From Human Capital to Algorithmic Capital: The Impact of AI on the Development of the Education System

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Abstract. With the rapid development of Artificial Intelligence (AI) technology, the education field is undergoing a paradigm shift from the traditional accumulation of "human capital" to the dominance of "algorithmic capital". In the wave of digital transformation, the education system is facing structural changes in the knowledge production mechanism, value evaluation standards and talent training models. This study focuses on how AI technology reconstructs the form and operation logic of capital in the field of education and systematically analyzes the deep impact of algorithmic capital on education goal setting, knowledge dissemination path, and education governance models. Its theoretical significance lies in breaking through the explanatory framework of traditional human capital theory and constructing a cognitive map of educational capital in the era of algorithms. The practical value is reflected in revealing the algorithmic trend of educational resource allocation and the crisis of educational equity and subjectivity caused by it and providing an early warning mechanism for dealing with the risk of algorithmic power intervening in the education system. The study further points out that this transformation of capital form not only reshapes the technical infrastructure of the education ecosystem but also poses new challenges to the ethical norms of talent training and the public nature of knowledge production, which provides a key thinking dimension for the adaptive reform of the global education system in the intelligent era.

Keywords: Human Capital, Algorithmic Capital, Artificial Intelligence, Education System.

1 Introduction

In the 60s of the 20th centuries, the human capital theory proposed by relevant scholars positioned education as an investment tool to improve individual productivity, and with the breakthrough of AI and big data technology, this theory is undergoing a fundamental reconstruction. Algorithms and data have become new factors of production, giving rise to Algorithmic Capital-subverting the efficiency of traditional education by optimizing resource allocation, such as GPT-4 can surpass decades of human professional training in a few weeks, resulting in the "100,000-hour rule" invalidating. Under the impact of technology, the education system is in a double dilemma, and relevant reports

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point out that the current education system is facing the danger of "double de-embedding". Externally, it lags algorithm-driven labor market changes and internally falls into the "paradox of automation". The civilization-level transformation marked by ChatGPT is driving the transition from "human-machine collaboration" to "algorithm-led", which is far deeper than previous industrial revolutions, reshaping the growth pole of wealth and shaking the foundation of civilization-digital Taylorism has infiltrated the field of education, and the anthropocentric cognitive framework has encountered existential challenges. In this context, the construction of human-machine symbiotic civilization needs to break through the traditional economic paradigm and innovate from the dimensions of technical ethics (algorithmic human rights), wealth distribution, and power checks and balances, as shown by the third way advocated by the United Nations, which is not only a reconstruction of educational philosophy, but also a key transformation for the survival of human civilization. This transformation is not only a change in the concept of education, but also a reconstruction of the education system [1]. Based on this, this paper constructs a review framework on the theme of the impact of AI on the education system from Human Capital to Algorithmic Capital and discusses the evolution of education forms and the educational changes caused by the impact of AI, as well as the challenges encountered in the transformation process and the exploration of future development. By summarizing the relevant research literature, it will help everyone to understand the impact of AI on the development of the education system more comprehensively.

2 The Evolution of Educational Capital Forms

Traditional human capital theory was mainly formed in the era of industrial economy, and its core emphasizes the empowerment of individuals through education and training to promote economic development. With the development of the economy, the industrial age has taken a step forward to the digital age, and the form of educational capital has also changed. The traditional human capital theory is based on the logic of industrial economy, while algorithmic capital relies on digital technology to redefine the value creation path of capital. The comparison between the two reveals the evolution of educational capital driven by technology.

