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The Impact of Human-Computer Collaborative Blended Teaching Mode on Higher Education Students' Learning Outcomes

Danqing Wang[*, 1]
[1]*Sichuan Geely College, China*

Abstract: With the rapid acceleration of the digital transformation of education, the human-computer collaboration blended teaching mode has gradually become an important direction of teaching reform in higher education. This article explores the impact of this model on the learning effect of higher education students, which significantly improves the depth of learning at the cognitive level; effectively enhances learning confidence and mental toughness at the emotional level; and promotes the dual enhancement of learning engagement and management ability at the behavioral aspect. In order to maximize its benefits, it can be achieved in four aspects: transformation of teachers' roles, in-depth application of technology, innovation of the evaluation system, and ethical inclusiveness. The strategy system aims to break the homogenization dilemma of the traditional teaching mode, promote the deep integration of education equity and personalized learning, and provide intelligent solutions for higher education teaching quality improvement.

Keywords: human-computer collaboration, blended learning, learning effectiveness, teacher transformation, technology application

1. Introduction

The rapid development of artificial intelligence technology is reshaping the education environment, promoting the traditional teaching mode to the intelligent, hybrid direction of deep transformation. In a higher education environment, students' demand for personalized learning paths and instant feedback is becoming increasingly important, and the traditional unidirectional knowledge transfer mode makes it difficult to meet their diversified learning needs. The emergence of human-computer collaboration blended teaching mode is not only a response to technology-enabled education, but also an inevitable choice for teaching paradigm innovation. By integrating the precision of artificial intelligence and the humanistic guiding power of teachers, the model builds a new learning model with the collaboration of technology, teachers and students. From the theoretical level, its innovative value lies in exploring the deep mechanism of the integration of human-computer collaboration and blended teaching, and expanding the theoretical boundaries of the application of educational technology; from the practical dimension, the study provides a framework of optimization that can be set up in higher education, and solves the structural problem of teaching quality improvement.

2. Connotation Analysis of Human-Computer Collaboration Blended Teaching Model

2.1 Concept and characteristics of human-computer collaboration

Human-computer collaboration refers to the cooperative work mechanism between artificial intelligence and teachers based on complementary roles in the teaching environment. Its core lies in breaking the one-way logic of "human" or "technology" in traditional teaching, and building a two-way empowering teaching community through the deep integration of intelligent algorithms and human intelligence. The model has three significant features. First, two-way suitability: the AI system dynamically adjusts support strategies based on learner behavioral data, including resource push, difficulty adaptation, etc. At the same time, human teachers optimize teaching decisions based on AI feedback, forming a closed loop from data-driven to humanistic adaptation. Second, dynamic support. Through real-time interactive interfaces, such as intelligent question-answering robots and virtual

Corresponding Author: Danqing Wang
Sichuan Geely College, China
Email: 568780573@qq.com

learning assistants, AI provides instant feedback and personalized guidance to make up for teachers' energy limitations. Teachers focus on irreplaceable aspects such as emotional motivation and complex problem-solving. Third, task sharing: AI undertakes repetitive tasks, such as homework correction, and learning situation analysis. In this way, teachers can be released from mechanical work, focusing on instructional design, thinking guidance and value shaping, and achieve a balance between technical efficiency and educational warming. This collaborative paradigm not only reshapes the distribution of roles in the teaching process, but also creates a new type of learning environment with intelligent support and humanized care for learners through the complementary advantages of humans and machines.

2.2 Connotation and advantages of blended teaching

Blended teaching is a teaching mode that deeply integrates traditional face-to-face teaching and digital learning, and its focus is on building a diversified, flexible and personalized learning ecology through online and offline linkage. Its connotation includes three major elements. First, diversification of resources, including videos, simulation software, online databases and traditional teaching materials; second, path independent. Students can choose the pace and mode of learning based on their interests and abilities; third, the interaction of three-dimensional, combining classroom discussion, online collaboration, AI instant feedback and other multimodal interactions. This model has significant advantages. This model can break through the time and space limitations. Online platforms support pre-study before class and post-class expansion, solving the problem of fixed schedule and limited resources in the traditional classroom; this mode also supports differentiated learning, accurately identifying students' needs through technological tools such as intelligent assessment and learning analytics systems, and promoting hierarchical tasks and resources to meet the differences in individual abilities. Blended teaching also helps to improve teaching flexibility. Teachers can adjust their teaching strategies according to the dynamic learning situation, realizing an accurate match between "teaching" and "learning". Blended learning not only keeps the humanistic concern of face-to-face teaching, but also expands the scope of teaching through digital technology, providing structural support for the development of advanced thinking skills and lifelong learning ability.

