

Research on the Path of Human Efficiency Improvement in Automotive Testing Enterprises Under the Background of Digital Transformation

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Abstract: With the rapid development of new energy vehicles and intelligent connected technologies, the automotive testing industry has ushered in dual opportunities of technological transformation and market expansion, while also facing the challenge that traditional human efficiency management models are incompatible with digital business needs. Based on the background of digital transformation, this paper focuses on the core issue of human efficiency improvement in automotive testing enterprises. By analyzing the current situation of human efficiency management in automotive testing enterprises and the opportunities brought by digital transformation, it constructs the implementation path of human efficiency improvement empowered by digitalization from four dimensions: management model, business process, talent system, and technology application. The research results show that digital transformation can break through traditional human efficiency bottlenecks through process optimization, data-driven decision-making, and skill upgrading, providing support for automotive testing enterprises to achieve high-quality development.

Keywords: Digital Transformation; Automotive Testing Enterprises; Human Efficiency Improvement; Path Research; Data-Driven.

1. Introduction

The automotive industry is in a period of in-depth transformation featuring "electrification, intelligence, connectivity, and sharing". As of 2024, the ownership of new energy vehicles in China has exceeded 40 million, and the penetration rate of intelligent connected vehicles has surpassed 35%. The iteration of automotive product structures has expanded testing items from traditional safety performance and emission testing to new testing fields such as battery performance, autonomous driving systems, and vehicle networking functions. Testing standards have become more stringent, and the amount of testing data has grown exponentially. Meanwhile, the 14th Five-Year Plan for the Modernization of Market Supervision clearly proposes to "promote the digital transformation of inspection and testing institutions and improve service efficiency and quality". Policy orientation and market demand have jointly driven the automotive testing industry into a critical stage of digital upgrading[1].

As a core indicator measuring enterprise operational efficiency, human efficiency directly determines the service capacity and profitability of automotive testing enterprises. Traditional automotive testing enterprises generally have the problem of "valuing equipment over management and experience over data". Issues such as rigid staffing, cumbersome testing processes, and lagging skill updates have become prominent, leading to low human efficiency. According to industry research data, the daily per capita testing volume of traditional testing enterprises is only 60% of that of digital enterprises, while the proportion of personnel training costs is 30% higher. In this context, how to use digital transformation to break through human efficiency bottlenecks has become a core proposition for automotive testing enterprises to achieve sustainable development.

This paper focuses on the interdisciplinary field of digital transformation and the automotive testing industry, constructs a theoretical framework for human efficiency improvement, enriches the research dimensions of digital transformation in the service industry, and provides a reference for subsequent research in related fields. Practical significance: Aiming at the specific pain points of human efficiency management in automotive testing enterprises, it proposes actionable digital solutions to help enterprises reduce operational costs, improve service quality, and enhance core competitiveness in market competition. At the same time, it provides practical examples for the overall digital upgrading of the industry[2].

2. Definition of Relevant Concepts and Theoretical Basis

2.1. Definition of Core Concepts

Digital Transformation: Refers to the process in which enterprises use digital technologies such as big data, artificial intelligence, and the Internet of Things to systematically restructure business processes, management models, and organizational structures, realize data-driven decision-making, and improve operational efficiency. For automotive testing enterprises, digital transformation is not only the intelligent upgrading of testing equipment but also a comprehensive shift from "equipment-driven" to "data-driven".

Human Efficiency: Namely human resource effectiveness, refers to the ratio of human resource input to output within a certain period of time. Core measurement indicators include per capita output value, daily per capita testing volume, testing efficiency per unit time, and personnel training return rate. The human efficiency of automotive testing enterprises has the dual characteristics of "technology-intensive" and "service-intensive", relying not only on the professional skills

of testing personnel but also being affected by process collaboration efficiency.

