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Educational dilemmas and practical pathways in the era of digital intelligence

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Abstract. With the deep integration of digital-intelligent technologies into the field of education, the current educational ecosystem is undergoing reconstruction and transformation. At the same time, it faces a "knowledge–cognition–subject" three-dimensional dilemma. From an educational perspective, this study critically analyzes three contradictions emerging during technology-enabled education: the expansion of curriculum content suppressing effective learning, fragmented learning hindering the development of higher-order thinking, and algorithmic dependence undermining learners' autonomy. Subsequently, this study proposes targeted practical pathways based on "structural reconstruction." It emphasizes that educational reform in the digital-intelligent era should uphold humanistic values and promote fundamental transformation in educational development.

Keywords: digital-intelligent technology, three-dimensional dilemma, practical pathways, humanism

1. Introduction

With the deep penetration of digital-intelligent technologies across various sectors of the economy and society, digitalized education has become a core issue in global educational reform. Since the Ministry of Education of China launched the National Education Digitalization Strategic Action in 2022, "promoting educational digitalization" has been incorporated into the national strategic agenda. The National Education Work Conference held in 2024 further emphasized "deepening AI-enabled educational transformation," aiming to shift digital education from expansion in scale to enhancement in quality. Driven by both policy initiatives and technological iteration, emerging technologies represented by big data, artificial intelligence, and cloud computing are reshaping the educational ecosystem. According to the Ministry of Education, as of April 2025, the National Smart Education Platform in China has registered over 163 million users, with a total of 60.8 billion page views.

However, alongside technological empowerment, education faces three-dimensional structural dilemmas. First, knowledge overload has led to curriculum expansion and homogenized evaluation standards, producing "growth without development" [1]. Second, fragmented learning methods undermine deep learning abilities, significantly weakening the cultivation of higher-order thinking in Bloom's cognitive taxonomy. Third, excessive application of intelligent technologies may result in weakened learner subjectivity, with some students developing algorithmic dependency tendencies. These dilemmas reflect the tension between instrumental rationality and the rationality of educational values in technology application, potentially diverting education from its core purpose of "nurturing individuals" and falling into a trap of technological efficiency.

In view of this, the present study focuses on the fundamental contradictions of digital-intelligent education. By deconstructing the generative mechanisms of the "knowledge–cognition–subject" three-dimensional dilemma, it seeks practical pathways to return education to its essential purpose. The study aims to address a central question: How can a new educational paradigm of "technology for good" be constructed, enabling digital-intelligent education to genuinely serve the holistic development of humans? Addressing this question is not only key to resolving the current crises of educational involution, mediocrity, and alienation but also an essential step toward realizing the strategic goal of China Education Modernization 2035 to "develop high-quality education with Chinese characteristics that reaches world-class standards."

2. Literature review

Current academic research on educational transformation in the digital-intelligent era primarily revolves around several core dimensions. First, studies on technology-driven educational transformation indicate that emerging technologies represented by big data and artificial intelligence are promoting a leap in educational forms from digitalization to digital-intelligence [2].

However, while this transformation enhances educational efficiency, it also brings profound challenges. OECD demonstrates that excessive use of technology may weaken substantive interaction between teachers and students, providing critical evidence for understanding the dual nature of technology-enabled education [3].

Second, research on knowledge overload has also developed a relatively systematic understanding. Lu reveals mechanisms by which generative AI exacerbates knowledge explosion, noting that educational institutions' belief in "more knowledge is better" leads to continuous expansion of curriculum systems [4]. Sun proposed the concept of "growth without development," which precisely describes the disconnect between the increase in knowledge volume and the improvement of educational quality [1]. Notably, Sun and Xiong (2023) found that the promotion of performance-based evaluation increasingly highlights education's screening function, further reinforcing the involution trend caused by knowledge overload [5].

