

# Practical Dilemmas and Optimization Paths of Digital Employee Management for SMEs Under the Wave of Low-Carbon Transition

Zhengzhao Li <sup>1, \*</sup>

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**Abstract:** Against the backdrop of advancing “dual-carbon” goals and the digital economy’s deep penetration into industries, SMEs face dual pressures from green low-carbon transition and digital management reform. As a core driver of strategic delivery and organizational efficiency, the quality of digital transformation in employee management directly shapes low-carbon strategy execution outcomes, acting as a critical link between digital innovation and green production. From the coupled dual transformation perspective, this paper defines the core meanings of low-carbon transition and digital employee management, and clarifies their internal synergies. Given SMEs’ inherent limits—tight resources, weak management foundations, and talent shortages—it examines key practical hurdles in digital employee management, and proposes a multi-dimensional optimization framework covering strategy restructuring, capacity building, institutional innovation, digital enablement, and cultural development. The findings provide theoretical support and practical references for SMEs to deepen the integration of digital governance and low-carbon growth.

**Keywords:** Low-carbon transition; Digital employee management; Small and medium-sized enterprises; Green human resource management; Dual-carbon strategy

## Introduction

With the in-depth implementation of China’s carbon peaking and carbon neutrality goals, socio-economic development has entered a new phase of comprehensive green and low-carbon transformation. Low-carbon upgrading and green high-quality development have evolved from macro policy guidelines into fundamental operational principles for market entities across industries, becoming a core driving force for enterprises to break developmental bottlenecks and build long-term competitive advantages. Meanwhile, the iterative upgrading of emerging digital technologies including big data, artificial intelligence, and cloud computing has continuously reshaped corporate production paradigms, governance systems, and human resource management models. Digital transformation has emerged as a pivotal strategic choice for enterprises to address market uncertainties and achieve sustainable high-quality development[1].

As the cornerstone of national economic development, SMEs dominate industrial low-carbon upgrading and digital innovation due to their large quantity and extensive industrial coverage. The low-carbon and digital transformations of SMEs are not independent evolutionary processes but mutually infiltrating, restrictive, and coordinatively coupled developmental mechanisms. As micro-level practitioners of corporate production, technological innovation, and strategic implementation, employees constitute the fundamental human support for dual transformations. Their environmental awareness, digital literacy, and professional operational competencies directly determine the effectiveness of corporate low-carbon production and the maturity of digital management systems.

The superimposed dual transformation scenario has triggered fundamental changes in the connotation, boundary, and value orientation of corporate employee management. On the one hand, low-carbon transition compels enterprises

<sup>1</sup> Hainan College of Vocation and Technique, Haikou 570216, China.

\* Corresponding author. Email: [741790987@qq.com](mailto:741790987@qq.com).

to abandon extensive traditional management paradigms and integrate green emission reduction and low-carbon conservation concepts into daily job practices, so as to cultivate a new workforce equipped with environmental awareness, low-carbon operational capabilities, and green innovative thinking. On the other hand, digital transformation enables human resource management to break away from empirical and labor-intensive traditional modes and evolve toward data-driven, intelligently empowered, and refined modern governance, realizing full-process digitalization in talent recruitment, on-the-job training, performance appraisal, incentive mechanism design, and talent retention[2].

Restricted by inherent limitations such as insufficient capital investment, weak technological foundations, talent shortages, and imperfect institutional systems, most SMEs only conduct superficial digital employee management construction, which fails to adapt to the practical requirements of low-carbon transformation. These deficiencies give rise to numerous managerial bottlenecks that hinder the high-quality green and digital development of SMEs. Existing academic studies have extensively explored the human resource empowerment effects of corporate digital transformation[3][4] and the influencing factors and practical outcomes of green human resource management[9]. Nevertheless, systematic research focusing on the adaptability dilemmas and operational obstacles of digital employee management in the specific context of low-carbon transition remains insufficient, and studies on the coupling mechanism and collaborative governance paths of dual transformations are still incomplete. Although prior literature has discussed human resource planning issues in the digital transformation of SMEs[1], the in-depth coupling logic between digital upgrading and low-carbon development has not been fully explored. On this basis, this study targets the operational characteristics of SMEs, systematically sorts out practical dilemmas of digital employee management under dual transformations, and constructs feasible optimization paths to fill existing research gaps and provide practical strategies for SMEs to achieve coordinated green and digital transformation.

