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Conditions of College Students' Successful Autonomous Learning under the Background of "Internet+Education" and Collaborative Support Mechanism with Teachers and Students

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Abstract

With the continuous promotion of the strategy of "Internet plus Education", the digital transformation of higher education has entered a stage of deep integration, and the scene, resource supply and behavioral logic of college students' autonomous learning have undergone systematic changes. Based on the current situation of digital practice in higher education, this paper systematically defines the core connotation of college students' autonomous learning in the context of "Internet plus education" from three dimensions of learning subject, technical environment and institutional support. Through empirical investigation, qualitative analysis and linear multiple regression analysis, six key success conditions of autonomous learning are determined: metacognitive condition ($\beta=0.372$, $P<0.001$), teacher guidance conditions ($\beta=0.241$, $P<0.001$), digital resource conditions ($\beta=0.186$, $P<0.001$), learning community conditions ($\beta=0.127$, $P<0.001$), intelligent tool support conditions ($\beta=0.094$, $P<0.001$), and system evaluation conditions ($\beta=0.079$, $P<0.001$). Based on this, a collaborative support mechanism of "hierarchical collaboration and dynamic adaptation" between teachers and students was constructed. The results of this study suggest that current self-directed learning among college students is not simply "student self-directed learning", but a new form of learning in a human-machine collaborative environment with metacognitive ability as the core, digital resources as the support, and teacher-student two-way interaction as the guarantee. Therefore, colleges and universities can start from three aspects: optimizing the curriculum system, changing the role of teachers, and improving the platform ecology to provide material and human conditions and find practical solutions to promote the cultivation of college students' autonomous learning ability in the "Internet plus Education" environment.

Key words: Internet+education; College Students' autonomous learning; Success conditions; Collaboration between teachers and students; Digital intelligence education

1. Introduction

Many influential countries and international organizations are intensively introducing policies to promote the in-depth integration of intelligent technology and all elements of education, forming a differentiated overall promotion pattern of "people-oriented, ability priority, scene landing". The policy paths and core focus of different countries have distinct characteristics.

1.1 Relevant policies of several representative organizations and countries

1.1.1 Global framework of the United Nations and international organizations

UNESCO's global action framework of "AI in Education"[1]: released in 2021, the core principle is to adhere to the human centered AI education concept, which clearly requires that AI education must take the promotion of educational inclusion and equity as the bottom line, avoid expanding the digital divide between and within countries, and promote the implementation of the inclusive education goal of "AI for all".

UNESCO's Global ICT in Education Policy Guide [2]: provides a toolkit for policy-making for all Member States to help countries formulate top-level planning for intelligent education in combination with their national conditions, focusing on supporting low-income countries to make up for the shortcomings of intelligent education infrastructure and narrow the digital gap in global education.

The Action Programme of the Transform Education Summit [3]: after its release in 2022, it continued to promote the implementation, made clear that intelligent education was the core direction of action, and required countries to establish national policy frameworks, promote the next generation of digital technology to comprehensively reshape the education system, promote education equity and improve education quality with intelligent education, and support the realization of the United Nations sdg4 quality education goal.

1.1.2 Market oriented policy system in the United States

The United States does not have a unified national mandatory intelligent education policy, which is mainly promoted through federal acts and market guidance:

First, the federal government has set up a special fund through the Every Student Succeeds Act (ESSA) [4] to support the States to carry out AI education application innovation pilot, focusing on funding the development of personalized adaptive learning tools for K12 stage.

Second, the educational technology office under the Ministry of education has continued to release the National Educational Technology Plan [5]. The latest version focuses on the design of AI enabled personalized learning paths, and encourages universities and science and technology enterprises to jointly develop innovative products for intelligent education.

Third, the overall policy takes market innovation as the core driving force. Technology enterprises such as Google and Microsoft have deeply participated in the construction of intelligent education ecology, forming a promotion mode of "policy setting, enterprises' singing, and schools' independent choice".

1.1.3 EU's ethical priority policy system

The EU's smart education policy is characterized by risk prevention and ethical norms:

First of all, the Regulation (EU) 2024/1689 laying down harmonised rules on artificial intelligence (AI act) [6], which came into force in 2024, explicitly brought the AI system in the field of education into the regulatory scope of "high-risk AI applications", requiring that all intelligent education products for students must pass strict compliance assessment, and prohibiting the use of AI for opaque automated evaluation and discriminatory screening of students.