Moreover, studies on the cognitive dimension reveal the profound impact of digital-intelligent technologies on learning patterns. Wang and Lu point out that extracurricular online learning based on digital-intelligent technologies exhibits significant fragmentation, with clear deficiencies in the systematicity of knowledge structures and reliability of cognitive processes. Their research further indicates that when the knowledge acquisition process is excessively simplified and ubiquitous, it alienates learners' cognitive attitudes: it diminishes reverence for the value of knowledge, suppresses intrinsic motivation to learn, and ultimately fosters a shallow processing habit of fragmented information rather than deep reflection and knowledge integration [6]. Subsequent research by Yan supports this finding, with theoretical analysis showing that convenient knowledge provision models effectively undermine the cognitive conflicts and intellectual challenges essential to constructivist learning. Collectively, these studies suggest that improper use of digital-intelligent technologies may trigger a superficialization crisis in education [7].

Finally, the crisis of learner subjectivity has emerged as another focal point of scholarly attention. Pintrich emphasizes the importance of learning autonomy [8], while Luo et al. demonstrate that algorithmic recommendation systems substantially weaken students' freedom of choice. This subjectivity crisis also involves issues of technological ethics [9]. As OECD warns in 2015, the application of educational technology entails risks such as insufficient data privacy protection and lack of algorithmic transparency, which together constitute a systemic challenge to learner subjectivity in the digital-intelligent era [3].

In summary, existing studies indicate that while the academic community has gained considerable understanding of the dilemmas in digital-intelligent education, limitations remain, including the lack of a systematic analytical framework, polarization in countermeasure research, and insufficient localization studies. Building on this body of research, the present study aims to construct a more comprehensive analytical model, providing new theoretical perspectives and practical pathways to address the dilemmas of digital-intelligent education.

3. Structural dilemmas of digital-intelligent education: reflections from an educational perspective

Amid the wave of digital transformation, the field of education is undergoing unprecedented change. Digital-intelligent education, as a product of the deep integration of technology and education, brings convenience but also gives rise to a series of structural contradictions. These contradictions not only affect teaching effectiveness but also profoundly alter the essential characteristics of education. This section systematically analyzes, from an educational perspective, the deep impacts of knowledge overload, fragmented learning, and algorithmic dependency on the educational process.

3.1. The inhibitory effect of knowledge overload on effective learning

Research in cognitive science has shown that the human information processing system has inherent physiological constraints. Sweller's (1988) cognitive load theory explicitly states that working memory has a clearly limited capacity, which directly determines the threshold of human information processing ability [10].

In today's digital learning context, the complex cognitive matrix formed by the simultaneous presentation of multiple knowledge modules, intelligent recommendation of related resources, and continuous push of real-time interactive information forces learners into a state of constant attention switching. This manifests as a cognitive dilemma in which learners face "receiving new information—insufficient time for deep processing—being forced to receive more new information," thereby interfering with the autonomous construction of their knowledge systems. Under these conditions, knowledge cannot be organically integrated and instead accumulates in discrete, fragmented forms. From a cognitive mechanism perspective, this state not only reduces immediate learning efficiency but, more importantly, obstructs the effective consolidation of information into long-term memory. The brain is unable to adequately encode and organize newly received information, resulting in difficulties in forming a systematic cognitive structure.

Furthermore, the more profound negative impact lies in the systematic suppression of metacognitive functions. Metacognition, as a uniquely human higher-order cognitive function, comprises two interrelated dimensions: first, the understanding of one's own cognitive processes, namely the ability to clearly grasp one's cognitive characteristics and limitations; and second, the ability to monitor and regulate cognitive activities, including the flexibility to dynamically adjust strategies according to learning progress. In an ideal learning state, learners can use this system to achieve dynamic optimization of learning strategies, forming a positive self-regulatory cycle. However, sustained knowledge overload keeps learners' cognitive resources chronically at full capacity, severely compressing metacognitive activities. This is manifested in the commonly observed "illusory learning" phenomenon in digital learning environments, meaning that learners may browse a large amount of content, yet perform poorly in deeply understanding the essence of knowledge or transferring knowledge across contexts. More alarmingly, prolonged exposure to such conditions may lead to the degradation of metacognitive abilities, gradually eroding learners' core capacity for autonomous learning.