2.2. Theoretical Basis

Data-Driven Decision-Making Theory: This theory holds that data is the core production factor of enterprises. Through the collection, analysis, and application of data, decision-making can be made more accurate and efficient, reducing deviations caused by empirical decision-making. In automotive testing enterprises, in-depth mining of testing data and personnel performance data can provide quantitative basis for human efficiency optimization[3].

Business Process Reengineering Theory: The core is to fundamentally restructure the existing business processes of enterprises, eliminate redundant links, and achieve process efficiency. Digital technology provides technical support for the reengineering of automotive testing processes, breaking the limitations of the traditional linear process of "offline registration - manual testing - paper filing".

Human Capital Theory: Emphasizes that improving the quality of human capital through education, training, and other methods is the key for enterprises to improve efficiency. Under digital transformation, the skill structure of automotive testing personnel needs to transform to "technical operation + data analysis", and the upgrading of human capital forms a synergistic effect with technology application.

3. Current Situation and Problem Analysis of Human Efficiency Management in Automotive Testing Enterprises

3.1. Current Situation of Industry Human Efficiency Management

Currently, China's automotive testing enterprises are mainly divided into three categories: state-controlled testing institutions, chain brand testing enterprises, and regional small and medium-sized testing institutions. From the perspective of human efficiency management, the industry as a whole presents a "polarization" characteristic: leading chain enterprises have achieved a daily per capita testing volume of 15-20 vehicles and a per capita output value of over 300,000 yuan/year through preliminary digital upgrading; while small and medium-sized enterprises still mainly adopt traditional models, with a daily per capita testing volume of less than 10 vehicles and a per capita output value of only about 50% of that of leading enterprises.

From the perspective of personnel structure, among industry employees, 40% are over 45 years old, more than 60% have a college degree or below, and less than 20% have intelligent testing skills; from the perspective of management models, 70% of small and medium-sized enterprises still adopt the "team leader responsibility system", and performance evaluation relies on subjective evaluation, lacking data support; from the perspective of technology application, most enterprises have only achieved single-machine digitalization of testing equipment, without forming data linkage, and testing data is separated from personnel performance data[4].

3.2. Core Problems of Human Efficiency Management

3.2.1. Rigid Management Model and Lack of Data Support for Decision-Making

The human efficiency management of traditional automotive testing enterprises is mainly "experience-driven". Personnel scheduling relies on the subjective judgment of team leaders, which cannot be flexibly adjusted according to fluctuations in testing volume; performance evaluation focuses on the single indicator of "testing quantity", ignoring key dimensions such as testing quality and customer satisfaction; personnel training plans lack pertinence, only carrying out general skill training, which is disconnected from the application needs of intelligent testing equipment. Due to the lack of integrated analysis of testing data and personnel behavior data, enterprises cannot accurately identify inefficient links and high-potential talents, leading to blindness in management decisions[5].

3.2.2. Cumbersome Business Processes and Low Collaboration Efficiency

The traditional testing process is divided into five links: "customer registration - vehicle external inspection - indoor testing - report review - payment and document collection". Each link requires manual handover, resulting in delayed information transmission. For example, customer registration requires manual entry of vehicle information, taking 3-5 minutes; testing data needs to be manually summarized to the review end, which is prone to entry errors; if the review fails, manual tracing of problematic links is required, extending the testing cycle. According to research, "non-testing time consumption" accounts for 40% of the total time in the traditional process, and personnel spend a lot of time on process collaboration, diluting core testing efficiency.

3.2.3. Lagging Talent Skills and Insufficient Adaptation to Digital Needs

The testing needs of new energy and intelligent connected vehicles put forward new requirements for personnel skills: they not only need to master traditional testing technologies but also have capabilities such as battery testing, ADAS system calibration, and data anomaly analysis. However, among current industry employees, only 15% have received intelligent testing skill training, and most personnel are not proficient in operating new testing equipment, resulting in equipment utilization rate of less than 60%; at the same time, the industry lacks interdisciplinary talents who understand both testing technology and data analysis. The value of testing data cannot be fully tapped, making it difficult to optimize testing processes and improve human efficiency through data[6].