Secondly, the European Commission launched the Action Plan for the European Education Area at the same time [7] and set up a special fund to support member states in developing intelligent education tools that meet EU data security standards, focusing on ensuring students' personal data security and learning autonomy.

In general, the core logic of the EU's relevant policies is to "establish rules before development". While encouraging the application of technology, it strictly adheres to the bottom line of data security and algorithm fairness.

1.1.4 China's intelligent education policy system

China is one of the countries with the most systematic promotion of intelligent education policies in the world, and has formed a complete policy chain from top-level design to implementation details:

In 2026, the Ministry of education and other five departments jointly issued the "AI+Education" Action Plan [8], which clearly proposed to build a new form of intelligent education with man-machine collaboration, virtual and real combination, and ubiquitous accessibility, so as to promote the integration of all elements, the whole process and the whole scene coverage of intelligent technology and education. All provinces and cities have simultaneously issued supporting policies to integrate intelligent education into the core task of digital transformation of education, focusing on promoting the popularization and application of AI adaptive learning system, virtual simulation experiment, smart campus and other scenarios. The core orientation of the policy always adheres to "technology serves people", avoids the abuse of technology to replace students' independent thinking, and takes intelligent technology as the core of promoting educational equity and improving the quality of talent cultivation. Under this policy background, most colleges and universities in China have completed the construction of the infrastructure of smart campus. The total number of online course resources has exceeded 10 million. The channels for college students to obtain learning resources have changed from the traditional single channel of classroom to the diversified supply mode of "online and offline integration, and intercommunication inside and outside the school".

1.2 Common trends in global policies

At present, the intelligent education policies of various countries have formed five obvious consensus directions: First, adhere to the core principle of taking human beings as the center, and make it clear that AI can not replace the leading role of teachers, and technology is always a tool to assist education. Second, promote education equity as the core policy goal, and deliver high-quality education resources to areas with weak education through intelligent technology. Third, open and shared global high-quality

education resources synergy. 43% of countries are promoting the transformation of "AI+Education". China has upgraded the international version of the National Smart education public service platform, built a global AI education service portal, a multilingual lifelong learning center and an international Chinese learning community, and promoted the cross-border flow of high-quality educational resources; The global intelligent education network (GSENet) [9] also clearly takes openness, inclusiveness and equity as the core direction of action, and calls on countries to collaborate to narrow the education gap and jointly support the implementation of the lifelong learning goal for all. Fourth, AI literacy popularization and ability hierarchical training in the whole learning period. Many countries have incorporated AI related content into the national education system: China has implemented AI education since the age of 6, with at least 6 hours of relevant courses per week; India plans to open AI and Computational Thinking courses in grade 3 from the 2026-2027 academic year, and simultaneously launch the training of ten million teachers [10]; Singapore has made it clear that all higher education students must study AI compulsory modules from 2027, and built a hierarchical ability framework covering "understanding AI, using AI, collaborating with AI, and surpassing AI" [11]; OECD and the European Union have also launched an AI literacy framework for primary and secondary schools, covering comprehensive dimensions such as technical ethics and social impact. Final, we should promote technology application and risk management under human-computer cooperation. While encouraging innovation, we should issue ethical norms to protect students' rights and interests, and avoid algorithm discrimination, data leakage and other issues. All countries generally regard security and compliance as the core premise for the implementation of intelligent education: In the AI governance framework for higher education [12], Singapore focuses on risks such as academic integrity, algorithm bias, and degradation of students' metacognitive ability, and establishes institutionalized safe use norms; UNESCO clearly puts forward the "people-oriented" AI education principle, which requires avoiding the expansion of the digital divide between and within countries by technology application [13]; The 2026 World Conference on Digital Education synchronously released the artificial intelligence education ethics: a reference framework [14] to delineate a unified ethical boundary for the application of global intelligent education.

1.3 Difficulties in implementing national policies

However, at the practical level, the current college students' autonomous learning still faces many practical difficulties: Some students have "lost their way" in massive digital resources, which seems to spend a lot of time browsing the learning content, but have not formed a systematic knowledge system; Some colleges and universities simply equate autonomous learning with "letting students watch online classes themselves", weakening the guidance and support role of teachers, resulting in autonomous learning becoming "laissez faire learning" without supervision and feedback. In addition, the intelligent support function of some platforms only stays at the resource push level, and cannot adapt to the personalized learning rhythm of students from different disciplines and different foundations [15].

