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# Digital Transformation of Foreign Language Education: Elements, Challenges, and Pathways

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***Abstract:*** *In the era of artificial intelligence, the digital transformation of foreign language education constitutes, in essence, a systematic restructuring of teaching objectives, processes, resources, and ecosystems, driven by data and underpinned by intelligent technology. Its core manifestations involve a triple transformation: human-machine collaborative teaching agents, multi-modal physical-virtual integrated resource platforms, and the dynamic competency mapping assessment paradigm. This research reveals significant structural contradictions confronting the transformation: compatibility challenges between technological applications and the highly interactive nature of foreign language learning, equity crises arising from digital literacy disparities, the cognitive dissolution of language learning objectives by generative artificial intelligence, and a theoretical void regarding the digital adaptation of its inherent humanistic attributes. This study posits that resolving these challenges necessitates multi-dimensional collaboration. Proposed pathways include: constructing a data-driven Intelligent Resource Analysis System (IRAS) and an Embedded Assessment Framework (EAF); developing integrated physical-virtual intelligent spaces to bridge teaching and research synergies; establishing a tiered system for advancing teacher digital literacy; and designing a closed-loop governance mechanism based on "data collection-diagnosis-intervention-iteration". This study proposes both a theoretical reference and practical paradigms for building a resilient digital ecosystem for foreign language education*

**Keywords—foreign language education; educational digitization; educational ecosystem; digital literacy; intelligent technology**

## 1. INTRODUCTION

The deep integration of disruptive technologies, including artificial intelligence, big data, and cloud computing, has propelled the global digital transformation of education from conceptual exploration into a new phase of systemic restructuring. As a frontier domain for fostering cross-cultural competencies, foreign language education (FLE) is undergoing a profound transformation driven by the dual imperatives of "technological empowerment" and "paradigm shift". UNESCO 2021 emphasizes that digital technologies will reshape the modes of knowledge delivery, the spatio-temporal boundaries of education, and assessment mechanisms. Against this backdrop, FLE necessitates the construction of a new ecosystem characterized by "human-machine symbiosis, integration of virtual and real contexts, and the unity of learning and application" through the digital reengineering of teaching elements, resource formats, and evaluation systems (Shu et al., 2023). Existing research indicates that digital transformation manifests not merely as the integration of technological tools, but as a systemic innovation impacting educational objectives, teacher roles, curriculum content, and managerial frameworks (Kukulska-Hulme & Viberg, 2020). At its core lies learner-centered, data-driven personalized learning (Sajja et al., 2025). Consequently, clarifying the intrinsic coupling mechanism between technological logic and educational principles during the transformation process has become a prerequisite for constructing a modern foreign language education system.

Nevertheless, numerous structural tensions within this transformational process require urgent resolution. On the one hand, the ideal prospects of technological empowerment face practical challenges: uneven distribution of digital infrastructure exacerbates disparities in FLE between urban and rural areas (Shortt et al., 2023); deficiencies in teachers' digital literacy diminish the efficacy of technology integration (Hockly, 2021); and ethical risks precipitated by generative artificial intelligence pose significant challenges to traditional assessment systems. On the other hand, theoretical advancement lags behind practical developments. Existing research predominantly focuses on isolated cases of technology application, lacking systematic deconstruction of the transformational elements and dynamic adjustments in pathway design (Mesenhöller, 2025). Particularly noteworthy is the absence of an effective theoretical paradigm for the digital adaptation of FLE's inherent humanistic dimensions, such as cultural dissemination and affective interaction (Bendoly & Oliva, 2025). In light of this, the present study focuses on three core dimensions: first, deconstructing the constituent elements of FLE digital transformation and their interactive relationships; second, elaborating the practical dilemmas encountered in this transformation; and finally, designing implementation pathways that balance

technological potential with educational essence. The aim is to provide theoretical support for constructing an open, resilient, and sustainable ecosystem for digital foreign language education.