3.2.4. Superficial Technology Application and Failure to Form a Human Efficiency Empowerment Closed Loop

The digitalization of most automotive testing enterprises remains at the level of "equipment intelligence", only realizing the automatic collection of testing data, without building a closed-loop system of "data collection - analysis - application - optimization". Testing equipment is not interconnected with management systems and training systems, leading to: testing data cannot be automatically linked to personnel performance and needs to be manually counted; equipment failure data cannot be timely pushed to maintenance personnel, affecting equipment use efficiency; personnel skill gaps cannot be accurately identified through

testing data, resulting in insufficient training pertinence. Technology application has not effectively empowered human efficiency improvement.

4. Mechanism of Digital Transformation on Human Efficiency Improvement in Automotive Testing Enterprises

4.1. Data Integration Breaks Information Barriers and Realizes Precision Management

Digital transformation constructs a unified data platform to integrate testing business data (testing volume, testing qualification rate, equipment utilization rate), personnel data (attendance, operational proficiency, performance indicators), and customer data (peak arrival hours, demand types), forming a data base for human efficiency management. Through data modeling and analysis, enterprises can: accurately identify peak testing hours, optimize personnel scheduling, and reduce personnel idleness; establish a multi-dimensional performance evaluation system, quantify personnel contributions by combining data such as testing quality and customer satisfaction; provide data support for talent allocation through matching analysis of personnel skills and testing tasks, promoting the transformation of management from "empirical judgment" to "data-driven decision-making"[7].

4.2. Digital Reconstruction of Processes Improves Collaboration Efficiency

The reconstruction of testing processes by digital technology is reflected in three dimensions: "onlineization, automation, and linkage". Onlineization realizes the whole-process online handling of customer appointment, information filling, and report inquiry, reducing the time spent on manual registration; automation realizes the automatic synchronization of data between testing equipment and management systems through IoT technology, avoiding manual entry errors; linkage constructs the whole-process data linkage of "registration - testing - review - payment". For example, vehicle information filled in online by customers is automatically synchronized to testing equipment, testing data is automatically pushed to the review end, and review results are fed back to customers in real time. Digital processes can reduce the proportion of "non-testing time consumption" to below 15%, significantly improving the core work efficiency of personnel.

4.3. Technology Empowers Talent Upgrading and Builds a Skill Adaptation System

Digital transformation provides technical support for talent skill upgrading: on the one hand, VR/AR technology is used to build virtual testing training scenarios, allowing personnel to practice intelligent equipment operation in a simulated environment, reducing training costs and improving training effects; on the other hand, big data analysis is used to identify personnel skill gaps. For example, for personnel who frequently have abnormal testing data, special training courses are pushed to achieve "precision training"; at the same time, digital tools simplify complex operations. For example, the automatic calibration function of intelligent testing equipment reduces the difficulty of personnel operation,

enabling personnel with weak skill foundations to quickly get started and improving the operational capability of the entire team.

4.4. Intelligent Tools Replace Repetitive Labor and Release Human Value

The application of artificial intelligence and robot technology can replace repetitive labor in the testing process: intelligent guidance robots replace manual work to complete vehicle guidance and positioning, reducing the configuration of guidance personnel; AI visual recognition technology replaces manual work to complete vehicle appearance testing, improving recognition efficiency by 50%; automatic data review systems replace manual work to complete the preliminary review of testing reports, with a review accuracy rate of 99%. The replacement of repetitive labor frees testing personnel from tedious basic work, allowing them to focus on core work such as testing data anomaly analysis and complex fault diagnosis, realizing the upgrading of human value[8].