In this context, clarifying the successful conditions of College Students' Autonomous Learning under the background of "Internet+education" and building a teacher-student collaborative support mechanism suitable for the new scene can not only respond to the needs of the implementation of the digital education strategy,

but also effectively solve the pain points existing in the current practice of College Students' autonomous learning, which has important practical significance for improving the quality of higher education personnel training and cultivating high-quality talents suitable for the intelligent era.

2. Literature basis and concept definition

2.1 Relevant research status at home and abroad

The research on Autonomous Learning in foreign countries started earlier. Zimmerman's social cognitive theory of autonomous learning [16] divides autonomous learning into three core links: self planning, self-monitoring and self reflection, and constructs a classic analytical framework for autonomous learning behavior. Garrison's inquiry community model [17] focuses on the analysis of the interactive relationship among cognitive existence, social existence and teaching existence in the online learning scene, which provides an important theoretical basis for the research of autonomous learning in the network environment. In recent years, with the development of artificial intelligence technology, foreign research has begun to pay attention to the supporting effect of intelligent agents on autonomous learning. Relevant studies [18] pointed out that adaptive intelligent partners can significantly improve learners' metacognitive monitoring ability, but can not completely replace the emotional support and value guidance brought by interpersonal interaction.

The research on Autonomous Learning in domestic academic circles has gradually increased since 2000. The early research mainly focused on the construction of autonomous learning mode in the traditional classroom scene. With the promotion of digital education, relevant research began to turn to the direction of autonomous learning strategies and influencing factors in the online learning environment. Through the bibliometric analysis of the relevant literature of CNKI from 2016 to 2026, it can be found that the current domestic research is mainly concentrated in three directions: First, the current situation investigation and scale development of College Students' autonomous learning ability; The second is the analysis of the impact of online learning platform on autonomous learning behavior; The third is the practical exploration of the autonomous learning mode under the specific curriculum scenario [19].

However, there is an obvious research gap in the existing research: Most studies have isolated the influencing factors of autonomous learning, and have not systematically refined the core success conditions of autonomous learning in the "Internet+education" scenario; At the same time, most studies define the relationship between teachers and students as a one-way relationship between "instructors and learners", and do not combine the current new educational form of human-computer collaboration to build a two-way interactive and dynamically adaptive teacher-student collaboration support mechanism. This paper is to explore this gap in depth.

2.2 Definition of core concepts

In this paper, the autonomous learning of College Students under the background of "Internet+education" is not the independent learning of students without the guidance of teachers in the traditional sense, but refers to a new learning form in which learners, guided by their own development needs, actively use

various digital resources and intelligent tools, independently set learning goals, plan learning paths, monitor learning processes, reflect on learning results, and complete knowledge construction and ability improvement under the collaborative support of teachers [20]. Its core features are reflected in three aspects [20]: The first is the ubiquity and accessibility of learning resources, which breaks the time and space constraints of the traditional classroom; The second is the intelligent empowerment of learning tools. AI tools can provide immediate support for learners; The third is the symbiosis of teacher-student relationship. Teachers have changed from a one-way transmitter of knowledge to a guide, supporter and collaborator of autonomous learning.

3. Research design and data collection methods

In this paper, the quantitative and qualitative hybrid research method is used to systematically identify the success conditions of College Students' autonomous learning. In the quantitative research part, based on Zimmerman's theoretical framework of autonomous learning [16], combined with the domestic "Internet+education" practice scenario, this study designed a 33-item "Questionnaire on Influencing Factors of College Students' Autonomous Learning Effectiveness in the Background of Internet+Education", which was distributed to undergraduates from five universities at different levels in Guangdong, and a total of 1287 valid questionnaires were collected. The samples covered all disciplines such as liberal arts, science, engineering, business and art, ensuring the representativeness of the samples.

In the qualitative research part, this study uses the purposive sampling method [21], and selects 24 college students who have outstanding performance in autonomous learning, 12 front-line teachers and 6 university teaching managers to conduct semi-structured in-depth interviews. The interviews focus on core issues such as "key supporting factors encountered in the process of autonomous learning", "main obstacles existing in current autonomous learning" and "effective forms of collaborative support between teachers and students". The interviews have accumulated more than 180000 words of transcripts, providing solid qualitative data support for subsequent condition identification and mechanism construction.

4. Empirical data analysis on the success conditions of College Students' Autonomous Learning

This chapter is based on the survey data of 1287 valid questionnaires, and through descriptive statistics, exploratory factor analysis and multiple linear regression analysis, self-compiled "Questionnaire on Influencing Factors of College Students' Autonomous Learning Effectiveness in the Background of 'Internet+Education'", which is used to systematically test the rationality of the six success conditions, quantify the influence weights of different conditions on autonomous learning effectiveness, and provide solid data support for the construction of subsequent teacher-student collaborative support mechanism.

