

# Development Trends and Practical Approaches for Personalized Learning in the Era of Digital Transformation in Education

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**Abstract:** *Digital transformation represents an inevitable trend in social and historical development, presenting both new opportunities and challenges for educational innovation. As digital technology integrates with education, personalized learning—a new “human-centered” learning model—has increasingly highlighted its essence, characteristics, and value. Under digital transformation, personalized learning evolves from “individual experience” to “collective intelligence collaboration”; from “content-centric” to “ecological synergy”; from “fixed learning” to “dynamic generation”; and from “focusing on teaching outcomes” to “pursuing the educational process.” Within this developmental framework, the following practical approaches for personalized learning are proposed: returning to the essence of education to advance individual development; addressing student differences to foster learning intelligence; synergizing humans and machines to achieve human-machine symbiosis; and improving operational mechanisms to ensure resource quality.*

**Keywords:** Educational digitization, Personalized learning, Developmental trends, Practical approaches.

## 1. Introduction

In January 2025, the Central Committee of the Communist Party of China and the State Council issued the “Outline of the Plan for Building an Education Powerhouse (2024–2035),” stating that “digital education will open new avenues for development” [1]. In April of the same year, the Ministry of Education and eight other departments issued opinions on accelerating digital education, emphasizing the need to “deeply implement the national digital education strategy, adhere to application-oriented approaches, and expand access to high-quality educational resources” [2]. With the advancement of digital technologies such as machine learning, deep learning, semantic analysis, and sentiment analysis, alongside the emergence of typical AI service systems and tools like learner models, adaptive learning, learning analytics, and learning engineering, traditional education is undergoing profound transformation and systemic restructuring [3]. Fully leveraging digital technologies to achieve educational equity and enhance teaching quality, while advancing personalized learning, holds significant importance for promoting holistic human development and elevating national literacy. It also provides robust support for advancing educational modernization and building an education powerhouse in the new era.

## 2. Personalized Learning in the Era of Educational Digital Transformation

Educational digital transformation represents a global strategy adopted by nations worldwide to respond to societal digitalization trends. Its core objective is to re-examine educational development pathways in the information and intelligence era, leveraging digital technologies and tools to deliver more innovative and personalized learning experiences that cultivate students adaptable to future societal demands. Consequently, educational digital transformation is viewed as a shared strategic choice for education, offering vital pathways and methodologies for achieving sustainable

educational development and comprehensively enhancing educational quality [4]. Educational digital transformation constitutes a complex systemic endeavor playing a vital role in advancing China’s educational reform and development. Supported by “Internet Plus” technology and driven by next-generation information technologies such as artificial intelligence, big data, and blockchain, it comprehensively transforms and reconstructs educational models, governance systems, organizational structures, and talent cultivation approaches [5].

In the development of educational pedagogy, the primary challenge in personalized learning lies in delivering instruction tailored to students’ varying abilities [6]. Research on the definition of personalized learning converges on two main perspectives: one views it as highly individualized adaptive learning, where learners select content and methods suited to their knowledge base, interests, learning styles, behavioral traits, and other personalized factors, achieving holistic development through the learning process; The other defines it as developing teaching plans based on individual differences, executing instruction according to students’ distinct characteristics, emphasizing differentiated teaching to stimulate each student’s potential and enable free and harmonious development [7]. Therefore, personalized learning focuses on shaping students’ character and highlighting their unique traits. It is indispensable in teaching, addressing the current educational call to meet each student’s real needs, and holds significant educational value and profound meaning. It represents a new “human-centered” learning model emphasizing learner autonomy and choice, fundamentally addressing students’ diverse needs to achieve personalized development. Characterized by multidimensionality, openness, and flexibility, personalized learning enables a “student-centered” teaching philosophy. Its essence lies in addressing individual developmental needs to foster holistic growth. Within the context of educational digital transformation, personalized learning exhibits the following characteristics: First, it respects students’ individualized needs; second, it aligns with the developmental

demands of the future digital era; third, it promotes students' lifelong sustainable development. Based on this, personalized learning operates on the premise of respecting individual differences, aims to cultivate well-rounded individuals, and is guided by adapting to future developmental requirements. Through its multidimensional, open, and flexible features, it achieves students' comprehensive development [8][9].