## Concept Definition and Logical Correlation

### Core concept definition

Corporate low-carbon transformation refers to systematic and profound institutional and operational reforms initiated by enterprises to respond to national dual-carbon policies and adapt to green industrial upgrading. By optimizing energy consumption structures, renovating production processes, adopting energy-saving and low-carbon technologies, adjusting operational management modes, and reconstructing industrial value chains, enterprises can shift from high-energy, high-emission extensive production to intensive, refined, low-carbon, and eco-friendly development, ultimately achieving coordinated progress in economic, social, and ecological benefits. For SMEs, low-carbon transition is not a single emission-reduction behavior but an all-round

upgrading covering production, management, talent cultivation, and corporate culture.

Digital employee management represents an innovative human resource management paradigm in the digital economy era. It refers to the standardized and intelligent operation of full-cycle human resource management processes, including employee information collection, vocational training, performance evaluation, salary accounting, talent development, and employee relationship maintenance, based on digital technologies and intelligent management platforms. Its core essence lies in restructuring traditional human resource workflows with data as the core production factor, eliminating efficiency bottlenecks and decision-making biases caused by manual management, and realizing precise allocation, efficient governance, and scientific empowerment of human resources. As a key component of corporate digital transformation, it lays a solid foundation for the digital upgrading of SMEs[2].

### Internal correlation between low-carbon transition and digital employee management

Low-carbon transformation and digital employee management feature in-depth symbiosis and two-way empowerment, forming an inseparable interactive relationship that jointly supports the high-quality development of SMEs (**Figure 1**).

First, the two strategies share highly coordinated developmental goals. The implementation of low-carbon strategies relies on dual driving forces of technological innovation and organizational reform, and both green technological upgrading and organizational green governance optimization require the support of high-quality interdisciplinary talents. Through systematic talent cultivation, precise human resource allocation, and standardized institutional incentives, digital employee management integrates scattered individual human capital into corporate organizational innovation capacity and green development competitiveness, providing solid human resource guarantees for the implementation of low-carbon strategies.

Second, the implementation of the two transformations is mutually dependent. The refined advancement of corporate low-carbon transition requires real-time energy consumption monitoring, accurate carbon accounting, and dynamic emission reduction effect tracking, all of which rely on digital data collection and analytical capabilities[8]. Digital employee management provides standardized and systematic human resource data support for low-carbon transformation, enabling quantitative measurement, real-time tracking, and targeted optimization of employees' low-carbon work behaviors, thereby resolving the fuzziness and extensiveness of traditional green management modes.

Third, the two mechanisms shape employee behaviors bilaterally. The ultimate realization of low-carbon production depends on employees' active participation in operational practices, technological innovation, and daily management. Digital management tools strengthen employees' green work behaviors through real-time data feedback, visu-