## 2. The Connotation and Driving Factors of Digital Transformation in FLE

### 2.1 The Connotation of Digital Transformation in FLE

The digital transformation of foreign language education refers to a profound process of systemic reform, driven primarily by data and leveraging new-generation information technologies such as artificial intelligence, big data, and cloud computing (Jiang, 2025). This transformation fundamentally restructures the foreign language teaching process, resource modalities, evaluation mechanisms, and the educational ecosystem. Its essence transcends the mere superimposition of technological tools. Instead, it represents a strategic upgrade in language knowledge delivery models, intercultural competency cultivation systems, and self-acquisition mechanisms, achieved through the mutual empowerment of technology and pedagogy (Alsaleh, 2024).

From an elemental perspective, this transformation encompasses three core dimensions. (1) Instructional Agency: A shift from "teacher-centered" instruction to human-machine collaboration. Intelligent tutoring systems and teachers form dual instructional forces, with personalized learning pathway design replacing standardized course delivery. (2) Resource Mediums: An evolution from print textbooks to a multimodal digital landscape. Immersive language application environments are constructed leveraging virtual simulation scenarios and social learning platforms. (3) Evaluation Paradigms: A move away from summative testing towards dynamic competency mapping. Learning analytics technologies continuously track microdata concerning speech production, pragmatic errors, and interaction strategies, generating learner digital profiles to drive precise intervention.

This process signifies the profound deconstruction and reconfiguration of traditional language education paradigms (Higgs, 2003). Its core objective is to establish a new educational ecosystem centered on the development of learner digital literacy. Examined philosophically, the digital transformation marks a fundamental shift in the axiological logic of foreign language education. The transmission of knowledge gives way to cognitive empowerment, and language skill training evolves into the cultivation of intercultural digital citizens (McMyler, 2022). This concretion manifests as a reconstruction of threefold value. (1) In knowledge provision, ubiquitous learning networks, unrestricted by time and space, dissolve the traditional classroom's knowledge monopoly. Knowledge acquisition shifts from passive reception to on-demand activation. (2) In competency development, deep learning models supported by intelligent corpora drive the acquisition of language rules from explicit memorization to implicit construction. Intercultural interaction competence achieves embodied experience through contextual dialogues with social chatbots. (3) In educational rrelationships, both teachers and students become co-producers of digital knowledge — teachers evolve into wisdom-based curriculum designers and builders of cognitive scaffolding, while learners, empowered by tools like intelligent writing assistants, become creators of linguistic digital artifacts.

Ultimately, this transformation culminates in a new educational philosophy characterized by Digital Resilience (Salimova et al., 2025). It entails reshaping the essential function of foreign language education in cultural dissemination through a dynamic equilibrium between technology and humanity. Its profound nature extends far beyond the superficial application of technology, constituting, in essence, a paradigm shift in language education philosophy for the era of information civilization.

### 2.2 Driving Forces for the Digital Transformation of FLE

The digital transformation of foreign language education represents a systemic leap driven by a confluence of three-dimensional kinetic forces: technological revolution, institutional change, and societal demand.

The Technology Enablement Dimension constitutes the foundational driving force. AI-driven natural language processing (NLP) technologies have fundamentally reconfigured language learning interfaces, enabling precision pedagogy such as real-time grammatical correction, contextualized dialogue simulation, and training in cross-cultural pragmatic strategies. Big data learning analytics capture learners' digital traces (e.g., eye-tracking foci, interaction response latency) to construct individualized language proficiency development profiles, forming the algorithmic core for adaptive learning systems. Meanwhile, cloud computing and 5G technologies underpin ubiquitous learning environments, facilitating distributed collaborative language practice that transcends physical spatial constraints. Crucially, intelligent technologies are evolving from auxiliary tools into integral pedagogical structural elements.

The institutional regulation and demand transformation dimensions form a bidirectional driving mechanism (Peng et al., 2026). On one hand, policy frameworks like the Education Informatization 2.0 Action Plan and the Action Plan for Promoting Digital Education mandate the establishment of national standards for digital resources in foreign language education, linking language course accreditation to digital literacy metrics. Concurrently, the rollout of educational "New Infrastructure" projects (e.g., the National Smart Education Platform) necessitates a fundamental restructuring of traditional foreign language teaching systems. On the other hand, Globalization 4.0 is precipitating distinctive shifts in the language demands of digital natives. The proliferation of cross-cultural virtual collaboration scenarios, the need for Industry-Specific Purposes Language (LSP) powered by intelligence, and the demand for critical discourse analysis skills tied to digital citizenship collectively catalyze a

paradigm shift in foreign language education objectives towards "Digital Intercultural Competence" (DIC).