4.1 Descriptive statistics of basic characteristics of samples

The 1287 valid samples of this survey cover full-time undergraduates from five universities at different levels in

Guangdong (Sun Yat sen University, South China University of technology, Shenzhen University, Guangdong Neusoft University and Lingnan Normal University). The demographic characteristics of the samples are as follows:

4.1.1 School distribution:

296 from Sun Yat sen University, 246 from South China University of technology, 335 from Shenzhen University, 191 from Guangdong Neusoft University and 219 from Lingnan Normal University. It basically meets the proportion of full-time undergraduates in the above five universities.

4.1.2 Gender distribution:

672 boys, accounting for 52.2%; There are 615 female students, accounting for 47.8%, and the proportion of male and female is basically in line with the overall gender distribution characteristics of undergraduates in colleges and universities in Guangdong Province.

4.1.3 Grade distribution:

Grade distribution: 321 freshmen, accounting for 24.9%; 358 sophomores, accounting for 27.8%; 342 junior students, accounting for 26.6%; 266 senior students, accounting for 20.7%. The sample distribution of each grade is relatively balanced, avoiding the deviation caused by a single grade sample.

4.1.4 Subject distribution:

306 liberal arts students, accounting for 23.8%; 269 science students, accounting for 20.9%; 386 engineering students, accounting for 30.0%; 192 business students, accounting for 14.9%; 93 art students, accounting for 7.2%, 41 sports students, accounting for 3.2%. It covers all mainstream disciplines in colleges and universities, ensuring the universality of research conclusions.

4.1.5 Digital learning experience:

92.3% of the subjects said they had completed learning experience of no less than one online course, and 76.8% of the subjects had used at least one AI learning tool to assist autonomous learning, indicating that the samples in this survey generally have autonomous learning experience in the "Internet+education" scenario, and can make accurate judgments on the questionnaire items according to their own experience.

4.2 Item composition and dimension division of questionnaire

By reviewing and comparing previous similar literature, conducting theoretical analysis, and consulting senior university teachers and student representatives, this study developed a 33-item Questionnaire on Influencing Factors of College Students' Autonomous Learning Effectiveness under the Background of "Internet + Education". The questionnaire is divided into 6 dimensions, including 6 items for metacognitive competence, 5 items for digital resource conditions, 5 items for intelligent tool support, 7 items for teacher guidance conditions, 6 items for learning community conditions, and 4 items for institutional evaluation conditions. The 5-point Likert scoring method is used to score from 1 to 5 points respectively representing "Strongly Disagree", "Disagree", "Neutral", "Agree" and "Strongly Agree".

4.3 Reliability and validity

This study first tested the internal consistency reliability of the questionnaire as a whole and each dimension. The results showed that the cronbachs α coefficient of the questionnaire as a whole was 0.917, and the cronbachs α coefficient of the sub dimensions corresponding to the six core conditions were: metacognitive ability dimension 0.872, digital resource condition dimension 0.846, intelligent tool support dimension 0.829, teacher guidance condition dimension 0.881, learning community condition dimension 0.835, and system evaluation condition dimension 0.813. The cronbachs α coefficient of all dimensions was higher than the good standard of 0.80, indicating that the internal consistency reliability of the questionnaire was good, and the measurement results were stable and reliable.

In terms of validity test, this study first used KMO test and Bartlett ball test to determine whether the data were suitable for factor analysis. The test results showed that KMO value was 0.892, and the P value of Bartlett ball test was less than 0.001 ($\chi^2/df=2376.42/276=8.610$), reaching a very significant level, which met the premise of exploratory factor analysis. Then factor extraction was carried out by principal component analysis, and orthogonal rotation was carried out by the maximum variance method. Finally, six common factors with eigenvalues greater than 1 were extracted, and the cumulative variance interpretation rate of the six common factors reached 72.46%, indicating that the extracted six factors can explain the information of most items in the questionnaire, which fully corresponds to the six success conditions derived from the previous theory, proving that the dimension division of this study has good structural validity.