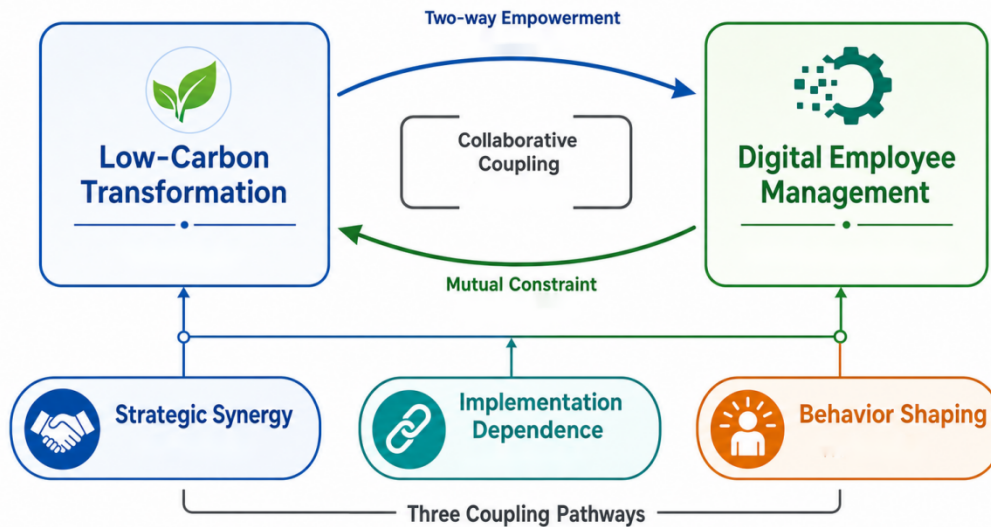


**Figure 1 | Conceptual Framework Diagram**

alized performance presentation, and personalized incentive guidance, promoting the transformation of low-carbon concepts from institutional constraints to conscious employee behaviors. Meanwhile, the green development orientation of low-carbon transition drives employees to upgrade their professional green competencies, which in turn promotes the iterative optimization of corporate digital employee management systems.

The superimposed scenario of dual transformations endows digital employee management in SMEs with new developmental characteristics. First, the management goals are dual-oriented, balancing operational efficiency improvement through digital governance and ecological value empowerment for green low-carbon development. Second, the management subjects are compounded, as employees act as both managed objects and innovative subjects of green and digital transformation with dual attributes of passive management and active innovation[6]. Third, the evaluation system is diversified, replacing the single economic benefit evaluation model with a three-dimensional assessment framework covering economic, social, and ecological values to comprehensively measure employees' job value. These characteristics bring more complex operational challenges to digital employee management compared with traditional single-scenario governance.

## Practical Dilemmas of Digital Employee Management Under Low-Carbon Transition

### Vague strategic positioning and incomplete top-level planning

Most SME managers hold biased perceptions of digital employee management, simply equating it with basic digital tools such as online attendance, electronic file entry, and office informatization. They regard digital upgrading merely as a cost-saving and efficiency-improving auxiliary means for human resource work, ignoring its strategic supporting value for corporate low-carbon transformation. Few enterprises incorporate digital employee management into the overall strategic layout of low-carbon and digital upgrading, resulting in separated and disjointed advancement of the two transformations without unified top-level design and systematic implementation plans.

Cognitive limitations of management teams lead to fragmented, short-sighted, and arbitrary digital human resource construction. The scattered investment of digital resources and unsystematic layout of tool selection, system construction, and talent training hinder coordinated development. Additionally, most SMEs hold a wait-and-see attitude toward dual transformation, worrying about the capital cost and trial-and-error risks of integrated digital and low-carbon reform, which reduces their initiative in transformation[1]. This passive state makes digital employee management unable to match the pace of low-carbon upgrading and restricts its empowering effect on corporate green development.

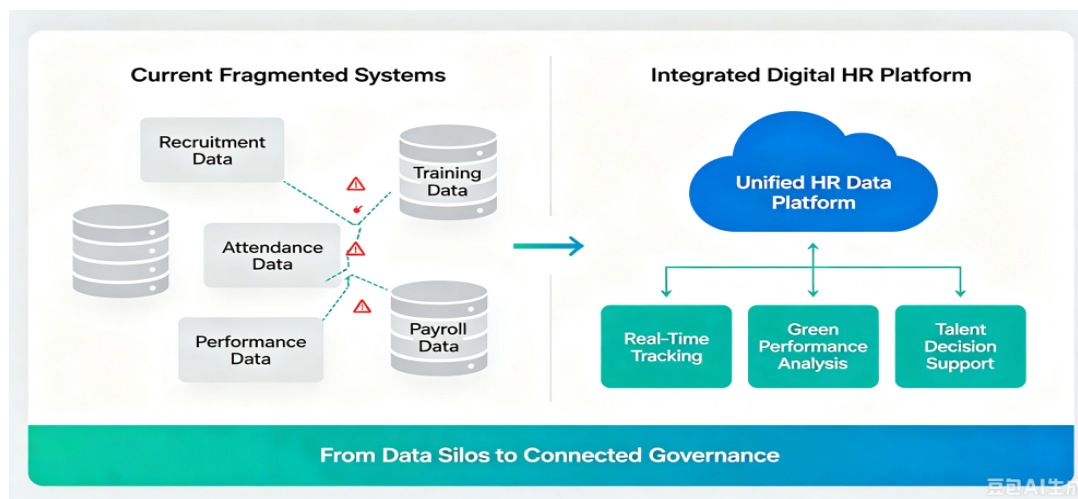


**Figure 2 | Diagram of the Fragmented State of Digital Management Systems**

### Significant skill gaps and insufficient interdisciplinary talents

Dual transformation raises interdisciplinary and diversified competency requirements for enterprise employees, who are expected to possess both digital operation and data analysis capabilities and professional knowledge in low-carbon production, emission reduction, and environmental governance. However, SMEs are currently facing prominent talent shortages and skill mismatches that restrict dual transformation progress.