### **3. Development Trends of Personalized Learning in Educational Digital Transformation**

As digital technology and education converge, educational informatization in this new development phase has incorporated fresh dimensions, ushering in a new era of educational digitalization [10]. On one hand, the seamless integration of digital technology and education has fundamentally transformed learning methods. The digital transformation of education has profoundly disrupted traditional learning methods. Students can now access knowledge and learning resources through convenient tools like online learning platforms and digital courses, free from the constraints of time and space, thereby opening new pathways and possibilities for learning. On the other hand, the application of digital technology has also stimulated students' creativity and motivation. Through the use of digital teaching tools and multimedia resources, students can understand and master knowledge in a more intuitive and vivid manner, sparking their interest and initiative in learning. Against the backdrop of rapid technological iteration, personalized learning—as a novel educational paradigm—is increasingly revealing its essence, characteristics, and value. Correctly understanding the relationship between digital transformation and personalized learning, clarifying the developmental trajectory of personalized learning, promoting students' comprehensive and individualized growth, and advancing the formation of a lifelong learning society are imperative.

#### **3.1 From “Individual Experience” to “Collective Intelligence Collaboration”**

“In human-machine collaborative learning, data-driven educational decision-making manifests as machines leveraging learners' behavioral data, physiological information, and academic assessment data to achieve precise perception and effective modeling of the learning process. This enables the exploration of underlying learning mechanisms, serving as a reference for personalized resource recommendations and learning path planning services.” [11] Data-empowered personalized learning is built upon big data analytics with a data-centric approach, offering distinct advantages and characteristics compared to traditional experience-driven methods. In conventional teaching, instructors deliver lessons based on their pedagogical expertise without focusing on students' learning states. While teachers can gauge student progress through observation and questioning, these methods fail to achieve bidirectional interaction between teaching and learning, hindering the emergence of effective personalized learning. The emergence of digital intelligence technologies has propelled personalized learning forward. By collecting, analyzing, and providing feedback on learners' behavioral data throughout the entire learning process, these technologies integrate human and

machine intelligence to achieve swarm intelligence collaboration [12]. This provides a basis for teachers to conduct precise instruction and evaluation, helping them understand student learning situations in real time and adjust teaching strategies promptly. Simultaneously, learners can proactively collect, organize, analyze, and utilize learning data through intelligent devices. This enables them to access diverse learning resources, analyze learning behaviors and trajectories, diagnose learning issues, and receive tailored recommendations—ultimately achieving scientific intervention and guidance in their learning journey.

#### **3.2 From “Content-Centric” to “Ecosystem Collaboration”**

Resources constitute the foundational elements mobilized for learning support services and form the bedrock of personalized learning support. Establishing a learning support service operation mechanism with clear chains and transparent processes underscores the paramount importance of resources [13]. “Digital learning resources” refer to the diverse resources, tools, and data provided by digital technologies in educational processes. Against the backdrop of digital transformation, the supply of learning resources is shifting from “content-centric” to “ecosystem-driven collaboration.” This shift not only delivers more high-quality, diverse, and open resources to meet personalized learning needs but also addresses the varied learning demands of the broader public. Digital empowerment of personalized learning facilitates the transition of learning resources from “single-factor” to “multi-factor” approaches, enabling diverse resources to form an adaptive, self-organizing, and self-optimizing educational ecosystem through continuous aggregation and interaction. This is elaborated in three key dimensions: First, learner-centered development and delivery of resources tailored to individual learning characteristics and needs. In terms of course content, knowledge is selected and delivered according to learners' needs, while course design and development align with their learning styles. Resource presentation and production are tailored to learners' requirements and interests. Second, it shifts from fragmentation to systematization. Digital-enabled personalized learning emphasizes a holistic mindset characterized by: first, transitioning from fragmented knowledge to systematized knowledge; second, evolving from single knowledge systems to diverse knowledge systems. Third, it is characterized by openness and sharing. In a sense, education is a future-oriented social collaborative activity involving both learners and educational institutions. Therefore, in the process of digitally empowered personalized learning, resource providers adopt an “open” mindset. That is, resource providers are “ecosystem-based” organizations that facilitate full communication and interaction among stakeholders including learners, teachers, and educational institutions.