Based on the above analysis, the current content provision paradigm in digital education urgently needs a fundamental shift from quantity-driven to quality-prioritized. The core of this transformation lies in reconstructing the basic logic of knowledge provision, with the key being the establishment of a learner-centered knowledge supply model that prioritizes cognitive development. This enables a paradigm shift from information transmission to meaning construction.

3.2. Fragmented learning and its impairment of deep cognition

In the ongoing digital transformation of education, the widespread adoption of fragmented learning patterns presents a structural contradiction with traditional cognitive development principles. This contradiction not only manifests as overt fragmentation of knowledge systems but also exerts profound, systemic effects on learners' cognitive mechanisms. Therefore, this study analyzes the issue from two critical dimensions: cognitive construction mechanisms and neural plasticity, based on findings from cognitive science and educational neuroscience.

First, from the perspective of cognitive construction, fragmented learning undermines the integrity of knowledge systems. Piaget's theory of cognitive development posits that cognition is a constructive process that progresses from lower to higher levels through assimilation, accommodation, and equilibration, building upon existing schemas. Genuine learning requires the dialectical integration of assimilation and accommodation. However, the fragmented presentation of knowledge disrupts this balance. Learners can quickly achieve superficial assimilation of information, but due to insufficient contextual support and limited opportunities for cognitive extension, they struggle to achieve deep accommodation. This imbalance produces "mosaic-like" knowledge structures in learners, where individual knowledge points may be accurately grasped, yet overall cognitive schemas remain fragmented. In disciplines emphasizing logical coherence, such fragmented cognition often manifests as shallow conceptual understanding and difficulty in transferring knowledge across contexts.

Further research indicates that this imbalance in cognitive structures triggers deeper neural changes. Modern neuroscience demonstrates that brain cognitive functions are closely related to usage patterns. The high-frequency, short-duration attention-shifting characteristic of fragmented learning not only hinders full activation of prefrontal executive functions but also affects hippocampal consolidation of memory information. Specifically, when learners frequently shift attention, the brain struggles to maintain sustained activation of specific neural circuits. As a result, learners in long-term fragmented learning environments often exhibit insufficient cognitive endurance when facing complex tasks requiring sustained focus and deep thinking.

It is important to note that these changes, spanning cognition and neural mechanisms, form a self-reinforcing closed-loop system. With cumulative exposure to fragmented learning, learners' brains gradually adapt to this shallow information-processing mode, leading to continuous degradation of deep cognitive abilities. This degradation, in turn, reinforces dependence on fragmented learning, creating a persistent vicious cycle. In the long term, this cycle not only constrains improvements in current learning outcomes but may also have irreversible negative effects on the development of lifelong learning capacity.

Confronting this serious challenge, educational practice must seek systemic breakthroughs. Constructing theme-integrated deep learning frameworks, which preserve the advantages of digital learning while restoring the integrity of knowledge systems, may provide a critical pathway to resolving this dilemma.

3.3. Algorithmic dependency and the weakening of learner autonomy

In the rapid development of digital-intelligent education, the deep integration of algorithmic technologies is triggering a structural transformation of the educational paradigm of learner autonomy. This transformation not only involves technical innovations in teaching formats but also touches upon the fundamental issue of human subjectivity within educational activities. Therefore, this study analyzes the profound impact of algorithmic dependency on educational subjectivity from two dimensions—constructivist learning theory and the essential nature of educational relationships.

From the perspective of constructivist learning theory, algorithmic dependency is altering the essential nature of learning. Constructivism posits that learning is a process in which learners actively construct the meaning of knowledge based on prior experiences, with learner subjectivity and agency at its core. However, in current educational practice, algorithmic systems are gradually taking over critical aspects such as learning path planning, content recommendation, and performance evaluation, resulting in a continual transfer of learners' decision-making authority. Specifically, learning objectives are preset by algorithms rather than autonomously established by learners; learning content is pushed by algorithms rather than actively explored; and learning evaluation is determined by algorithms rather than guided by diverse value systems. This shift transforms a previously exploratory and creative learning process into a passive technical workflow driven by algorithmic instructions, fundamentally weakening learners' subject position within the educational process.