2.3 The integration logic of human-computer collaboration and blended teachings

The integration of human-computer collaboration and blended teaching is essentially the deep combination of technical rationality and educational humanity. From the perspective of technological empowerment, AI provides decision-making support for blended teaching through data collection and analysis, such as learning behavior tracking and knowledge mastery modeling, for example, the intelligent recommendation system can dynamically match learning resources and learner needs, breaking through the traditional blended teaching resources pushing the sloppy features. In the dimension of teaching reconstruction, human-computer collaboration promotes the transformation from "knowledge authority" to "learning collaborator" for teachers, teachers and AI co-designed online independent learning, AI instant feedback, offline in-depth seminar teaching activities chain, forming a technology-assisted cognitive construction. Teachers guide the double helix structure of thought sublimation (An, Wang, & Shi, 2024). In the dimension of interaction innovation, AI-driven virtual assistants and intelligent question-answering robots are integrated with offline group collaboration and teacher-student dialogues to build a human-computer interaction network, which not only retains the advantages of emotional transmission in face-to-face teaching, but also extends the spatial flexibility and data depth of interaction through technology. This integration is not a simple superposition, but through the division of roles and complementary functions of man and machine, reshaping the chain of blended teaching resources, teaching activities, teaching evaluation, and creating a new learning environment for learners that is both efficient and warm.

3. The Effect of Human-Computer Collaboration Blended Teaching Model on Higher Education Students' Learning Effect

3.1 Cognitive level effect enhancement

The human-computer collaboration blended teaching model builds a more efficient in-depth learning scenario for students at the cognitive level by integrating artificial intelligence technology and teacher guidance. The intelligent system can analyze students' learning behavior data in real-time, accurately provide personalized learning resources, and help students get focused reinforcement in their weak parts. The human-computer interaction interface transforms abstract concepts into concrete cognition through multimodal knowledge presentation, such as graphic analysis and dynamic simulation, effectively breaking through the time and space limitations of the traditional classroom on the analysis of complex issues. More importantly, teachers can be released from repetitive explanations and put more energy into guiding students to carry out inquiry-based learning, and through the process of human-computer collaboration to complete the task, the students' problem-solving ability, critical

thinking and knowledge transfer levels have been significantly improved (Cheng, 2024). This blended support mechanism of AI and teachers makes cognitive development both technologically precise and humanistic temperature, providing a double guarantee for the training of higher-order thinking ability.

3.2 The optimization of the effect on the emotional level

The human-computer collaboration blended teaching model effectively optimizes the emotional learning experience of higher education students through the combination of technological empowerment and humanistic care (Liu, Ding, & Wang, 2024). The instant positive feedback provided by the intelligent system, such as "clear steps to solve the problem, keep up the good work" and other personalized comments, will significantly enhance the students' self-confidence in learning, especially for the formation of the psychological lifting effect on the disadvantaged students. The 24-hour online Q&A function of the virtual assistant teacher not only releases the anxiety of classroom questioning, but also transforms learning pressure into exploration motivation through the design of interesting knowledge breakthroughs. As teachers transform from knowledge transmitters to emotional guides, they have more opportunities to observe students' emotional changes in the human-computer collaborative classroom, and through offline group discussions and personalized guidance, they can help alleviate the negative emotions brought about by academic confusion in a timely way. This double support with both technological temperature and humanistic temperature not only reduces learning anxiety, but also cultivates positive mental toughness in human-computer interaction, so that the learning process presents a positive trend of synergistic development of emotion and cognition.

3.3 Effective change in the behavioral aspect

The human-computer collaboration blended teaching model effectively promotes positive change in higher education students' behavioral model by reconstructing the learning scenario. The digital portrait of learning behavior constructed by the intelligent system enables students to clearly quantify process data such as the length of pre-study, the frequency of classroom interaction, etc., which, in conjunction with the dynamic learning planning table designed by the teacher, significantly improves the precision of the execution of the learning plan (Zhang et al., 2023). For example, in programming practical training, AI teaching assistants capture code debugging paths in real-time, generate visual learning track diagrams, help students intuitively identify critical thinking breakpoints, and urge students to form the habit of reviewing on the same day. This data-driven two-way feedback mechanism has also given rise to the formation of the human-computer collaborative learning paradigm. Intelligent assessment before class to locate knowledge blind spots, mixed reality technology in class to support immersive practice, and after class to generate personalized error sets for targeted training. After adopting this model, the average daily effective learning time of students will be extended, and the access to cross-platform learning resources will be increased, realizing a double increase in the degree of learning engagement and self-management ability empowered by technology.