2.1 Characteristics of Traditional Human Capital

Schultz's theory of human capital states that economic development depends on human knowledge and skills, which are the key to the continuous improvement of productivity [2]. Traditional human capital is dependent, and its core logic is to promote economic growth by increasing individual productivity through investment in education and training. This theory has played an important role in the process of industrialization, and its characteristics can be summarized in the following four aspects. First, human capital is naturally dependent on the individual, and its formation requires long-term investment in education and health, but its value realization must be through labor practice. For example, if an engineer's expertise is not put into production, the value of his capital will not be translated into real economic gains. This dependency leads to the limited

mobility of human capital, and the individual's career choice and job participation directly affects the efficiency of capital. Second, human capital can actively create value compared with the passivity of physical capital. The rise of Silicon Valley confirms this characteristic, with high-quality talent amplifying the value of physical capital and even giving birth to new industries through technological innovation (e.g., integrated circuits, the Internet). At the national level, the rapid economic reconstruction of Germany and Japan through vocational education after World War II also highlights the decisive role of human capital in macroeconomic development. Secondly, timeliness: The technological iteration of the industrial era is relatively slow, but human capital still faces timeliness constraints. For example, the value of computer skills in the '90s would have shrunk dramatically within a decade if they had not been upgraded with technology. Therefore, the traditional education system's emphasis on "one-time education" has become insufficient, and lifelong learning has become a necessary means to maintain the capital stock. Finally, since the Industrial Revolution, every technological change, from mechanical engineering to electrification, requires the structure of human capital to adapt to it. For example, the proliferation of automated assembly lines has reduced the need for manual labor but increased the requirements for equipment operation and maintenance skills. Individuals need to achieve capital appreciation through continuous learning (e.g., vocational training, and academic qualifications) to avoid being eliminated by technological advances.

2.2 The Core Composition of Algorithmic Capital

With the development of disruptive innovation in digital technology, algorithmic capital has become a new form of capital in the field of education. Its essence is to transform human behavior and cognitive processes into quantifiable and optimized capital resources through the collaboration of data, algorithms and computing power, and achieve exponential growth in value creation. Algorithms and AI-driven data extraction marked the rise of algorithmic capitalism. This force is profoundly changing the rules, regulations, and discourse of global governance, making algorithms and AI the new agents of capitalism [3]. Its competitiveness depends on the "multiplication effect" of the four elements. First, through the capitalization of learning behavior data, data assets, learners' online behaviors (such as click paths, correct answering rates, and interaction frequency) are captured and structured in real-time to form multi-dimensional data assets. Adaptive learning platforms like Knewton analyze tens of millions of students' answers to build knowledge mastery models and then sell the data to educational institutions or publishers, which directly translates into commercial revenue. The uniqueness of a data asset lies in its replicability and cumulative value-added – the more frequently it is used, the higher the prediction accuracy of the model, and the marginal cost is close to zero. The second intelligent system, the technical carrier of adaptive education, is based on machine learning and natural language processing, and the intelligent system can dynamically adjust the teaching content, difficulty and path. Duolingo optimizes course design through A/B testing, increasing learning efficiency by 200%. iFLYTEK's AI Companion evaluates language pronunciation in real-time and generates

error correction solutions. These systems not only replace some of the teacher's functions, but also help students master the pace of learning and better understand the text content in the adaptive learning system and realize the "long-tail effect" of capital appreciation through large-scale services (such as learning solutions for thousands of people) [4]. Third, decision-making automation, from experience-driven to algorithm-driven, traditional education decision-making (such as curriculum design and resource allocation) relies on the experience of managers, while algorithmic capital realizes accurate decision-making through predictive models and optimization algorithms. For example, Coursera uses learner data to predict course completion rates and automatically adjust teaching resource delivery strategies. Government education departments can also make use of regional learning data analysis to optimize the direction of financial investment. This process reduces the uncertainty of human decision-making and improves the efficiency of capital allocation.