The weakening of subjectivity further leads to a structural imbalance in educational relationships. In traditional education, teacher-student relationships are founded on equitable dialogue and meaningful interpersonal engagement: teachers convey knowledge and inspire wisdom through direct guidance, while students achieve cognitive development and personal growth through interaction. The intervention of algorithmic systems fundamentally alters this intersubjective dynamic. On the one hand, learners' subjectivity is reduced to that of data objects, with their learning processes simplified to quantifiable behavioral variables. On the other hand, teachers' subjectivity is marginalized to that of system overseers, with their educational judgment supplanted by algorithmic models. This dual weakening of subjectivity not only risks marginalizing core elements of education that cannot be quantified, such as emotional exchange and value guidance, but may also fundamentally undermine the humanistic foundations of education.

A detailed analysis reveals that the weakening of subjectivity induced by algorithmic dependency manifests on three levels: cognitively, learners' capacity for active knowledge construction is diminished; relationally, teacher-student interactions are simplified; and at the value level, the humanistic care embedded in education is attenuated. This multidimensional weakening of subjectivity warns that the positioning and role of algorithms in education must be critically reconsidered.

4. Structural reconstruction pathways for digital-intelligent education

4.1. Constructing flexible knowledge boundaries through subtractive thinking

Confronting the problem of knowledge overload in digital-intelligent education, the core of structural reconstruction lies in applying subtractive thinking to establish flexible knowledge boundaries aligned with human cognitive principles. Research in cognitive science indicates that the limitations of working memory require learning content to be carefully filtered and organized. Thus, traditional supply models aimed at comprehensive coverage must be abandoned in favor of focusing on core disciplinary concepts. Specifically, an intelligent dynamic filtering system should be established, which decomposes complex content into modular units suitable for current cognitive load through knowledge modularization technologies. This system can monitor learners' cognitive states in real time, automatically adjusting the learning pace when metacognitive load approaches a threshold —for example, slowing video playback by 20% and inserting immediate comprehension checks to ensure quality knowledge assimilation. Simultaneously, the system can intelligently distinguish foundational knowledge from extended content based on learners' real-time performance data, automatically generating personalized learning paths when mastery of core concepts is insufficient.

A deeper reconstruction pathway involves transforming subtractive thinking into systematic educational practice. First, on the technological support side, multidimensional metacognitive tools, such as intelligent learning dashboards, should be developed. These dashboards not only display key indicators in real time, including knowledge mastery and cognitive load intensity, but also visually present the completeness of the knowledge structure, helping learners build clear self-awareness. Second, regarding algorithmic optimization, intelligent educational systems should move beyond simple content push models toward deep cognitive support. For example, when the system detects repeated errors on specific types of knowledge, it can automatically match relevant explanatory videos and variant exercises. Third, the transformation of evaluation systems should emphasize learners' integrative abilities. By analyzing learners' problem-solving pathways and patterns of knowledge transfer, new evaluation standards oriented toward depth of understanding can be established.

The essence of this systematic transformation is to ensure that technological innovation genuinely serves cognitive development principles. By respecting human cognitive limitations while fully leveraging the potential of digital-intelligent education, this approach enables meaningful and sustainable learning outcomes.

4.2. Promoting deep cognitive development through thematic integration

To address the superficial cognition resulting from fragmented learning, this study proposes a systematic reconstruction approach centered on thematic integration. The aim is to reshape learners' deep cognitive abilities through structural reforms that consider both cognitive construction and neural mechanisms.

At the level of cognitive construction, thematic integration strategies focus on resolving the "mosaic-like" fragmentation of knowledge systems. This strategy is concretely implemented by establishing a learning framework centered on interdisciplinary themes and adopting core-question-oriented instructional design. For example, when teaching the theme of "Artificial Intelligence Ethics," the system not only integrates diverse knowledge modules from philosophy, computer science, and law, but also employs intelligent algorithms to construct an interdisciplinary concept network, revealing the intrinsic connections of knowledge across disciplines within the thematic framework. To ensure depth of thematic learning, a "focused learning protection" mechanism is implemented, setting 25-minute foundational learning units during which the system automatically filters irrelevant information, enabling students to maintain sustained engagement in thematic inquiry. This design adheres to fundamental principles of knowledge construction while cultivating systemic thinking abilities through thematic integration.