A more fundamental driving force stems from the redefinition of the teaching-learning relationship (Chen & Murray, 2025). Educators must transform into "digital curators", as exemplified by Cambridge English's teacher data analytics dashboards that integrate course design, learning alerts, and teaching reflection. Learners, conversely, gain access to lifelong language development ecosystems through intelligent tutoring systems. This reconstruction of pedagogical core values within the digital realm signifies that the driving forces have deepened beyond technological application to a level of educational philosophy transformation.

## 3. The Real-World Dilemmas of Digital Transformation in FLE

While digital transformation in foreign language education currently progresses with considerable momentum, it remains deeply constrained by a core contradiction: a fundamental decoupling between technological application and pedagogical practice (Yu & Liu, 2026). This disjunction is most prominently manifested in the poor compatibility between digital technologies and the inherent mechanisms of foreign language teaching and learning. A pervasive phenomenon within many institutions is the prioritization of infrastructure over empowerment—significant investments are made in smart platforms and VR/AR equipment, yet the underutilization of these technological tools persists due to inadequate teacher training on technology integration and the absence of targeted programs to enhance the digital literacy of both instructors and students.

A more profound issue lies in the design logic of many digital tools, which frequently fails to adequately incorporate the core, discipline-specific characteristics of foreign language acquisition. This includes the essential need for high-context interaction and the negotiation of meaning. While tools such as automated scoring systems or grammar checkers may offer efficiency gains in discrete areas, they often fall short of supporting the development of situated communicative competence, which necessitates immersive cultural understanding and the cultivation of social presence.

Furthermore, the dissonance between traditional standardized testing frameworks and the evolving standards for assessing technology-mediated competencies impedes the deeper integration of digital pedagogies. Instructors are frequently compelled to make pragmatic compromises between cultivating digital literacies and meeting the demands of conventional high-stakes assessment regimes.

Beyond technological support, the digital transformation of foreign language education faces significant systemic ecosystemic challenges. Foremost among these are technology ethics concerns: the extensive collection of learning data involves sensitive language trajectory privacy, while its transnational processing raises complex issues of data sovereignty and compliance with cross-border data flow regulations. Concomitantly, automated assessment algorithms reliant on training data risk exacerbating linguistic evaluation biases or marginalizing non-mainstream learning styles if they lack transparency or are not built with inclusive design principles.

Secondly, the digital divide presents a renewed barrier to educational equity. Weak foundational network coverage and shortages of electronic devices in underdeveloped regions restrict access to high-quality resources like holographic conversational practices, thereby exacerbating regional imbalances in educational resource allocation.

More fundamentally challenging to the discipline itself is the reconceptualization pressure exerted by artificial intelligence, particularly large language models (LLMs), on the very nature of language learning objectives: When highly accurate, real-time machine translation becomes readily available, the urgency and unique value ascribed to cultivating cross-cultural communicative competence risk being undermined, leading to cognitive dissonance regarding educational goals (Siu, 2024). Should these systemic dilemmas remain unresolved, the digitalization of foreign language education risks becoming confined to superficial instrumental upgrades, ultimately failing to achieve the substantive pedagogical innovation, enhanced quality and efficiency demanded by the core aims of language education.

## 4. Pathways for the Digital Transformation of FLE

### 4.1 Optimizing Resource Analysis and Evaluation Methods

The core imperative of digital transformation in foreign language education lies in reforming the educational resource system and its evaluation paradigm through data intelligence. Traditional resource allocation, reliant on experiential decision-making and static evaluation criteria, struggles to dynamically capture the differentiated needs of teachers and students. Within the digital context, it is necessary to establish an Intelligent Analysis System (IAS) integrating learning behavior tracking, competency model profiling, and resource feature annotation. Leveraging big data mining technologies, this system enables fine-grained diagnostics of students' multi-dimensional language competencies (e.g., grammatical accuracy, pragmatic fluency, intercultural sensitivity). Concurrently, it applies knowledge graph technology to deconstruct the cognitive complexity and skill orientation of resources (e.g., textbooks, MOOCs, corpora), constructing a Resource-Competency Mapping Matrix. Empirical studies indicate that intelligent graded reading platforms based on natural language processing (NLP) can adaptively tailor learning materials for learners at different CEFR (Common European Framework of Reference for Languages) levels by dynamically adjusting text difficulty coefficients (such as vocabulary recurrence rates and syntactic complexity) (Yuan, 2025). Such "Data-Driven Resource Allocation Mechanisms"

not only optimize resource distribution efficiency but also liberate teachers from laborious manual screening, shifting their focus towards personalized instructional design and decision support.