3 AI-Induced Revolution in Education

3.1 Personalized Reconstruction of the Education Model

AI in Education encompasses the development and application of AI tools and technologies aimed at facilitating learning and improving teaching methods. Through big data analysis and deep learning algorithms, AI technology is driving the transformation of education models from "standardized production" to "precise customization", and these systems can adapt to the learner's progress and help the learner like a teacher [5]. The intelligent learning system built based on the knowledge graph can track the cognitive trajectory of students in real-time and accurately locate the blind spots of knowledge. The Knewton platform in the United States has dynamically adjusted the difficulty of exercises according to students' answers, improving learning efficiency by 39%. The Zhixue Network system developed by iFLYTEK in China generates a personalized knowledge mastery map for each student by analyzing tens of millions of homework data. This kind of accurate portrait not only covers subject knowledge but also captures emotional states through technologies such as expression recognition and speech analysis and realizes two-dimensional modeling of cognition and emotion. The application of these tools has promoted the reform of education and teaching and promoted the personalized reconstruction of education models [6].

3.2 The Integration and Innovation of Virtual and Real Teaching Scenarios

Intelligent technologies are reshaping the boundaries of interaction between physical and digital spaces. Mixed reality (MR) technology creates immersive classrooms that allow anatomy students to take a 360-degree view of human organ structure, and mechanical engineering students to disassemble virtual engines. Nanyang Technological University (NTU) in Singapore has built an AI-driven holographic classroom where teacher images can be projected in real-time to multiple campuses around the world. What is more noteworthy is the rise of the education metaverse, the "Yuan Shi Classroom" platform developed by Beijing Normal University supports teachers and students

to carry out cross-time and space collaboration in the form of digital avatars, and experimental data shows that this virtual and real integration teaching mode has increased the knowledge retention rate to 2.3 times that of traditional classrooms.

3.3 Intelligent Transformation of the Evaluation System

Traditional educational evaluation is undergoing a paradigm shift from "result-oriented" to "process-value-added". The AI-driven formative evaluation system continuously collects multi-dimensional data in the learning process (including answer time, modification traces, collaboration records, etc.) to build a dynamic growth model. The intelligent writing evaluation system developed by East China Normal University can not only automatically correct grammatical errors but also analyze the deep elements such as argument logic and emotional expression. The International Baccalaureate Organization (IBO) has piloted the use of AI-assisted scoring, with 92% consistency between the system and human experts. This intelligent evaluation system is reshaping the perception of education quality, making evaluation truly a tool for development rather than a yardstick for selection.

3.4 A Technical Breakthrough for Educational Equity

AI provides a new way to solve the imbalance of educational resources. The practice of AI dual-teacher classrooms in schools in mountainous areas of Yunnan Province shows that the collaborative teaching of intelligent teaching assistants and local teachers has increased the average score of mathematics by 21 points. The distributed learning system supported by the knowledge federation technology can realize the cross-regional sharing of high-quality educational resources under the premise of protecting data privacy. More fundamentally, breakthroughs in natural language processing technology are removing language barriers, and UNESCO's AI Translation Classroom project has achieved real-time translation between 76 languages, allowing students in remote areas to directly listen to Harvard and Cambridge courses. AI technology is driving innovation in education, improving students' ability to solve real-world problems and accelerating the learning process. The judicious use of AI can help reduce the burden on teachers and allow them to focus on developing students' critical thinking and ethical behavior [7].

3.5 The Intelligent Challenge of Educational Ethics

There are multiple ethical risks lurking behind technological empowerment. Algorithmic bias may lead to specific groups being misjudged by the system, and MIT experiments show that the error rate of an intelligent tutoring system for the prediction of knowledge points of African American students is 15% higher than that of white students. Data security has become a key issue, and sensitive information such as biometric data and emotional data generated in the education process is at risk of being abused. To this end, the European Union has issued a Code of Ethics for AI in Education, which requires algorithms to be explainable and data collection to be explicitly

authorized. The education sector is exploring the establishment of an "augmented intelligence" model of human-machine collaboration, which not only maintains the dominant position of teachers, but also gives full play to the auxiliary value of AI.