From the perspective of neural mechanism optimization, achieving thematic integration requires corresponding neuroscientific support. First, based on the characteristics of thematic learning, an intelligent review system grounded in Ebbinghaus' forgetting curve is established. The system automatically pushes personalized review content according to the complexity of thematic material during critical memory periods (e.g., 24 hours, Day 7, and Day 30 post-learning). For instance, in a course on Principles of Economics, the system provides students with concise video lectures on core theories and interdisciplinary case analyses during optimal time windows. Additionally, multisensory immersive learning environments can be developed around thematic content. By using VR technology to create thematic scenarios, students engage in thematic exploration through visual, auditory, and tactile channels. This multisensory integration effectively strengthens the neural representation of thematic knowledge.

These reform measures, centered on thematic integration, constitute a comprehensive cognitive development support system: at the front end, knowledge systems are reconstructed through thematic selection and systematic integration; at the mid-level, neuroscientific principles optimize the thematic learning process; at the back end, intelligent technologies ensure the effectiveness of thematic learning. The coordinated action of these three dimensions not only repairs cognitive damage caused by fragmented learning but also, through the deep promotion of thematic integration, fully leverages the advantages of digital education, providing a feasible practical pathway for cultivating higher-order thinking skills.

4.3. Dual-track coordination to reshape educational algorithm logic

The current issues arising from algorithmic dependency, such as rigid learning paths and content homogenization, essentially stem from the overreach of technological logic into the constructive learning process. Reconstructing learner autonomy requires a systematic design from both the constructivist perspective and the dimension of educational relationships, ensuring that while algorithmic advantages are fully utilized, the learner's subject position in education is preserved.

From the standpoint of constructivist learning theory, the application of algorithmic technologies in education must reassess the balance between technological enablement and learner sovereignty. The most critical aspect is embedding agency-protection mechanisms within the technical design: on one hand, developing configurable algorithmic frameworks that allow learners to adjust recommendation logic according to cognitive habits, achieving personalized learning parameters; on the other hand, establishing a dual-channel feedback system that processes algorithmic recommendations in parallel with learner-labeled interest tags, ensuring that the initiative in knowledge construction remains firmly with the learner. This algorithmic design not only aligns with the core constructivist principle that "learning requires interaction between the learner and the environment," but also strengthens learners' metacognitive abilities through technical means, creating a virtuous interaction between algorithmic assistance and learner development.

The reconstruction of the educational relationship's essence requires algorithmic systems to shift from intervening in intersubjectivity to promoting intersubjectivity. Traditional teacher-student interactions, once mediated by algorithms, face challenges such as weakened emotional connections and the marginalization of educational judgment. To address this, it is imperative to build a human–machine collaborative educational ecosystem. Crucially, algorithm design should preserve the openness of educational dialogue by setting up unstructured interaction spaces, such as open discussion forums, free-text feedback, and real-time online conversations, encouraging teachers and students to engage creatively beyond algorithmic constraints. Simultaneously, an experience-driven algorithmic optimization mechanism led by teachers should be established. By recording teachers' corrective actions on system recommendations, a dynamically updated teaching-strategy knowledge base is formed. For instance, in an intelligent grading system, when metaphorical or non-standardized content is detected, the system can retain the original interaction record while generating improvement suggestions based on teachers' historical corrections, ultimately forming a closed-loop enhancement mechanism spanning algorithmic preliminary analysis, deep teacher-student interaction, professional teacher decision-making, and autonomous system iteration. This design respects teachers' professional judgment while leveraging technology to improve educational efficiency, positioning algorithms as bridges to reconstruct intersubjective relationships in education.

Together, these pathways converge on a core proposition—the ultimate goal of digital-intelligent education is to achieve human excellence through technology. Whether through agency protection under the constructivist framework or the reconstruction of intersubjectivity in educational relationships, technology must be positioned as an assistant. Only by adhering to a human-centered rather than technology-dominated approach can the dignity of learner subjectivity be safeguarded, allowing digital-intelligent education to truly drive the modernization of education.