4 Strategies for Enhancing Learning Effectiveness Based on Human-Computer Collaboration Blended Teaching Model

4.1 Teacher role transformation strategy

Under the human-computer collaboration blended teaching model, teachers' role transformation should be based on the dual positioning of technology enablers and growth guides. First of all, teachers should change from knowledge transmitters to knowledge data analysts, accurately identify common weaknesses and individual learning preferences in the class through the student cognitive map generated by the intelligent platform, and design differentiated task packages accordingly (Pang & Wang, 2024). For example, in the programming course, for the algorithmic understanding blind spot in the system feedback, the teacher can disassemble the traditional unified lecture into a basic strengthening group, an innovative expansion group, and push the stepped learning resource package. Secondly, teachers should become the designers of human-computer collaborative activities, transforming one-way explanations into blended interactions of AI-guided learning and teacher's focus: releasing pre-study tasks through the intelligent system before the class, guiding students to discuss AI-generated simulation cases during the class, and organizing offline flip classrooms using the results of data analysis after the class. More importantly, teachers need to strengthen the function of emotional guidance, play a leading role in the areas of value shaping and critical thinking cultivation that technology cannot touch, capture students' emotional changes through face-to-face communication, guide in-depth dialogues in group collaboration, and help students maintain their learning subjectivity in the human-computer co-existence environment. This transformation requires teachers to possess both the technical literacy to interpret digital images and the humanistic sentiment to stimulate the internal drive to learn, finally realizing the integration of technological precision and educational warmth in a symbiotic way.

4.2 Technology depth application strategy

In the technology depth application strategy of

human-computer collaboration blended teaching model, it is necessary to build a complete closed loop of data collection, intelligent analysis and dynamic feedback. First of all, a multimodal learning behavior database should be established to collect multi-source data such as classroom interaction, online learning track, and homework completion process in real-time through intelligent sensing devices, forming a full-dimensional digital portrait covering cognition, emotion, and behavior (Chen & Geng, 2024). For example, in programming practical training, the system can accurately record students' code debugging paths and error types, combined with facial expression recognition technology to capture the thinking cardinal points, and provide teachers with a distribution map of cognitive difficulties. Second, the development of adaptive learning resources push engine, based on the knowledge graph and algorithmic model, to transform fragmented learning resources into dynamic learning paths. For example, in math courses, the system can automatically push dynamic geometric demonstrations and variation practice problems of different difficulty levels according to students' mastery of function image translation laws. In addition, it deepens the embedded integration of intelligent tools and teaching scenarios, introduces tactile feedback gloves in virtual simulation experiments, and configures AI-assisted coding tools in literature analysis tasks, so that the technology shifts from peripheral assistance to kernel support. At the same time, a human-machine collaborative evaluation system is constructed, combining traditional test scores with AI-generated process evaluation reports to form a three-dimensional evaluation matrix covering knowledge mastery, thinking quality, and metacognitive ability. The key to the in-depth application of technology is to break through the superimposition of a single function and turn to the intelligent reconstruction of the whole chain of teaching, not only to maintain the accuracy of the technical tools, but also to avoid the coldness of the algorithm through humanized design, and ultimately to achieve the same frequency resonance between technical empowerment and the essence of human education.