On the one hand, limited by inadequate salary levels, narrow development platforms, and weak brand influence, SMEs struggle to recruit high-end interdisciplinary talents with both digital literacy and green professional capabilities, resulting in insufficient external talent introduction channels. On the other hand, the internal talent structure of SMEs is unreasonable: older employees have low acceptance and weak operational ability of digital tools, while young employees with basic digital skills generally lack professional low-carbon and green management knowledge. Furthermore, constrained by insufficient training funds and professional teachers, SMEs cannot establish systematic and normalized training systems. The single and rigid existing training modes fail to make up for employees' dual deficiencies in digital and green competencies, resulting in low talent cultivation efficiency[5] and hindering the implementation of digital management and the promotion of low-carbon technologies.

### Backward assessment system and absent green incentive mechanisms

Performance appraisal and incentive systems are core institutional tools to guide employee behaviors and implement corporate strategies. Low-carbon transformation requires enterprises to incorporate ecological performance and green contribution into employee evaluation systems to

form long-term standardized guidance for green work behaviors. Nevertheless, most SMEs still adopt traditional performance appraisal modes that focus excessively on output, operating performance, and financial indicators while neglecting green dimensional assessments including carbon emission reduction, energy conservation, green innovation, and environmental compliance.

Although a small number of SMEs with ESG layouts have begun to count corporate-level energy consumption and carbon emission data, they fail to decompose macro green development goals into personalized job indicators, leading to disconnection between corporate green performance and individual employee performance[8]. The imperfect green assessment system and missing incentive mechanisms make employees' low-carbon behaviors unrecognized and unrewarded, resulting in insufficient internal motivation for active green production and low-carbon innovation. Meanwhile, managers cannot identify human resource allocation defects and job emission reduction loopholes through assessment data, which deprives the performance evaluation system of its diagnostic, optimizing, and guiding functions and impedes the refined advancement of corporate low-carbon transformation.

### Inadequate system integration and severe data island problems

The core value of digital employee management lies in realizing precise human resource allocation and strategic empowerment through integrated analysis of full-scenario human resource data, which relies on effective system integration and data interconnection. However, the digital construction of SMEs is generally disorderly and fragmented. Independent digital systems are adopted for recruitment, training, attendance, performance, salary, and employee file management, with inconsistent statistical standards and incompatible data ports, resulting in isolated data resources.