#### **3.3 From “Fixed Learning” to “Dynamic Generation”**

In traditional education, learners' activities are predominantly teacher-directed. This conventional model features fixed learning content, schedules, spaces, instructors, materials, and activities, often resulting in passive or “receptive” learning. With advancements in AI and big data, learners' time and

space for learning have transformed, shifting the learning paradigm from “fixed learning” to “dynamic generation.” The dynamically generated learning model, underpinned by new-generation information technologies like “digital natives” and “digital twins,” empowers learners with more open and abundant resources [14]. Within digital-intelligent learning environments, learners can freely access and present resources tailored to their needs. They can also make personalized selections and autonomously construct learning experiences based on their learning styles, interests, and cognitive levels to meet individual development demands. This dynamic generation learning model not only stimulates learners’ motivation and enthusiasm but also fosters the development of their critical thinking and innovation capabilities, cultivating autonomous learning and problem-solving skills. Moreover, dynamic generation learning manifests not only in the spirit of learners’ proactive exploration and self-construction but also achieves mutual benefits for both educators and learners. Through interactive collaboration between teachers and learners, students gain deeper learning experiences during self-directed exploration, enhancing both learning outcomes and effectiveness. Consequently, applying the dynamically generated learning model not only elevates student learning but also inspires pedagogical innovation and improvement among educators. In summary, this model holds significant value and importance for enhancing learning quality.

### **3.4 From “Focusing on Teaching Outcomes” to “Pursuing the Educational Process”**

The core essence of education lies in fostering human development. For personalized learning to promote students’ individual growth, it must center on human development as its core principle, shifting its value orientation from “focusing on teaching outcomes” to “pursuing the educational process.” Learner-centered educational philosophy emphasizes “student-centeredness,” achieving the full development of every student through personalized learning. In recent years, the maturation of next-generation information technologies — represented by big data, artificial intelligence, and cloud computing—has revolutionized education. Simultaneously, the application of digital technologies has spawned new learning methods, tools, and spaces, expanding possibilities for digitally empowering personalized learning. For digital-enabled personalized learning to achieve optimal results, it must prioritize the educational process as its value orientation and continuously enhance teaching quality. However, due to insufficient understanding of education’s essence, many educational researchers believe there is no inherent link between technology application and teaching effectiveness, which has hindered the adoption of digital technologies in education to some extent. Furthermore, data analysis often focuses on students’ “learning” rather than “teaching,” making it difficult to adequately address students’ personalized development. To address these issues, some researchers are shifting their focus toward achieving “student-centered” approaches. Scholars like Zhao Shulan argue that a “learner-centered” approach requires education to transition from “focusing on teaching outcomes” to “pursuing the educational process”—that is, prioritizing each student’s development throughout their learning journey [15][16]. The deep integration of digital technology with education and

teaching serves as a crucial pathway to realize this transformation.

## **4. Practical Approaches to Personalized Learning ( ) in the Context of Educational Digital Transformation**

Learning in the digital transformation era must center on foundational knowledge and core competencies. Education must not only flip the classroom but also reimagine curricula, update subject content, and construct meaningful learning approaches to cultivate innovative talent [17]. Numerous scholars globally have proposed application scenarios for digitally supported education, establishing new paradigms and frameworks for educational digitization. In the digital era, the integration of digital information technology with education has grown increasingly tight. Numerous researchers have introduced concepts such as educational artificial intelligence [18], new-subject teachers [19], and educational knowledge graphs [20] into the educational field. In recent years, the application of modern information technologies like artificial intelligence in education has matured significantly, greatly facilitating the smooth implementation of personalized learning.

