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Analysis of MOOC User Adoption Patterns Based on the Diffusion of Innovations Theory

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Abstract: Research on the diffusion of smart education technologies is critical for enhancing their implementation in higher education contexts. As an innovation within smart education, Massive Open Online Course (MOOC) platforms have been extensively adopted and promoted across higher education institutions, enabling the global exchange and dissemination of educational resources. This study centers on MOOCs, employing the theoretical framework of technological innovation diffusion to investigate their diffusion trajectories and to systematically analyze the characteristics of MOOC adopters. The results indicate that from 2014 to 2024, the diffusion of MOOCs conformed to an S-curve model. In China, MOOC users are presently transitioning from the "early majority" phase to the "late majority" phase. During this diffusion process, the "early majority" and "late majority" groups constituted the largest proportions of adopters, with university faculty and students identified as the principal agents driving diffusion. In sum, smart education technologies have attained extensive adoption within the educational sector.

Keywords: Technology Diffusion; S-Curve; MOOC; Diffusion Characteristics

1. Introduction

In recent years, the integration of emerging technologies such as artificial intelligence, big data, and the Internet of Things into the educational sector—along with the enhancement of instructional resources and the open dissemination of high-quality educational materials—has facilitated the convergence of information technology and pedagogical practices. This convergence has established a technological foundation for blended learning. Notably, innovative instructional models, including MOOCs, SPOCs, and flipped classrooms, have catalyzed significant shifts in educational paradigms, methodologies, and delivery mechanisms. The blended learning approach effectively combines the collaborative advantages of traditional classroom settings with the personalized features of online learning, thereby providing a robust framework for the deep integration of information technology and education. With the ongoing development of intelligent teaching platforms and the continuous expansion of online course offerings, the learner population has grown substantially, positioning online education as a prominent area of inquiry within both educational sciences and computer information disciplines. Currently prevalent intelligent teaching platforms include MOOC (Massive Open Online Course), XuetangX, Chaoxing Learning Pass, iClass, Yuke, NetEase Open Course, Tencent Classroom, DingTalk Education, ClassIn (Online Interactive Classroom), and AI Learning Classroom. Among these, MOOCs epitomize the "Internet + Education" paradigm, representing a novel online course delivery model that leverages internet technologies to facilitate the open sharing of educational resources, drive pedagogical innovation, enhance broad access to high-quality educational content, accelerate the fusion of educational innovation with technological advancements, and exemplify the diffusion of smart education technologies.

The Diffusion of Innovations theory was first proposed by the American scholar Everett Rogers in the 1960s. This theory posits that the diffusion of innovations is a fundamental social process, whereby innovations take a certain amount of time to spread through specific channels within particular social systems. [1]. "Innovation" refers to new things, designs, inventions, or even novel ideas, behavioral trends, or practices. The diffusion process comprises four essential elements: the innovation itself, communication channels, time,

and the social system. All four elements are indispensable. As an educational technology innovation, the smart teaching platform functions as an intermediary in knowledge dissemination, serving as a vital vehicle for knowledge diffusion. The promotion and application of educational technology share certain similarities with the diffusion of general technological innovations.

2. Review of Related Research

In recent years, research on smart education has become increasingly extensive. Zhu et al. proposed that smart education refers to education developed with the support of information technology, encompassing education supported by intelligent technologies, education for learning intelligent technologies, and education that promotes intelligent development[2].Yang et al. argued that the integration of information technology into education is demonstrated through innovative applications developed using technologies such as the Internet of Things, big data, cloud computing, and ubiquitous networks[3].Regarding the definition of technological innovation diffusion, Zhang builds upon the concept to define technology diffusion as the process by which innovations in educational technology applications spread among members of the education system over time through specific channels[4].Regarding the study of factors influencing technology diffusion, numerous scholars have applied innovation diffusion theory to online education research, focusing on five key elements: relative advantage, compatibility, complexity, trialability, and observability[5].Zhao developed a model of factors influencing MOOC diffusion and sharing based on the ISM framework, categorizing these factors into four dimensions: course platform functionality, learner characteristics, instructor support, and the development and application environment[6]. Building upon the Unified Theory of Acceptance and Use of Technology (UTAUT), Zhao et al. analyzed the factors influencing college students' willingness to use MOOCs from five perspectives: motivation, opportunity, capability, perceived complexity, and perceived usefulness[7].Regarding technological diffusion models, both domestic and international scholars primarily study innovation diffusion using various approaches. These include the Bass model and its variants, as well as models based on cellular automata and agent-based simulations. Mehmood et al. proposed a variable analysis model to predict innovation adoption across different diffusion stages. By examining three variables—time, project, and adopter—they analyzed information diffusion on the internet and within social networks, forecasting the number of individuals adopting trending online information[8].Building upon existing technology diffusion models, Kannan Aadharsh et al. established the Marseille diffusion model and applied it to cloud diffusion, demonstrating that cloud diffusion exhibits both log-log and logistic growth patterns[9]. Regarding research on the diffusion process, Yan et al. posited that educational informatization constitutes an innovation diffusion process. This process primarily encompasses two stages: innovation adoption and innovation application. The core of diffusion lies in secondary innovation within schools, with key influencing factors including improvements in basic school hardware and software infrastructure, as well as enhancements in teachers' information literacy[10]. Zhai et al. divided the diffusion process into five stages: testing and evaluation, implementation, refinement, expansion, and decline[11]. Song categorized the S-shaped cumulative curve of innovation adoption rates into four phases: initiation, takeoff, maturity, and decline [12].