5. Conclusion

The advent of the digital-intelligent era has brought unprecedented opportunities and challenges to educational development. Through systematic analysis, this study reveals three major structural dilemmas in the current digitalization of education: first, the phenomenon of knowledge overload has become increasingly prominent, resulting in "quantity growth without quality improvement" and compressing the space for effective learning; second, fragmented learning patterns weaken the cultivation of higher-order thinking, leading to deficiencies in deep learning abilities; third, excessive reliance on technology partially undermines learner autonomy, affecting the fundamental educational mission of nurturing individuals. The underlying root of these dilemmas lies in the imbalance between technological tools and educational values, which urgently requires rational institutional design and technological governance to restore equilibrium.

In response to these challenges, this study proposes an innovative solution of "structural reconstruction": in the curriculum system, subtractive thinking is introduced to establish dynamic knowledge filtering mechanisms, preserving the necessary cognitive space for deep learning; in teaching models, thematic integration is employed to optimize cognitive mechanisms and facilitate interdisciplinary knowledge integration; in cultivating learner autonomy, a constructivist approach establishes a virtuous interaction between technology application and educational essence, ensuring the healthy development of teacher-student relationships.

In alignment with the strategic goal of "accelerating educational transformation in the information age" proposed in China Education Modernization 2035, it is necessary to adopt a more dialectical perspective on technology-enabled education. Future educational development should adhere to the fundamental principle of "human-centered, technology-enabled," constructing a new paradigm of smart education with Chinese characteristics. This requires fully leveraging technological advantages in educational practice while maintaining the original educational mission, establishing a dynamic balance between instrumental rationality and value rationality, and ensuring that digital-intelligent technologies genuinely serve as empowering tools to promote high-quality educational development.

References

[1] Sun, J. Y. (2020). Knowledge Densification and Elementary Education Reform: Predicaments and Breakthroughs. Contemporary *Education and Culture*, 12(4), 1–6+118. https: //doi.org/10.13749/j.cnki.cn62-1202/g4.2020.04.001

[2] Men, J. Q., & Wang, X. Y. (2025). Research on the Development of Ideological and Political Education in Higher Education Institutions in the Era of Digital-Intelligent Technologies: Value, Realistic Dilemmas and Practical Approaches. *Journal of Adolescent Studies*, (1), 21–28. https: //doi.org/10.16399/j.cnki.qsnyj.2025.01.007

[3] OECD. (2015). Students, computers and learning: Making the connection. OECD Publishing. https: //doi.org/10.1787/9789264239555-en

[4] Lu, Z. X. (2024). The Reform of Teaching Knowledge in the Knowledge Transformation of the Intelligence Era. *Educational Research,* 45(2), 55–66.

[5] Sun, Y. T., & Xiong, D. S. (2023). How Does Educational Involution Occur?—Theoretical Considerations Based on Meritocracy. *Fudan Education Forum*, 21(4), 5–10. https: //doi.org/10.13397/j.cnki.fef.2023.04.013

[6] Wang, J. Y., & Lu, Z. X. (2020). Avoiding Ethical Risks: The Chinese Wisdom for the Returning to the Origin of Education in the Age of Intelligence. *Educational Research*, 41(2), 47–60.

[7] Yan, G. C. (2021). Information Technology Revolution and School Education Reform: Reflection and Prospect. *Journal of East China Normal University (Educational Sciences)*, 39(7), 1–15. https: //doi.org/10.16382/j.cnki.1000-5560.2021.07.001

[8] Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review,* 16(4), 385–407. https: //doi.org/10.1007/s10648-004-0006-x

[9] Luo, J. H., Shen, J., & Li, H. Z. (2025). Predicaments and Reshaping Path of College Students' Subjectivity in the Era of Digital Intelligence. *Journal of Northeastern University (Social Science)*, 27(2), 137–142. https: //doi.org/10.15936/j.cnki.1008-3758.2025.02.014

[10] Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2), 257–285. https: //doi.org/10.1016/0364-0213(88)90023-7