### **4.1 Returning to the Essence of Education: Advancing Individual Development**

The purpose of education lies in developing students’ autonomous abilities, including the capacity for independent decision-making, planning, and evaluation. In the era of digital intelligence, personalized learning emphasizes that students must gain a comprehensive understanding of their own knowledge, abilities, interests, motivations, and beliefs. They should possess a high degree of autonomy and initiative, clearly identifying both challenges and strengths in their academic development. By leveraging digital technologies and intelligent services, students enhance their knowledge acquisition and competency cultivation, flexibly adapting to and evaluating the personalized learning support services provided by machines. The core principle of personalized learning is recommending learning resources and planning learning paths based on students’ needs and interests. However, it is noteworthy that such recommendations and planning are fundamentally based on machine-preset rules, similar to previous human-driven educational interventions. Compared to traditional classroom teaching, this approach does not represent a substantive change—it merely shifts the “human-driven” model to a “machine-driven” one. This shift may transfer decision-making authority away from students, potentially weakening their autonomy and independent thinking abilities in learning. Personalized learning should be explored from the perspective of “individual development,” with its ultimate goal being to awaken students’ self-awareness, strengthen their self-cognition abilities, and elevate their level of self-consciousness to cultivate autonomous learning capabilities. Through self-awareness, value judgment, rational reflection, and independent decision-making, students can rationally evaluate and reasonably select the personalized learning support provided by machines. Through adjusting and refining self-plans, validating and revising self-evaluations, guiding and inspiring self-reflection, resolving conflicts in self-awareness, and

strengthening and reconstructing self-consciousness, students can achieve self-planning, self-monitoring, self-evaluation, self-reflection, and self-regulation of their learning. This simultaneously enhances learning autonomy and initiative, increases students' control over their studies, and cultivates sound learning habits.

#### **4.2 Addressing Student Differences to Foster Learning Intelligence**

Personalized learning emphasizes addressing student differences by proposing tailored instructional strategies based on individual learning foundations, abilities, and styles, thereby stimulating motivation [21]. This approach promotes full learner engagement and holistic development, highlighting the learner's central role in the classroom and reflecting the shift from knowledge-centered to learner-centered education. As "digital individuals" in the digital transformation era, students inevitably exhibit unique characteristics and abilities during their learning journey. Therefore, the digital transformation process must fully consider these diverse traits and capabilities, guiding students to actively engage in classroom learning and unleash their potential. Curriculum design should account for variations in students' personalities and learning abilities, providing course systems better suited to their individual development needs [22]. For instance, in computer programming education, students of different age groups exhibit distinct personality traits and interests influenced by factors such as age, gender, learning styles, and personal preferences. With the advancement of educational informatization, digital educational resources continue to expand. Under the digital transformation paradigm, meeting students' personalized development needs requires leveraging these digital resources to enhance learning efficiency and outcomes. However, due to the diversity and variability inherent in digital educational resources, it is impossible to provide all learners with the same type or quantity of resources. Furthermore, given the significant differences among individual students, teachers must consider variations in cognitive levels and learning styles during personalized instruction. Targeted teaching guidance should encourage active classroom participation while enhancing students' personalized learning capabilities, thereby fostering the emergence of learning wisdom.