Existing diffusion research primarily focuses on defining the diffusion of scientific innovations, methodologies, and technology-related advancements. The literature centers on conceptualizing the diffusion of technological innovations, analyzing influencing factors, and constructing models of the diffusion process. Current studies on MOOC innovation diffusion mainly address MOOC development, factors influencing diffusion, diffusion theories, and diffusion pathways. This study analyzes the development trajectory of MOOCs over the past decade, compiles relevant statistical data, and applies technological innovation diffusion theory to examine the dynamic evolution of educational technology throughout its diffusion process. Through data analysis, it aims to identify the characteristic S-curve patterns of technological diffusion.

3. Analysis of the Diffusion Process of MOOCs

Educational technology innovation is a comprehensive diffusion process. As an example

of such innovation, MOOCs spread through channels such as the internet and interpersonal interactions within educational systems, including universities and research institutions, over a certain period. Online courses, gradually adopted by teachers, students, and social workers via MOOC platforms, have facilitated the dissemination, learning, and recreation of knowledge. Rogers summarized the characteristics of innovation, identifying relative advantage, compatibility, complexity, trialability, and observability as key factors[1]. By synthesizing and analyzing both domestic and international scholarly research on the diffusion of innovative technologies, and examining MOOC course data from Chinese universities, it can be concluded that the diffusion of MOOC platforms offers relative advantages, promotes the integrated development of education and technology, and exhibits characteristics such as complexity and compatibility inherent to technological innovation.

3.1 Data Source

To gather information as comprehensively as possible, this study collected MOOC-related reports from educational websites such as Class Central, The Chronicle of Higher Education, Inside Higher Education, and EdSurge. It also tracked blogs, news articles, and reports from major MOOC platforms, including Coursera, edX, FutureLearn, Udacity, XuetangX, and China University MOOC. This data serves as the basis for analyzing the diffusion of smart education technologies.

3.2 The Diffusion Curve Pattern of MOOCs

The annual cumulative adoption curve for most technological innovations follows an S-shaped pattern, corresponding to distinct diffusion stages. Rogers [1] divides the S-curve into the early adoption stage, the rapid growth (takeoff) stage, and the stabilization stage. Based on Rogers' S-curve theory, this paper uses the annual cumulative number of MOOC registrants as the cumulative adopters, the number of new registrants as the adoption rate, and the difference in adoption rates between consecutive years as the diffusion acceleration. This approach generates a statistical table of MOOC diffusion metrics from 2014 to 2024 (see Table 1). Plotting the diffusion curve of MOOCs over the past decade, with time as the horizontal axis and the cumulative number of adopters at corresponding time points as the vertical axis, reveals that the diffusion process of Chinese university MOOCs from 2014 to 2024 follows an S-shaped curve (see the cumulative curve in Figure 1). From the perspective of China's educational informatization development, smart education technologies exhibit distinct phase characteristics across different historical periods. By integrating MOOC diffusion metrics (Table 1: Diffusion Metrics of Chinese University MOOCs, 2014–2024), we analyze the phased diffusion patterns of smart education technologies within China.