The establishment of a dynamic assessment framework constitutes a pivotal fulcrum for bi-directional transformative innovation in both teaching and learning. The singular benchmark of traditional summative assessments fails to accommodate the demands for cultivating diverse competencies in the digital era, necessitating the implementation of an Embedded Assessment Framework (EAF). This framework integrates formative assessment within learning scenarios such as virtual simulation dialogues, AI-powered writing feedback systems, and multimodal tasks, generating individual competency progression heatmaps through continuous data streams (Heitink et al., 2016). Taking an intelligent spoken language training platform as an example, it synthesizes speech recognition and discourse analysis modules to provide real-time feedback on learners' prosodic accuracy, turn-taking competence, and pragmatic strategy application levels, while generating visual progress reports. Research demonstrates that such immediate feedback mechanisms can significantly shorten the training cycle for oral fluency (Qun, 2025). Simultaneously, the system conducts multi-dimensional attribution analysis—incorporating metrics such as resource usage frequency, interaction satisfaction, and goal achievement rates—to form a closed-loop resource iteration mechanism. This could entail dynamically optimizing grammar micro-lesson repositories based on error-clustering analysis or augmenting virtual immersive scenarios according to identified cultural cognition gaps. This approach serves the dual purpose of enabling students to access precisely targeted learning scaffolds on demand and empowering teachers to engage in pedagogic reflection and resource reorganization based on evidence chains. Ultimately, an individualized empowerment loop, integrating assessment, resources, and teaching into a triadic framework, is established.

### 4.2 Increasing Investment in Intelligent Application within Learning Ecologies

The deep-seated development of digital transformation in foreign language education necessitates the reconstruction of intelligent learning ecologies as its physical substrate. The inherent spatio-temporal constraints of traditional classrooms and their unidirectional resource dissemination model are inadequate platforms for emerging digital pedagogies, necessitating the establishment of an intelligent ecological system integrating physical space, virtual environments, and data interaction. This ecosystem leverages Internet of Things (IoT) sensing technologies (e.g., eye-tracking, voice localization) to capture learner behavior data in real-time, augmented by Augmented Reality (AR) to establish immersive cultural contexts, thereby anchoring language skill development within authentic communicative scenarios. We can consider the "digital twin system" of an intelligent language lab: utilizing a distributed sensor matrix, it synchronously records discourse strategies, non-verbal communication cues, and affective state fluctuations during group collaboration, generating dynamic interactional maps (Segovia & Garcia-Alfaro, 2022). Such intelligent practices within these ecologies not only enhance learners' situated linguistic competence but also precipitate vast databases documenting pedagogical processes, furnishing empirical research with primary evidence. Hardware investments must align with human-centered design principles to eschew technological determinism—for example, preserving nodes for teacher affective mediation intervention in Mixed Reality (MR) conversation training, thereby maintaining a dialectical synthesis between technological empowerment and humanistic care.

The core value of intelligent ecologies lies in forging a bidirectional channel empowering both teaching practice and academic research. Current foreign language pedagogy research is often hindered by contextual fragmentation—leading to the "laboratory effect" dilemma—whereas embedded intelligent systems enable a symbiotic "teaching-as-research" mechanism. Based on real-time databases from learning ecologies, attribution models correlating teaching behaviors with learning outcomes can be established: (1) Employing Natural Language Processing (NLP) to analyze classroom discourse, identifying teacher move patterns that facilitate higher-order critical thinking development; (2) Utilizing Social Network Analysis (SNA) to decode meaning negotiation pathways in online collaboration, quantitatively validating the efficacy of Task-based Language Teaching (TBLT) implementation (Farhood et al., 2025).