#### **4.3 Synergizing Humans and Machines to Achieve Human-Machine Symbiosis**

"The role positioning and subject dispute between humans and machines are core issues requiring attention and resolution in human-machine collaborative learning [23]." Therefore, we must re-evaluate the value positioning of digital technologies and intelligent educational products in student learning from the perspective of "human-machine relations." This implies not only recognizing the positive impact and guidance role of machine intelligence diagnostics in student learning but also prioritizing the "autonomy" and "agency" of student learning. On one hand, machines can perform data-driven modeling and analysis of students' knowledge structures, cognitive levels, emotional attitudes, learning motivations, and learning styles from the perspectives of data perception and modeling. Through this approach, machines can provide students with more

systematic and precise personalized learning support services. This personalized support delivers learning content and strategies tailored to individual differences based on students' characteristics and needs. Simultaneously, through data-driven analysis, machines can better understand learners' needs and proactively adjust and provide feedback during the learning process to meet their learning objectives and aspirations. This enhances learning outcomes, strengthens motivation and learning attitudes, and promotes students' comprehensive development. On the other hand, it is crucial to emphasize that students must possess a high level of "self-awareness" and should not uncritically accept the machine's intelligent diagnosis and precise interventions. Students should rationally evaluate the intelligent academic analysis results provided by machines and utilize these insights to adjust their learning objectives and strategies.

Through student-machine interaction, we can prevent machines from solely relying on data to dictate learning content and schedules, thereby overlooking student autonomy and initiative. Simultaneously, we must avoid granting excessive freedom that could lead to aimless, unrestrained use of learning resources and services [24], potentially causing cognitive inertia. Thus, personalized learning should grant students a degree of "autonomy." Machines can develop personalized learning paths based on student progress, provide adaptive resource recommendations, and design flexible learning plans. Concurrently, students can accurately evaluate, appropriately utilize, and promptly provide feedback on the intelligent educational services delivered by machines based on their subjective experiences. The ultimate goal is to strike a balance between "machine-driven interventions" and "student-driven autonomy," thereby optimizing the human-machine collaborative learning ecosystem.

#### **4.4 Improving Operational Mechanisms to Ensure Resource Quality**

Currently, the application of digital technology in classroom teaching remains superficial, with significant room for improvement—particularly in advancing personalized learning. To fully leverage digital technology's potential in empowering personalized learning during its deep integration with classroom instruction, it is essential to establish robust operational mechanisms and ensure the quality of digital resources [25]. Many regions have encountered misconceptions in advancing personalized learning, primarily manifested in three ways: first, blindly following trends and rushing into implementation without top-level design or scientific planning; second, over-reliance on advanced technological tools while neglecting issues such as teacher involvement and student experience; third, focusing excessively on developing new resources and applications while failing to leverage and integrate existing ones [26]. Therefore, it is essential to strengthen top-level design and scientific planning for the development of digital technology-enabled personalized learning, while establishing sound operational mechanisms. First, establish a project management mechanism aligned with the requirements of "Internet Plus Education" development. Second, create a teaching service mechanism compatible with the new curriculum reform and integrated with artificial intelligence.

Third, develop a support mechanism that complements digital technology-enabled personalized learning and aligns with teaching evaluation, including: - Establishing robust mechanisms for supplying high-quality digital resources - Implementing feedback mechanisms for digital resource usage - Creating open sharing mechanisms for digital resources

## 5. Conclusion

Personalized learning in the context of digital transformation represents a revolution in educational philosophy, learning approaches, instructional organization, and assessment methods. It signifies innovation in technology application and teaching methodologies, and profoundly reshapes future talent development models. This educational transformation is driving a comprehensive shift in teaching paradigms from “teacher-centered” to “learner-centered.” Leveraging big data analytics and artificial intelligence, educational systems can dynamically capture learners’ cognitive characteristics and developmental trajectories, constructing a comprehensive growth model spanning knowledge acquisition, competency development, and value formation. Within this new blended learning ecosystem, adaptive learning systems achieve a qualitative leap from standardized delivery to precision-tailored services through continuous optimization of instructional strategies. This intelligent education model, grounded in learner profiling, not only reconfigures teacher-student interactions but also achieves consistent development across teaching, learning, and assessment through data-driven closed-loop systems. With the deep integration of cutting-edge technologies like digital twins and brain-computer interfaces, personalized learning will transcend current boundaries, forming an open, collaborative, and lifelong intelligent learning network. This represents both a strategic choice for addressing future societal complexities and an indispensable path toward holistic human development and educational modernization.

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