5. Path of Human Efficiency Improvement in Automotive Testing Enterprises Under the Background of Digital Transformation

5.1. Build a Digital Management Platform to Realize Precise Control of Human Efficiency

Taking "data-driven human efficiency management" as the core, build an integrated data middle platform covering business, personnel, and equipment. The data collection layer integrates various data from testing equipment, CRM systems, attendance systems, and training systems to achieve real-time data synchronization; the data processing layer cleans data through ETL tools (Extract, Transform, Load) to ensure data quality; the data application layer constructs a human efficiency analysis model and outputs core indicator dashboards such as daily per capita testing volume, efficiency per unit time, and skill matching degree, providing visual support for management decisions. For example, a chain testing enterprise found through the data middle platform that Wednesday and Saturday are peak testing hours, and adjusted personnel scheduling accordingly, increasing the daily per capita testing volume during peak hours by 25%.

Build a multi-dimensional performance evaluation system based on the data middle platform, with indicators covering four dimensions: "quantity (testing volume), quality (testing qualification rate, customer complaint rate), efficiency (testing volume per unit time), and innovation (number of data anomaly discoveries)", quantifying personnel performance through weighted scoring; at the same time, use data mining to identify personnel skill gaps. For example, through analyzing testing data and personnel operation records, it is found that a tester has a high error rate in the battery testing link, and a special battery testing training course is automatically pushed. Practice in a certain enterprise shows that this model increases the training return rate by 40% and the personnel testing qualification rate by 15%.

5.2. Reconstruct Digital Business Processes to Improve Collaboration Efficiency

Optimize the front-end customer service process: Develop a WeChat mini-program or APP for enterprises to realize

functions such as online customer appointment, pre-filling of vehicle information, pre-payment of testing fees, and electronic delivery of reports. After customers arrive at the store, they directly enter the testing link, reducing the time spent on manual registration; reconstruct the back-end testing process: Realize the seamless connection between testing equipment and management systems through IoT technology. After the vehicle enters the testing line, the equipment automatically reads the vehicle information, starts the corresponding testing items, and the testing data is uploaded to the system in real time without manual intervention; simplify the review and payment process: Adopt the model of AI review + manual recheck. The system automatically reviews the completeness and compliance of testing data, generates electronic reports automatically after passing the review, and customers can complete the process by paying online.

Break the departmental barriers between "testing department, customer service department, and technical department" through a digital platform, and establish a cross-departmental collaboration process: The customer service department synchronizes customer needs to the testing department in real time, the testing department synchronizes abnormal testing data to the technical department, and the technical department provides solutions and feeds them back to the testing department and customer service department, forming a closed loop of "demand - execution - feedback". For example, after a customer puts forward the demand for "new energy vehicle battery health testing", the customer service department triggers the task through the system, the testing department prioritizes arranging personnel with battery testing skills, and the technical department synchronously provides testing standards and anomaly handling guidelines, increasing collaboration efficiency by 60%.

5.3. Build a Digital Talent System to Realize Skill Upgrading

Construct a digital talent training system according to the needs of personnel in different positions and levels: For the basic operation layer (testers), focus on intelligent equipment operation and standardized data recording training, adopting the model of "VR simulation + practical operation training"; for the technical backbone layer (technical supervisors), focus on data anomaly analysis and equipment fault diagnosis training, inviting equipment manufacturers and university experts to give special lectures; for the management layer (store managers), focus on data-driven decision-making and digital team management training, improving management capabilities through case teaching and sand table simulation. At the same time, establish a "skill certification + incentive mechanism", providing salary increases and priority promotion for personnel who pass intelligent testing skill certification to stimulate learning motivation.

On the one hand, introduce interdisciplinary talents with "testing technology + data analysis" capabilities through campus recruitment and social recruitment. For example, cooperate with universities offering automotive testing majors to set up "digital testing orientation classes" to cultivate talents suitable for enterprise needs in advance; on the other hand, select outstanding internal employees to participate in the "digital skill improvement plan", cultivating internal interdisciplinary talents through rotation learning (testing department + data department) and project practice

(participating in the construction of digital platforms). Through this model, a certain enterprise increased the proportion of interdisciplinary talents from 10% to 35% and the utilization rate of testing data by 50%.