4 Key Challenges in the Transformation Process

The introduction of AI has brought profound changes to the education system, and the transformation from Human Capital to Algorithm Capital is an inevitable trend in the development of education. However, this transformation has been accompanied by challenges such as data privacy, the role of teachers, educational equity, and evaluation systems [8]. In order to achieve the goal of AI-enabled education, it is necessary for all parties to work together to formulate corresponding policies and measures to ensure the smooth progress of education transformation, and emphasize the use of AI to improve the efficiency of human work in the field of education rather than replace teaching staff, and ultimately achieve the improvement of education quality and educational equity [9].

4.1 The Transformation of Human Capital and Algorithmic Capital

The traditional education system focuses on cultivating students' knowledge, skills and abilities, emphasizing the leading role of teachers and classroom activities, but with the development of AI technology, education gradually relies on data-driven algorithm systems, adaptive learning platforms, intelligent tools and personalized learning paths, emphasizing the dominance of technology in education. As AI technology advances, the education system shifts from a teacher-centric model to a learner-centered model that emphasizes personalized learning, implementing feedback, and data-driven decision-making processes.

4.2 Key Challenges in the Transformation Process

AI systems rely on large amounts of student data, and education data can contain sensitive information that can be accessed or misused without authorization. Second, AI systems can be able to be historically biased, leading to unequal treatment of specific groups. Scenarios where AI is used are crucial, and fairness is only affected if the output does not affect the scoring of the results [10]. The application of AI technology requires teachers to have not only the ability to teach, but also to master skills such as data analysis, technology integration, and application of AI tools, which makes it difficult for many educators to effectively use AI tools without the necessary technical training. Teachers need to transform from knowledge transmitters to learning facilitators and technology facilitators, facing the challenge of identity and career orientation. When the standard evaluation lags, the existing evaluation system may not be able to fully measure the effect of AI-assisted learning, and when the learning mode changes, the learning mode of students shifts from passive acceptance to active exploration and independent learning, and teachers need to adjust their teaching strategies to adapt to this change.

5 Future Outlook and Strategic Recommendations

In the context of the rapid penetration of AI into the education system, the future development of education should be centered on promoting equity, improving quality, and enhancing inclusiveness. First, policymakers should develop clear AI ethics and privacy protections to ensure the transparency and fairness of the technology and prevent algorithmic bias and data abuse. At the same time, the education department should increase AI training for teachers, improve their data literacy and technology integration capabilities, and enable them to effectively use AI tools for teaching and management. In addition, schools should introduce personalized learning paths and intelligent tutoring systems to meet the learning needs of different students and improve educational effectiveness. However, access to technology may also exacerbate disparities in access to education, especially in low-income and remote areas. Therefore, governments and all sectors of society should work together to close the digital divide and ensure that all students can equally benefit from the educational transformation brought about by AI. Through these comprehensive measures, AI will become an important force in promoting equity and quality in education, laying a solid foundation for students' all-round development and lifelong learning. In short, the transformation from Human Capital to Algorithmic Capital is an inevitable trend in the development of education. It is only through a holistic strategy and concerted efforts that we can ensure that this transformation not only improves the quality of education but also promotes educational equity and social progress.

6 Conclusion

This paper focuses on the transformation from Human Capital to Algorithmic Capital, and discusses the important trend brought about by the deep involvement of AI in the development of the education system and discusses how this change not only reshapes the way of knowledge impartation but also reconstructs the allocation logic of educational resources and the talent training model. This paper analyzes the transition from Human Capital to Algorithmic Capital by using literature analysis methods and concludes that the application of AI technology shows great potential in improving teaching efficiency, promoting personalized learning, and optimizing education management, but it also brings deep challenges such as the changing role of teachers, data ethical risks, resource inequality, and educational equity. In the future education system, algorithmic capital will play a key role in assisting educational decision-making and guiding learning paths, but it cannot completely replace the emotional communication and value guidance functions carried by human capital. Therefore, the reform of education should seek a balance between technology-driven and humanistic care, and build a people-oriented, technology-empowered, fair and efficient education ecosystem. Only in this way can AI truly help the education system move towards a more inclusive and intelligent stage of development.

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