4.4 Analysis of current situation differences in various dimensions

Through one-way ANOVA, we identified the significant differences in the perception of six success conditions among different groups

4.4.1 Grade differences:

The scores of junior and senior students in the metacognitive ability dimension were significantly higher than those of freshmen

and sophomores, and the P value of multiple comparisons after the event was less than 0.01, indicating that with the accumulation of learning experience, the autonomous planning and self-monitoring

ability of senior students will gradually improve. However, in the dimension of intelligent tool support, freshmen and sophomores scored significantly higher than senior students, reflecting that freshmen's acceptance and proficiency in using AI learning tools were significantly higher.

4.4.2 Subject differences:

Engineering students have the highest score in the dimension of intelligent tool support, which is significantly higher than that of liberal arts and art students, which is directly related to the fact that engineering majors use a large number of virtual simulation tools and programming assistant tools [22]. Liberal arts students get the highest score in the dimension of learning community conditions. The tradition of deliberative learning in the major of liberal arts makes students more accustomed to autonomous learning through peer interaction.

4.4.3 School level differences:

The scores of the subjects from double first-class universities in terms of digital resource conditions and teacher guidance conditions are significantly higher than those from ordinary undergraduate universities, reflecting that there is still a significant gap in the supply of software and hardware resources for autonomous learning in colleges and universities at different levels [23], and there is still much room for improvement in the construction of autonomous learning support system in ordinary undergraduate universities.

4.5 Regression analysis of success conditions on the effectiveness of autonomous learning

In this study, taking the effectiveness of College Students' autonomous learning as the dependent variable and the corresponding dimension scores of the six major success conditions as the independent variable, we constructed a multiple linear regression model to quantify the influence weights of different conditions on the effectiveness of autonomous learning. The regression analysis results are shown in the table below:

Table 1 Multiple Regression Analysis of Factors Influencing the Effectiveness of College Students' Autonomous Learning

independent variable	Denormalization coefficient b	Standard error	Standardization coefficient beta	T value	P value
constant	0.287	0.092	-	3.119	0.002
Metacognitive condition	0.372	0.031	0.372	11.99	<0.001
Teacher guidance conditions	0.241	0.028	0.241	8.607	<0.001
Digital resource conditions	0.186	0.027	0.186	6.889	<0.001
Learning community conditions	0.127	0.025	0.127	5.080	<0.001
Intelligent tool support conditions	0.094	0.023	0.094	4.087	<0.001
System evaluation conditions	0.079	0.022	0.079	3.591	<0.001

The adjusted R^2 value of the regression model is 0.683, indicating that the six independent variables can jointly explain the variation of 68.3% of the autonomous learning effect, and the overall explanatory power of the model is strong. The P values of all independent variables were less than 0.001, indicating that the six success conditions have extremely significant positive effects on the effectiveness of College Students' autonomous learning.

From the size of standardized regression coefficient, we can see the influence weight of different conditions: the influence weight of metacognitive ability condition is the highest, reaching 0.372, which is the core factor determining the effectiveness of autonomous learning; The second is teacher guidance conditions, with a weight of 0.241. This data directly breaks the cognitive misunderstanding that "autonomous learning does not require teachers' Deep Participation", and proves that effective teacher guidance is an indispensable key support for autonomous learning. The weight of digital resource conditions is 0.186, which is an important content foundation support. The weights of learning community conditions, intelligent tool support conditions, and system evaluation conditions are reduced in turn, and complementary support is formed for the effectiveness of autonomous learning from the three levels of peer interaction, technical assistance, and system guarantee.

4.6 Summary of empirical research

The quantitative analysis results of this study fully verify the scientificity of the six success- conditions derived from the previous theory, and clarify the influence priority of conditions through the data: when promoting the construction of autonomous learning mode, colleges and universities should not blindly give priority to investing a large amount of money to purchase intelligent equipment and platforms, but should put the cultivation of students' metacognitive ability and the promotion of teachers' role transformation at the core, and on this basis, gradually optimize the supply of digital resources, build peer learning community, improve the intelligent tool support system and multiple evaluation system, so as to truly build an efficient autonomous learning support system and avoid falling into the misunderstanding of "emphasizing technology and neglecting people [24-26].

5. Six conditions for college students' successful Autonomous Learning under the background of "Internet+Education"

Through factor analysis and subject coding of qualitative interview data, this study finally obtains six core conditions for college students' successful Autonomous Learning under the background of "Internet+Education". The six conditions are interrelated and work together to form a complete autonomous learning support system.