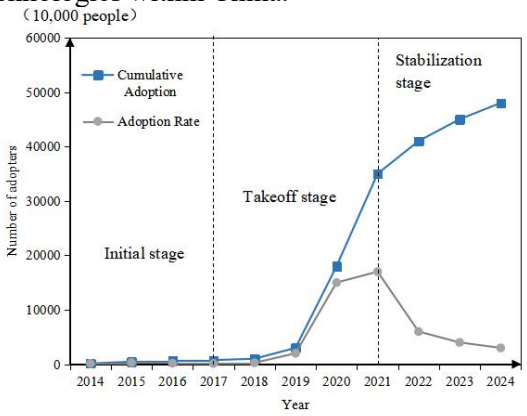

Figure 1. Diffusion Curve of MOOCs in Chinese Universities, 2014–2024

In 2013, Chinese universities began participating in initiatives to develop MOOCs. Over the past decade, under the guidance of the Ministry of Education, MOOC platforms have been widely adopted and disseminated. Universities have actively contributed to building and promoting online teaching resources. Initially, this educational technology innovation was adopted by only a small number of users, resulting in slow diffusion. From 2014 to 2016, during the initial diffusion phase, MOOCs continued to spread domestically. Through effective efforts in platform development, course creation, and promotion, the number of registered users on these platforms gradually increased. Beginning in 2014, high-quality courses were launched on MOOC platforms through two approaches: introducing foreign MOOCs and developing Chinese MOOC courses. These courses covered multiple disciplines, including computer science, social sciences, history, medicine, literature, folklore, arts, economics, and law.

In 2017, the diffusion acceleration was positive and showed a significant increase, marking the beginning of the diffusion takeoff phase. The state began participating in MOOC development by launching the first batch of high-quality

online open courses. During the diffusion process, the advantages of online teaching based on MOOC platforms became increasingly evident, with numerous educators participating in the creation of premium online courses and growing classroom participation rates. In 2019, the diffusion acceleration reached its highest point in nearly a decade, marking a first-order inflection point. Subsequently, the rate of adoption acceleration slowed, although the adoption rate continued to increase steadily. In 2019, MOOC platforms enhanced their functional design through the integration of new technologies, including artificial intelligence, machine learning, and virtual/augmented reality (VR/AR), to improve learner experiences. During the pandemic, MOOCs provided a critical platform for university online teaching, compelling countless educators to innovate through forced adaptation to digital instruction. In 2020, the World MOOC and Online Education Alliance was established, launching globally integrated courses and open lectures that attracted scholars worldwide to participate in learning.

In 2021, the adoption rate reached its peak, with the highest number of new adopters at this point. The diffusion acceleration turned negative, marking a second-order inflection point. Diffusion reached a critical threshold, achieving a "critical mass," corresponding to the successful diffusion of smart education technology in 2021 and entering a stable diffusion phase. In 2021, five ministries, including the Ministry of Education, introduced multiple policies to advance online teaching, such as the "Opinions on Vigorously Strengthening the Construction and Application of Online Educational Resources for Primary and Secondary Schools" and the "Several Opinions on Strengthening the Management of On-Campus Course Teaching in General Higher Education Institutions." Concurrently, the nation actively promoted the construction of new educational infrastructure, fostering the integrated development of online and offline education while driving digital innovation, intelligent upgrades, and convergent innovation in the education sector. In 2022, with the Ministry of Education implementing the "National Digital Education Strategy Action," the National Smart Education Public Service Platform officially launched. The deepening popularization of MOOCs has accelerated the rapid and stable development of online education in China, revolutionizing course development and classroom teaching across universities. New models and methods of online-offline teaching with Chinese characteristics continue to emerge.

Overall, the diffusion phase of Chinese MOOCs can be divided into three stages: The first stage, spanning 2014–2016, marked the initial phase of diffusion. During this period, the number of MOOC adopters remained relatively small, with only a handful of users registering on MOOC platforms. As the number of courses increased and uncertainty gradually diminished throughout the diffusion process, the number of adopters steadily grew. The second stage, spanning 2017–2020, marked the takeoff phase. The online teaching advantages of MOOC platforms became increasingly evident during this period. Numerous educators participated in developing high-quality online courses, and classroom participation rates rose significantly. Cumulative adoption grew rapidly, reaching tens of millions of users, with a large number embracing innovations in smart education technology. The third phase, spanning 2021–2024, marks the diffusion maturity stage. As the number of early adopters reached a critical mass, awareness of MOOC innovation spread widely, leaving fewer individuals unaware of the technology. Consequently, the growth rate of adopters slowed, and the pace of adoption began to decline. MOOC platforms, as a representative innovation in smart education technology, have achieved widespread diffusion and are now in a mature phase.

Table 1. Diffusion Indicators of MOOCs in Chinese Universities, 2014–2024

Year	Cumulative Adoption (10,000 people)	Adoption Rate (10,000 people)	Diffusion Acceleration
2014	150	150	0
2015	450	300	150
2016	620	170	-130
2017	750	130	-40
2018	1000	250	120
2019	3000	2000	1750
2020	18000	15000	13000
2021	35000	17000	2000
2022	41000	6000	-11000
2023	45000	4000	-2000
2024	48000	3000	-1000

