measurement of attitudes and motivation is still descriptive and qualitative in nature, so further research could combine it with standardized quantitative instruments to strengthen data triangulation

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