5.1 metacognitive ability conditions: the internal core driving force of autonomous learning

Metacognitive ability is the bottom core condition for college students' autonomous learning, which includes three levels of ability [27]: First, the ability to set independent goals, that is, students can combine their own professional development needs, jump out of the passive logic of "completing the tasks assigned by the teacher", and set clear and landing phased learning goals; The

second is the ability of process self-monitoring, that is, students can actively track their own learning progress in the process of autonomous learning, timely find problems such as distraction and low learning efficiency and make adjustments; The third is the ability of result self-reflection, that is, students can objectively evaluate their learning effectiveness after completing a stage of learning, summarize the existing shortcomings and optimize the follow-up learning path.

In the interview, a junior student who won a national scholarship said: "Many students think that autonomous learning is just looking for online courses, but I will make a clear list of autonomous learning for myself at the beginning of each semester. I will review the progress every two weeks. What I have learned and what is stuck should be clearly marked, so that I can not learn more and more disorderly in the vast amount of resources." the regression analysis results of this study also show that the interpretation of metacognitive ability on the effectiveness of College Students' autonomous learning reaches 37.2%, which is the highest contribution dimension of all influencing factors.

5.2 Digital resource conditions: accurate supply of adaptive learning content

High quality digital resources are not a simple stack of course videos, but a hierarchical resource system suitable for different learning foundations and different learning styles. This condition includes three core elements [28-29]: The first is the hierarchical adaptability of resources, which provides three kinds of learning contents with different difficulties, namely, entry-level, advanced level and expansion level, for the same knowledge point, so that students with weak foundation can consolidate the foundation and students with spare capacity can expand and explore; The second is the diversity of resources. In addition to video courses, interactive exercises, virtual simulation experiments, leading-edge literature guides and other resources in different forms are provided to meet the needs of autonomous learning in different scenarios; The third is the dynamic updating of resources, which can timely integrate the research results of frontier disciplines and the latest industrial practice cases into the resource system, and avoid the problems of outdated content and disconnection from reality of digital resources.

At present, there is a problem of "valuing quantity over quality" in the construction of online resources in some colleges and universities [30]. Many courses only upload videos of offline classes directly to the platform, without redesigning the scene of autonomous learning, resulting in students' experience of autonomous learning is far inferior to offline classes, which is also an important reason for the poor effect of many students' autonomous learning.

5.3 Support conditions for intelligent tools: man-machine collaborative learning assistant system

In the "Internet+Education" scenario, intelligent tools have become an indispensable support for college students' autonomous learning. Qualified intelligent learning tools can not be simply "AI question answering machines", but should provide reasonable support for students in three dimensions [31]: The first is cognitive support, which helps students complete repetitive work such as literature collation, data processing, knowledge points sorting, and releases students' time and puts it into deep thinking and creative exploration. The second is the learning path navigation support. Based on students' learning behavior data, identifies students' weak

points in knowledge, recommends suitable learning content for students, and avoids students' getting lost in resources. The third is the learning status early warning support. When the system recognizes that students' learning efficiency is low for a long time and their progress is seriously lagging behind, it will send a prompt in time, and synchronize the relevant information to the corresponding teachers, so as to realize the effective connection between intelligent early warning and manual intervention.

It should be noted that the support of intelligent tools must adhere to the bottom line of "smart for good", and cannot substitute for students' independent thinking process, so as to avoid students' dependence on AI tools and weaken their independent thinking ability.

5.4 Teachers' guidance: role transformation from "knowledge transmitter" to "learning designer" [32-33]

Many people mistakenly believe that autonomous learning is a teacher's "letting go". However, the empirical data of this study show that students' learning completion rate is less than 30% due to the lack of autonomous learning effectively guided by teachers, and the learning effect is far lower than that of the scene with moderate teacher intervention. In the new scene of "Internet+Education", the role of teachers is no longer a one-way knowledge transmitter in the classroom, but a "learning designer" of autonomous learning. Teachers need to build a knowledge framework for students' autonomous learning in advance, clarify the learning tasks and evaluation criteria at different stages, and provide targeted guidance when students encounter learning bottlenecks, rather than giving answers directly.

A national famous teacher interviewed shared her practical experience: "I will not finish all the knowledge points in class now, but upload the basic learning resources to the platform in advance, so that students can learn autonomously first. Therefore, the time in class is mainly used to organize discussions and answer common problems encountered by students in the process of autonomous learning, so students' initiative is much higher than before."