4.3 Evaluation system innovation strategy

In the evaluation system innovation strategy of the human-computer collaboration blended teaching model, it is necessary to establish a dynamic feedback mechanism for data collection. First of all, break through the limitations of the traditional single-result evaluation and establish a three-dimensional evaluation index system covering cognitive input, emotional involvement and behavioral effectiveness. Through the intelligent system real-time collection of classroom interaction frequency, online learning hours, project collaboration contribution and other multi-source data, combined with the teacher's observation records to form a three-dimensional evaluation file containing digital portraits and humanistic annotations (Wang, 2024). For example, in group programming tasks, AI not only records the efficiency of code completion, but also evaluates the depth of discussion through semantic analysis technology, while the teacher evaluates the quality of innovative ideas based on the thinking visualization chart. Second, the dynamic weight adjustment algorithm is developed to automatically optimize the evaluation dimensions according to the characteristics of the discipline and student differences. In literature appreciation courses, the system can increase the proportion of subjective expression in the evaluation, while in science and engineering experiments, the weight factor of operational accuracy is increased. At the same time, it establishes a dual-mode feedback mechanism of individual vertical comparison and group horizontal reference, clearly presenting the trajectory of students' knowledge mastery through radar charts, which not only maintains the visualization of individual progress, but also provides group portrait support for teachers to adjust their teaching strategies. Furthermore, in the future, the innovative human-machine collaborative feedback mode, AI generates personalized learning suggestion reports, while teachers focus on thinking quality, value guidance and other areas that are hard to reach by intelligence, and provide emotional incentives and directional guidance through offline exchanges. In the graduation design process, the system generates an innovation assessment report based on version iteration data, while the tutor analyzes the critical thinking development lineage with process documents. This innovative strategy not only transforms the evaluation from an appraisal tool to growth navigation, but also realizes the balance between accurate quantification and humanistic care through the integration of technology and educational wisdom, providing a two-round drive for teaching quality improvement.

4.4 Ethical and inclusive strategies

In the construction of the ethical and inclusive strategy of the human-computer collaboration blended teaching model, it is necessary to establish the ethical framework of human-computer collaboration with the value anchor point of technology for the better. The first task is to build a strong data security line of defense, realize the distributed storage and encrypted transmission of learning data through blockchain technology, and establish a mechanism for the whole life cycle of collection and use to ensure that students' privacy rights and interests are not infringed (Li, 2024). At the same time, an algorithmic ethical review is

carried out to verify the interpretability of the decision-making logic of the intelligent recommendation system, to avoid data bias leading to imbalance in the distribution of educational resources, for example, the introduction of a multi-dimensional dynamic calibration model in the identification of poor students instead of a single dependence on the frequency of device use. At the aspect of inclusive design, it is necessary to develop universal technical interfaces, configure voice interaction code editors for visually impaired students, and develop a real-time sign language synthesis system for hearing-impaired learners, so as to eliminate the threshold of technical use through multimodal interaction design. Establish a digital help system whereby senior students form a technology support group to help low-technology literacy students cross the digital divide. Meanwhile, a flexible learning mode switching mechanism is designed to allow students to switch freely between pure human-computer interaction, human-computer blended, and traditional classroom modes, respecting different learning style preferences. Humanistic care should be carried out throughout, and AI ethics workshops should be established to cultivate teachers' and students' awareness of technology critique through case studies. A manual review channel is set up in the intelligent evaluation session, and a double-insurance mechanism of initial screening by AI and final review by teachers is adopted for open-ended topics involving value judgment. What's more, it is important to maintain a sense of temperature in the application of technology, and set up an emotional buffer zone in the virtual learning space, such as AI teaching assistants adding weather care statements when pushing learning reminders, and teachers focusing on students with consecutive negative feedbacks in the data analysis, providing psychological support through offline interviews. This strategy, through the deep integration of technical rationality and educational sensibility, not only guards the baseline of educational fairness, but also provides ethical escort for personalized development, truly realizing intelligent education with warmth.

Conclusion

The human-computer collaboration blended teaching model builds a new ecosystem of intelligent education through the collaborative evolution of teachers, technology and students. Teachers are transformed from knowledge authorities to learning navigators, and teach precisely with the data support of intelligent systems, which not only maintains the humanistic warmth of education, but also improves the scientific precision of teaching. The in-depth application of technology breaks through the boundaries of the traditional classroom, and through adaptive learning paths and multimodal interaction design, teaching has shifted from standardized supply to personalized customization. The innovation of the evaluation system emphasizes process tracking and dynamic feedback, forming a double-helix evaluation structure that integrates data-driven and humanistic interpretations to promote whole-person development. The ethical and inclusive strategy sets value boundaries for the application of technology, and ensures that the dividends of technology benefit every learner through privacy protection, algorithm review and universal design. This innovation in teaching mode not only improves cognitive efficiency, but also has a far-reaching impact on the emotional connection and behavioral aspect, providing a practical paradigm for improving the quality of higher education that combines technical rationality and humanistic care.

Conflict of Interest

The author declares that she has no conflicts of interest to this work.

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