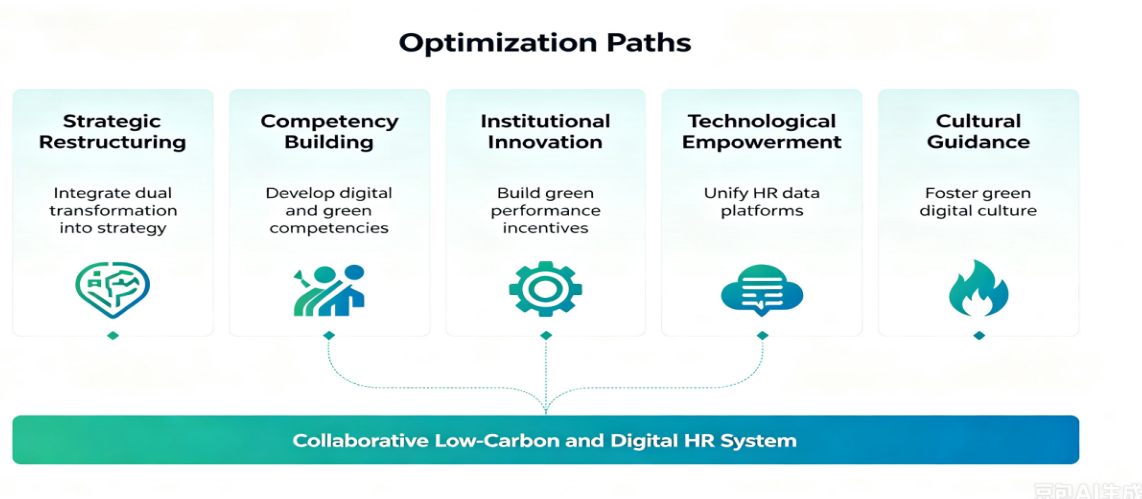


**Figure 3 | Multidimensional Optimization Path Model Diagram**

This fragmented construction mode causes repetitive data entry, redundant workflows, and low managerial efficiency. More importantly, enterprises cannot integrate employees' full-life-cycle job data to accurately evaluate the low-carbon competency and transformation adaptability of different posts and employees. In addition, the lack of professional data governance capabilities leads to low accuracy, timeliness, and validity of collected data, which further weakens data analytical value and fails to provide reliable data support for talent allocation, post optimization, skill training, and performance improvement in low-carbon transformation. (Figure 2)

### **Imbalanced humanistic value and hidden risks of rigid digital governance**

Digital governance improves the standardization and efficiency of employee management through quantitative indicators, intelligent algorithms, and full-process tracking, but it also brings risks of utilitarian and rigid management. Many SMEs over-rely on digital management tools, judging employee work value solely through quantitative data while ignoring post differences, job particularities, and employees' emotional needs, which weakens the humanistic attribute of human resource management.

In the low-carbon transformation scenario, green production optimization, low-carbon technological innovation, and energy-saving scheme improvement require employees' active exploration and independent innovation with high flexibility and subjectivity. However, the rigid digital management mode overemphasizes quantitative assessment and process constraints, inhibiting employees' subjective initiative and innovative enthusiasm. This easily triggers employee resistance and reduces their organizational identity and sense of belonging[4], hindering the progress of corporate green transformation and leading to a management dilemma of "efficiency improvement accompanied by talent loss".

## **Optimization Paths of Digital Employee Management Under Low-Carbon Transition (Figure 3)**

### **Strategic restructuring: Coordinate dual transformations and improve top-level design**

SMEs must abandon the fragmented and tool-oriented cognition of digital management and elevate digital employee management to a core strategic position coordinating digital upgrading and low-carbon transformation. The two transformations should be planned, deployed, and promoted synchronously. Enterprise managers need to fully recognize the integrated development trend of digital and green economies, clarify the organizational empowering value of digital employee management for low-carbon strategy implementation, and formulate phased and operable digital human resource upgrading roadmaps in accordance with industrial attributes, production characteristics, and low-carbon development goals.

Meanwhile, enterprises should establish special promotion teams composed of management, technical, human resource, and production personnel to coordinate system selection, talent allocation, capital investment, and institutional optimization. Breaking inter-departmental barriers and avoiding repetitive construction and resource waste can realize the high adaptation of digital employee management to low-carbon transformation, consolidating the organizational foundation for coordinated dual upgrading.

### **Competency building: Cultivate interdisciplinary talents to consolidate transformation foundation**

To address the shortage of interdisciplinary talents, SMEs should build a dual talent development system integrating external introduction and internal cultivation to comprehensively improve employees' digital literacy and green professional capabilities. In terms of internal training, enterprises should reconstruct the training system by incor-

porating digital tool operation, basic data analysis, low-carbon production technology, energy-saving management knowledge, and green innovative thinking into regular training courses. Diversified training modes including online micro-lessons, live teaching, offline practical training, and mentor-mentee pairing can reduce training costs, expand coverage, and meet the personalized learning needs of employees[5,6].

In terms of external talent introduction, enterprises should precisely recruit professionals in digital human resource management, green production technology, and carbon accounting according to dual transformation needs to optimize the talent structure. A hierarchical talent development mechanism should be established to formulate differentiated digital and green competency improvement plans for ordinary employees, technical backbones, and managers, forming a well-structured interdisciplinary talent echelon. Moreover, SMEs can make full use of government support policies and third-party training resources to carry out low-cost special skill training and make up for internal training deficiencies.

### **Institutional innovation: Construct green performance systems and strengthen incentive guidance**

SMEs need to systematically reform traditional performance appraisal and incentive systems to build a green-oriented, multi-dimensional, and well-regulated modern management system. On the one hand, enterprises should optimize the performance indicator system, break the single economic assessment orientation, and add targeted green indicators such as carbon emission control, energy conservation, green process optimization, low-carbon innovation proposals, and environmental compliance according to job characteristics. Refining quantitative standards, accounting methods, and assessment cycles can realize full quantification and tracking of employees' green job behaviors, decomposing corporate macro low-carbon goals into micro job tasks[8].