3.3 User Adoption Patterns of MOOCs

In the theory of innovation diffusion, Rogers categorizes adopters based on the sequence of their adoption within the diffusion process and the number of adopters at different stages. These categories include Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. These five stages account for 2.5%, 13.5%, 34%, 34%, and 16% of the total user population, respectively. Early adopters wield significant influence within the social system and are often termed "opinion leaders." As early adopters disseminate the innovation within their networks, more members of the general public mimic their behavior, accelerating the diffusion process. The diffusion curve's slope rises rapidly, marking the entry into the takeoff stage. Increasing numbers of potential adopters within the system begin considering whether to adopt the innovation based on acquired information or advice from adopters. During this phase, cumulative adoption grows steadily, with adopters comprising the early majority and late majority. Subsequently, the diffusion process slows, and finally, the curve's growth stabilizes, corresponding to the diffusion's stabilization phase. Adopters who accept the innovation later are termed laggards. Compared to earlier adopters, they tend to be less educated, have lower social status, and possess fewer interpersonal connections. By the time adopters in the late diffusion stage accept the innovation, it is no longer considered novel. Over time, this innovation gradually becomes obsolete.

To better study user adoption of MOOC platforms, the "diffusion rate" metric is employed. This represents the percentage increase in the number of users adopting the MOOC platform per unit time, specifically the annual percentage point growth rate of MOOC platform adoption. User numbers and adoption rate data are presented in Table 2.

Table 2. User Numbers and Adoption Rates of MOOCs in Chinese Universities, 2014–2024

Year	Cumulative Adoption (10,000 people)	Adoption Rate (10,000 people)	Diffusion Acceleration
2014	150	150	0.11%
2015	450	300	0.33%
2016	620	170	0.45%
2017	750	130	0.54%
2018	1000	250	0.71%
2019	3000	2000	2.13%
2020	18000	15000	12.75%
2021	35000	17000	24.78%
2022	41000	6000	29.04%
2023	45000	4000	31.92%
2024	48000	3000	34.08%

According to Rogers' classification of adopters, users of Chinese MOOCs are currently transitioning from the "early majority" to the "late majority" stage. During the diffusion process, the early majority and late majority constitute the largest proportions and exert significant influence on MOOC diffusion. Rogers noted that the early majority serves as the primary force in innovation diffusion, signifying that an innovation has begun to gain widespread acceptance. In the diffusion of MOOCs, educational institutions such as universities and open universities serve as the primary diffusion systems. Adopters of MOOC platforms are predominantly experts, scholars, and students. Representative domestic universities include the China National Open University, Peking University, Tsinghua University, Wuhan University, Nanjing University of Posts and Telecommunications, Northeastern University, and East China Normal University. Key operating entities include the China National Open University, NetEase, and Chaoxing Group. MOOC diffusion primarily occurs through two modes: human-content interaction (users engaging with MOOC course content) and human-human interaction (interactions between teachers and students via interpersonal networks). The richness, academic rigor, significance, and value of course content and resources on MOOC platforms significantly influence human-content interaction. By creating, adopting, applying, and sharing high-quality course resources, the number and frequency of users within higher education institutions gradually increase. Leveraging efficient teaching applications, online educational resources like MOOCs facilitate information sharing among users. During MOOC diffusion, scholars and university students expand the reach of MOOCs through learning from online course materials. Additionally, interpersonal communication enables them to recommend MOOC platforms to friends and classmates, allowing MOOC platforms to spread massively

across broader demographics. Therefore, it can be concluded that academic experts and university student groups are the primary drivers of knowledge graph software diffusion. Faculty and students (especially educators) serve as the core participants in teaching model reform and represent the early adopters.

4. Conclusion

Educational technology innovation is a comprehensive diffusion process. As an educational technology innovation, MOOCs feature mature information technology and open-sharing teaching resources, gaining increasing recognition and acceptance among educators and learners. During this diffusion process, educational technology also drives the promotion of educational values. This study focuses on the promotion of MOOCs and conducts an in-depth analysis of their diffusion characteristics based on innovation diffusion theory. The findings reveal that MOOCs exhibit distinct features such as complexity and compatibility. While university faculty and students constitute the primary diffusion agents, issues of insufficient agent participation exist. The diffusion process is influenced by factors including educational, information technology, commercial, and institutional environments. By constructing diffusion indicators, statistically analyzing MOOC adoption metrics, and plotting diffusion curves, the study concludes that China's MOOC diffusion can be divided into three phases: Phase I (2014–2016) represents the diffusion initiation stage; Phase II (2017–2020) marks the diffusion takeoff stage; and Phase III (2021–2024) signifies the diffusion maturity stage. Currently, the number of MOOC courses continues to grow, with the diffusion curve showing an upward trend though at a slowing pace. Chinese MOOC users are transitioning from the “early majority” to the “late majority” phase. Throughout the diffusion process, the “early majority” and “late majority” segments constitute the largest proportions, with university faculty and students serving as the primary drivers of diffusion.

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