5.5 Learning community conditions: collaborative support environment for peer interaction

Autonomous learning is not isolated individual learning, and a good peer learning community is an important supporting condition for autonomous learning. A stable learning community can provide students with three levels of support [34-35]: first, the sharing of learning resources. Community members can share high-quality learning materials and practical learning skills with each other to expand the scope of learners' learning. The second is the mutual encouragement of learning emotions. When students encounter setbacks in the process of autonomous learning and generate burnout, peer encouragement can effectively help them adjust their state and continue to complete learning tasks. The third is the scene support of collaborative inquiry. For complex interdisciplinary problems, members of the learning community can work together to explore from different angles and jointly complete learning tasks beyond the boundaries of individual ability.

At present, many autonomous learning support systems in colleges and universities ignore the construction of peer community, and do not build a stable online and offline cooperation and communication platform for students, which leads to many

students' autonomous learning in a "single fight" state, prone to learning burnout.

5.6 System evaluation conditions: a diversified and flexible evaluation system for autonomous learning

The traditional evaluation system with the final closed book examination as the core can not adapt to the process characteristics of autonomous learning. Scientific system evaluation conditions are an important guarantee for the sustainable promotion of autonomous learning. The evaluation system suitable for autonomous learning needs to meet three requirements [31, 36]. First, the diversity of evaluation dimensions, which no longer only take the final examination score as the evaluation standard, but include the completion of tasks in the learning process, the quality of inquiry reports, and collaborative contribution into the evaluation system. The second is the process of the evaluation cycle, which transforms the summative evaluation into the process evaluation throughout the semester, timely feedback the students' phased learning effect, and help students dynamically adjust their learning path. The third is the flexibility of the evaluation rules. On the basis of the unified basic requirements, students are allowed to choose different learning tasks according to their own interests and development directions, and fully respect students' personalized development needs.

6. The overall framework construction of teacher-student collaborative support mechanism

Based on the above six success conditions, this study constructs a "hierarchical collaboration and dynamic adaptation" collaborative support mechanism for college students' autonomous learning. This mechanism breaks the traditional linear logic of "teachers' one-way output and students' passive acceptance", and forms a closed-loop collaborative system of "students' independent initiation, intelligent tool assistance, teachers' precise support, and peer collaborative participation". The overall framework is divided into three levels.

6.1 Foundation layer: supporting system of man-machine collaborative autonomous learning environment

The basic layer is the technical base of the whole collaboration mechanism, which is uniformly carried by the smart education platform of colleges and universities. Its core function is to provide data exchange and tool support for teacher-student collaboration. This layer first breaks through the data barriers between the course platform, learning management system and intelligent partner tools, so as to realize the whole process tracking and synchronous sharing of students' learning behavior data, and avoid the formation of data islands between different platforms. At the same time, the platform provides teachers with design tools for autonomous learning tasks, supports teachers to quickly build hierarchical autonomous learning resource packs and set up learning nodes and early warning rules at different stages, and provides students with personalized learning dashboard, so that students can clearly see their learning progress and knowledge, and realize the visual monitoring of their learning process.

At this level, the intelligent system plays the role of "routine support", automatically completing routine work such as learning reminders, basic knowledge point answering, and learning progress statistics, freeing teachers from a large number of repetitive

transactional work, so that teachers can put more energy into targeted in-depth support work.

6.2 Middle tier: double helix interactive teacher-student collaborative execution system

The middle tier is the core executive part of the whole support mechanism. It constructs a double helix interactive structure of "students' independent exploration - teachers' precise support". The whole process is divided into four progressive steps:

The first step is the independent planning stage. Under the guidance of teachers, students make their own semester independent learning plans in combination with their own professional development goals, and submit them to teachers for review. Teachers provide optimization suggestions for students in combination with professional training requirements, and help students develop reasonable learning goals that meet both personal interests and training requirements.

The second link is the process promotion stage. Students learn according to the path of independent planning. The intelligent system tracks the learning behavior data throughout the whole process. When the system recognizes that students have problems such as lagging progress and weak mastery of knowledge points, it provides students with corresponding supplementary learning resources through intelligent partners to try intelligent intervention. If the students' learning status has not improved after the intelligent intervention, the system will automatically push the warning information to the teacher, and the teacher will carry out one-to-one targeted counseling according to the specific situation of students to help students break through the learning bottleneck.

The third link is the collaborative inquiry stage. According to the students' autonomous learning progress, teachers organize online and offline discussion activities, carry out collective explanations for common problems encountered in the process of students' autonomous learning, and guide students to form learning groups to carry out collaborative inquiry in groups. In this process, the teacher no longer directly gives the answer to the question, but participates in the group discussion as a collaborative member, and inspires students to complete the question inquiry by asking questions and guiding.