Such empirical evidence enables both the immediate refinement of pedagogical strategies and the iterative enhancement of theoretical innovation, thereby reconstructing explanatory frameworks for language acquisition mechanisms in the digital era. Concurrently, establishing a "Teaching-Research Coordination Platform" is critical: instituting the teacher-researcher role, developing low-code educational data mining toolkits, and supporting frontline teachers in conducting evidence-based classroom Action Research. This culminates in an upward-spiraling cycle of "practice-driven problem → data collection → theoretical refinement → strategy iteration", thereby fully activating the sustainable developmental momentum intrinsic to the integration of teaching and research.

### 4.3 Enhancing Teachers' Digital Literacy

Teachers serve as the core engine and key practitioners in the digital transformation of foreign language education (McCarthy et al., 2023). Their level of digital literacy directly impacts the implementation of digitally enhanced teaching philosophies, the effective application of technological tools, and the profound restructuring of teaching models. Enhancing the digital literacy of foreign language educators necessitates, first and foremost, the construction of a systematic, tiered, and sustainable professional development framework. This requires integrating multi-stakeholder resources (government,

universities, industry, technology platforms) to design progressive training curricula that blend the specific characteristics of foreign language disciplines with digital educational technologies.

Secondly, it is imperative to establish open, shared, and intelligently adaptive teaching support platforms. These platforms should aggregate high-quality digital foreign language teaching resource banks, exemplary lesson models, micro-credential courses, and online communities of practice (CoP). Utilizing intelligent recommendation engines, they should deliver precisely tailored content aligned with teachers' developmental stages and pedagogical needs, thereby supporting on-demand learning and immediate application.

Furthermore, robust incentive and safeguard mechanisms must be implemented. Outcomes such as teachers' active participation in digital competency training, development of digital resources, and attainment of relevant certifications should be formally integrated into faculty evaluation systems for promotion, performance assessment, and professional recognition frameworks. This integration is crucial for alleviating their pragmatic concerns and fostering intrinsic motivation.

Driving the development of digitally enhanced foreign language pedagogy requires not only empowering individual teachers but also guiding them towards achieving deep-seated transformations in their teaching models (Ma & Ismail, 2025). Proactive encouragement and guidance are needed to help teachers move beyond path dependency on technology merely supporting traditional lecture-based instruction. Instead, they should explore new, intelligent pedagogical models centred on learners, driven by tasks, and fostering collaborative inquiry.

This entails enabling teachers to fully leverage the potential of adaptive learning platforms, intelligent assessment tools, and corpus analysis software to implement differentiated instruction, provide targeted feedback, and facilitate process-oriented assessment, thereby effectively enhancing the cultivation of comprehensive language application skills. Concurrently, support should be provided for teachers to utilize technology to transcend classroom boundaries, designing and implementing hybrid ubiquitous learning activities that blend physical and virtual spaces to expand authentic language interaction domains.

Critically, teachers must be guided to develop a critical perspective amid this deep integration. This means thoughtfully embracing technological affordances while simultaneously engaging in profound reflection on the risks of alienation stemming from technological over-reliance, the quality and equity dimensions of digital resources, steadfastly upholding the humanistic values and social responsibilities inherent in foreign language education, and ensuring that digitally enhanced teaching ultimately serves the holistic development of learners.

### 4.4 Enhancing Data-Supported Instructional Analysis

A core efficacy of digital transformation in foreign language education lies in leveraging the pedagogical value derived from deep mining of multi-source data, thereby facilitating teaching precision and learning personalization (Jiang 2025; Wu & Huang, 2025). Specifically, establishing a comprehensive, all-dimensional, all-cycle learning big data aggregation system is essential to break down platform barriers. This system must systematically integrate both structured and unstructured data generated by students across diverse scenarios, including but not limited to interactive language platforms, virtual dialogic simulation environments, automated assessment systems, and real-time classroom feedback tools.

Applying AI-driven advanced analytics for in-depth interpretation of this data enables the transcendence of surface-level scores typical of traditional assessments. It allows the precise delineation of students' micro-level cognitive trajectories, such as physiological pattern limitations in phoneme generation, patterns of pragmatic failure in cross-cultural communication, or the effectiveness of strategy application under task-based conditions. This data-driven cognitive modelling equips foreign language teachers with process-oriented diagnostic insight.