On the other hand, supporting incentive mechanisms should be improved by linking green performance appraisal results directly with salary distribution, promotion, evaluation, and further training. Special incentives such as low-carbon innovation bonuses, energy-saving rewards, and green model employee honors should be set to mobilize employees' initiative in green production and innovation through a combination of material and spiritual incentives. Balanced weighting of economic and green performance can avoid behavioral deviations caused by single-indicator orientation and promote the internalization of green concepts in daily job practices.

### **Technological empowerment: Break data barriers and release data value**

Considering the capital and technical constraints of SMEs, digital management system integration and upgrad-

ing should be promoted gradually to eliminate data islands and realize full-scale data interconnection. SMEs can prioritize lightweight, low-cost, and easy-operating SaaS cloud platforms to integrate recruitment, training, performance, salary, and employee file management, building an integrated digital human resource system. Unified data standards and interface specifications can realize real-time data synchronization, reduce manual repetitive work, and improve refined management efficiency[2,7].

Furthermore, enterprises should establish standardized data management mechanisms for regular data verification, updating, and maintenance to ensure data authenticity and integrity. Big data analysis technology can be adopted to deeply mine employees' digital skills, green performance, post adaptability, and training effects, so as to accurately identify talent deficiencies, managerial loopholes, and transformation weaknesses. The analytical results can provide scientific data support for talent allocation, targeted training, performance optimization, and post adjustment. Meanwhile, enterprises should adhere to humanistic management principles, standardize data collection and application scope, protect employee privacy, and balance digital efficiency and humanistic care[4].

### **Cultural guidance: Shape dual-dimensional culture and consolidate transformation consensus**

Organizational culture serves as the core soft power for corporate transformation and the spiritual support for the integration of digital employee management and low-carbon development. SMEs should foster a synergistic cultural atmosphere of digital innovation and green low-carbon development to unify employees' ideological understanding of transformation. On the one hand, enterprises should popularize dual-carbon policies and green production knowledge through regular publicity, case sharing, energy-saving activities, and knowledge competitions, integrate low-carbon values into corporate development missions and employee behavioral norms, and guide employees to form green development recognition and conscious low-carbon work habits.

On the other hand, an inclusive digital innovation culture should be cultivated to eliminate employees' resistance to digital reform. Enterprises should encourage employees to actively learn digital skills, optimize production processes through digital tools, improve energy-saving technologies, and participate in digital and green innovative practices. Cultural infiltration can make efficient digital management and green low-carbon development the universal consensus and conscious behavior of all employees, realizing the deep integration of institutional constraints, technological empowerment, and cultural guidance.

## Conclusion

Under the integrated development of dual-carbon strategy and digital economy, the upgrading of digital employee management is an inevitable choice for SMEs to break human resource bottlenecks and achieve high-quality low-carbon development. The optimization of digital employee management can activate corporate human resource value, promote the implementation of green concepts, the iteration of green technologies, and the upgrading of green production, acting as a core bridge connecting digital innovation and low-carbon development. This study systematically summarizes five core dilemmas of digital employee management for SMEs under dual transformations and constructs a comprehensive and operable optimization system from strategic, talent, institutional, technological, and cultural dimensions based on SME operational characteristics.

The research concludes that the optimization of digital employee management in SMEs is not a simple technical upgrade but a systematic and collaborative reform covering strategic cognition, talent competency, institutional mechanism, digital technology, and organizational culture. Only by coordinating multi-dimensional improvements can the green empowering value of digital management be fully released to support the synergistic development of digitalization and low-carbon transformation in SMEs.

This study adopts qualitative theoretical analysis and literature review methods, lacking empirical data verification on the influencing effects and practical outcomes of digital employee management. Future research can select SMEs in specific industries and regions as research samples to quantitatively analyze the influencing mechanism of digital employee management on low-carbon transformation performance through questionnaires and empirical tests. Targeted optimization schemes can be formulated according to the differentiated characteristics of enterprises of different scales and industries, providing more operable theoretical support for the coordinated implementation of dual transformations.

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