The fourth section is the reflection iteration stage. After completing a stage of autonomous learning, students write a self reflection report to summarize the learning effect of this stage. Teachers combine students' learning process data and reflection report to provide personalized feedback for students, help students optimize the next stage of autonomous learning plan, and enter the next round of collaborative cycle.

6.3 Top layer: collaborative guarantee system of multiple subjects

The top layer provides system and resource guarantee for the whole teacher-student collaborative support mechanism, which is jointly participated by the teaching management department, secondary colleges and teacher development centers of colleges and universities. The teaching management department is responsible for revising the talent training plan, adjusting the course credit structure, leaving enough time and space for students' autonomous learning, reforming the traditional course evaluation system, and issuing multiple evaluation guidelines suitable for autonomous learning. The secondary colleges combine the characteristics of different disciplines to develop the digital

resource library of autonomous learning suitable for their own disciplines, and build an autonomous learning practice platform with discipline characteristics. The teacher development center regularly carries out skill training to help teachers improve their digital teaching design ability and autonomous learning guidance ability, and promote teachers' role transformation.

7. Implementation path and practice strategy of mechanism implementation

7.1 Reconstruction of autonomous learning space based on curriculum

Colleges and universities should take a single course as the basic unit to promote the reconstruction of autonomous learning space of "online and offline integration": No less than 30% of the class hours of each course should be set aside to support students' autonomous inquiry learning. Teachers should upload the learning resources of basic knowledge points to the platform in advance, and require students to complete autonomous learning before class. Classroom time is no longer used for repeated teaching of knowledge points, but for organizing in-depth interactive links such as problem discussion, case analysis and practice display. At the same time, the school should break the space restrictions of traditional classrooms, build a number of ubiquitous learning centers suitable for group cooperation and project exploration, and provide physical space support for students' offline autonomous cooperation.

The practice of "Teacher Education Collaborative Digital Intelligence System" in South China Normal University [37] has proved that this cross scene reconstruction of autonomous learning space can effectively break the space-time constraints of the traditional classroom, enable teachers' support to extend to the whole process of autonomous learning outside the classroom, and improve the evaluation score of normal students' autonomous learning ability by an average of 21.7%.

7.2 Promote the systematic upgrading of teachers' ability system

In view of the current problem that some teachers do not adapt to the guiding role of autonomous learning, colleges and universities should carry out the training of teachers' intelligent literacy and autonomous learning guiding ability in different levels and categories. For young teachers, focus on the training of basic abilities such as digital resource design, intelligent tool use, online interactive organization, etc. For senior teachers, focus on guiding them to change traditional teaching concepts, master the working methods of "learning designers", and learn to support students' autonomous learning through problem guidance and task design. At the same time, colleges and universities can bring the exploration of autonomous learning mode into the support scope of teaching achievement award to stimulate the endogenous motivation of teachers' participation in the mode reform.

7.3 Build an inter school collaborative autonomous learning resource sharing ecosystem

Relying on the collaborative quality improvement platform of higher education digitization, promote the co construction and sharing of autonomous learning resources among colleges and universities, and break the barriers of inter school resources.

Colleges and universities of the same type in the region can jointly develop the Cross University autonomous learning resource library, share high-quality MOOC resources, virtual simulation experiment resources, and practice project resources, and jointly carry out cross university autonomous learning seminar activities, so that students from different schools can form a learning community and further expand the boundaries of autonomous learning. The practice of the Huawu Education Forum [38] led by Fudan University has shown that the inter university collaborative symbiosis ecology can provide students with richer autonomous learning scenes and effectively improve the quality of top-notch innovative talents.

8. Conclusion and prospect

College Students' autonomous learning in the background of "Internet+Education" is not a subversion of the traditional learning mode, but an upgrade of the logic of talent cultivation under the empowerment of digital technology. The core goal of the six success conditions proposed in this study, as well as the teacher-student collaborative support mechanism, is not to replace the role of teachers with technology, but to liberate teachers from repetitive transactional work through human-computer collaboration, so that teachers can put more energy into the in-depth guidance and personalized support for students, and ultimately achieve a benign new education ecology of "students' active development, teachers' accurate support, and effective technology empowerment".

In the future, with the further development of artificial intelligence technology, the form of autonomous learning will continue to iterate. Subsequent research can further focus on the differentiated characteristics of different disciplines and develop a sub mode of teacher-student collaborative support suitable for different majors, so that this mechanism can be effective in more teaching scenes and provide more powerful support for the digital transformation of higher education and the cultivation of high-quality talents.

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