5.4. Deepen the Application of Intelligent Technology and Build a Human Efficiency Empowerment Closed Loop

Introduce intelligent testing equipment according to business needs, such as new energy vehicle battery testing systems, ADAS autonomous driving assistance system calibration equipment, and AI visual appearance testing equipment, realizing the collaboration of "automatic data collection by equipment - intelligent data analysis by systems - precise problem handling by personnel"; at the same time, install IoT modules for equipment to realize real-time monitoring of equipment operation status. When equipment malfunctions, the system automatically pushes early warning information to maintenance personnel, reducing equipment downtime and improving equipment utilization rate.

Closely combine the application of intelligent technology with the improvement of personnel efficiency to form a closed loop: Collect testing data and personnel operation data through intelligent equipment and digital platforms, and use big data analysis tools to identify key points for human efficiency improvement. For example, analysis finds that "personnel using AI-assisted testing have a 30% increase in efficiency per unit time", and thus promote AI-assisted testing tools; at the same time, optimize technology application through personnel feedback. For example, after testers propose the problem of "complex operation interface of intelligent equipment", the technical team simplifies the interface design to improve operational convenience. Through the two-way adaptation of technology and human resources, continuous optimization of human efficiency is realized.

6. Case Analysis: Practice of Digital Human Efficiency Improvement in An Automotive Testing Enterprise

6.1. Enterprise Overview

Enterprise A is a regional chain automotive testing enterprise with 10 testing stores and more than 200 employees. Before 2022, it mainly adopted the traditional testing model, with a daily per capita testing volume of 8 vehicles, a per capita output value of 180,000 yuan/year, and the proportion of intelligent testing business was less than 10%, facing problems of low human efficiency and high customer complaint rate. Starting from 2022, the enterprise launched digital transformation, focusing on human efficiency improvement to build solutions.

6.2. Measures for Digital Human Efficiency Improvement

Build an integrated data middle platform: Integrate testing data, personnel data, and customer data of 10 stores, develop a human efficiency management dashboard, and display core performance indicators of each store and each tester in real time; reconstruct business processes: Launch a customer appointment mini-program to realize the onlineization of testing processes, realize automatic synchronization of testing data through IoT technology, and cancel the manual data entry

link; build a digital talent system: Cooperate with local vocational colleges to carry out targeted training, offer intelligent testing courses, and carry out "skill competitions + certification incentives" activities internally; introduce intelligent equipment: Invest 5 million yuan to introduce battery testing systems, AI appearance testing equipment, etc., realizing the intelligence of core testing items.

6.3. Implementation Effects

After one year of digital transformation, the human efficiency of Enterprise A has been significantly improved: the daily per capita testing volume has increased from 8 to 16 vehicles, an increase of 100%; the per capita output value has increased from 180,000 yuan/year to 350,000 yuan/year, an increase of 94%; the testing cycle has been shortened from 60 minutes/vehicle to 25 minutes/vehicle, and the customer complaint rate has decreased by 70%; the proportion of intelligent testing business has increased to 45%, becoming a new profit growth point of the enterprise. This case verifies the feasibility and effectiveness of the human efficiency improvement path proposed in this paper.

7. Conclusion

Through research on human efficiency improvement in automotive testing enterprises under the background of digital transformation, this paper draws the following conclusions: Firstly, the current human efficiency management of automotive testing enterprises has problems such as rigid management models, low process collaboration efficiency, lagging talent skills, and superficial technology application, which are difficult to adapt to digital business needs; secondly, digital transformation provides support for breaking through

human efficiency bottlenecks through four mechanisms: data integration, process reconstruction, skill empowerment, and intelligent replacement; thirdly, automotive testing enterprises can achieve human efficiency improvement through four paths: building a digital management platform, reconstructing business processes, building a digital talent system, and deepening the application of intelligent technology.

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