The critical factor in translating data into genuine instructional efficacy is the construction of a closed-loop application mechanism encompassing diagnosis, intervention, and optimization. At the instructional level, precision learner profiles generated from data must form the scientific basis for teachers to design tiered tasks, dynamic grouping strategies, and targeted micro-interventions. At the learning level, an immediate, visualized feedback loop and adaptive progression mechanism must be established. This could involve creating personalized challenge gradients informed by the Zone of Proximal Development (ZPD) theory. Concurrently, macro-level learning analytics should function as a catalyst for instructional research (action research), supporting teachers in identifying textbook relevancy gaps and optimizing instructional design logic.

To safeguard the secure, ethical, and effective utilization of data, stringent data governance frameworks must be instituted, coupled with a significant enhancement of teacher data literacy. This empowerment enables educators to maintain critical discernment regarding analytical outcomes, engage in professional interpretation and pedagogical recontextualization, ensuring that data-informed insights ultimately serve student-centered, profound foreign language learning.

### 4.5 Refinement of the Data-Driven Evaluation and Management Mechanism

The establishment of an evaluation and management system centered on data constitutes a core driver for the digital transformation of foreign language education requiring the integration of multimodal information encompassing

classroom teaching behavior data, digital resource usage patterns, dynamic learning outcome assessments, and teacher development profiles to establish a comprehensive foreign language education data repository covering all domains which necessitates focus on three critical dimensions (Dai & Liu, 2024; Jiang, 2025).

Firstly, the construction of a standardized data acquisition system must unify interface specifications across learning terminals, teaching platforms, and management systems to eliminate information silos. Secondly, the development of intelligent diagnostic analysis tools requires the application of Learning Analytics technology to conduct multidimensional correlation analyses of language acquisition efficiency, digital resource suitability, and teaching strategy effectiveness. Thirdly, a visualized decision support system must be established to transform abstract data into actionable outputs including instructional adjustment recommendations, resource deployment forecasts, and curriculum optimization strategies.

The key characteristic of this mechanism lies in facilitating data feedback loops from the practice level of instruction thereby enabling a closed-loop feedback mechanism linking micro-level teaching behaviors with macro-level management decisions which promotes a shift in the evaluation-management paradigm from post-facto supervision towards process-oriented intervention.

Scientific decision-making necessitates support from a data-driven self-organizing ecosystem wherein grassroots teaching units such as smart classrooms and virtual teaching-research offices generate precise instructional adaptation plans through the routine collection of structured data like student language proficiency development trajectories and digital literacy growth matrices. At the institutional level, school management leverages data middleware to establish a cyclical "teaching-evaluation-improvement" model for dynamically allocating teaching resources and digital assets while educational administrative authorities must construct regional foreign language education data governance frameworks incorporating data ethics regulations and establishing open-sharing mechanisms. Representative cases demonstrably include adjusting grammar teaching emphases based on error distribution heatmaps derived from learner corpora and optimizing blended learning models through analysis of teacher-student interaction density.

## 5. Conclusion

This study comprehensively investigated the core dimensions of digital transformation in foreign language education within the artificial intelligence era, illuminating its nature, essential components, profound challenges, and pathways for action. This study confirmed that digital transformation within foreign language education constitutes not a mere addition of technologies but rather a systemic reconfiguration of educational objectives, processes, resources, assessment, and ecosystems through data-driven methodologies and intelligent technological integration. Its fundamental elements necessitate establishing a human-machine collaborative teaching entity, creating a multimodal resource platform seamlessly merging virtual and physical environments, and shifting towards a process-oriented assessment paradigm rooted in dynamic competency mapping—all targeting the cultivation of digitally literate learners possessing intercultural digital citizenship capabilities.

However, the transformation process has unveiled pronounced structural challenges. The digital transformation of foreign language education represents a highly complex systemic undertaking demanding the critical bidirectional harmonization of technological logic with pedagogical principles. Future efforts must progressively intensify research concerning language acquisition mechanisms, cultural dissemination models, and human-machine collaborative ethics under deep technological integration, thereby constructing a more inclusive, resilient, and sustainable digital foreign language education ecosystem. The theoretical analysis and practical pathway design presented in this study provide policymakers, institutional administrators, and front-line educators with systematic solutions and conceptual frameworks, aiming to propel foreign language education towards value reconstruction and high-quality development within the era of digital civilization.

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