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From Human-Computer Interaction to Entangled Symbiosis: Research on the Theoretical Model and Real-World Applications of "Teacher-Student-Machine" Triadic Interaction in New Engineering under the Digital Intelligence Era

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Abstract: In the context of the digital intelligence era, the "teacher-student" binary interaction mode of traditional engineering teaching has gradually transformed into the "teacher-student-machine" triadic interaction. As the teacher-student interaction mediated by machine becomes formalized and instrumentalized, the transfer of interaction center leads to the virtualization and technologization of teacher-student interaction, and the lack of emotional substitution leads to the detachment and indifference of teacher-student interaction, there is an urgent need to examine the situation of teacher-student interaction from the perspective of the times, reflect on the limitations of teacher-student interaction, and search for breakthroughs and paths for the reconstruction of teacher-student interaction. This study focuses on this emerging interaction mode and explores how human-computer interaction evolves into an "entangled" symbiotic relationship. By analyzing the application of digital intelligence technology in engineering education, the study reveals its role in reshaping the roles of teachers and students, teaching content and methods, and educational models. The study finds that intelligent machines are not only tools, but also subjects in education and teaching, promoting the development of engineering education towards personalization and efficiency, and providing theoretical and practical references for the construction of new engineering disciplines.

Keywords: New Engineering, Human-Computer Collaboration; Teacher-Student Relationship; Digitalization of Education.
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1.Introduction

With the rapid emergence of Artificial Intelligence, higher education is accelerating into the stage of intelligent education, marking the "first year of intelligent education". The advent of the era of digital intelligence in the field of education is of great strategic significance to the construction and development of new engineering disciplines in China. The new engineering education in the era of digital intelligence in the education system will pay more attention to digital and intelligent teaching, at the same time, the new engineering education emphasizes interdisciplinary teaching, the future may open "artificial intelligence +", "big data +" and other courses.Consequently, the intelligent education system with the concept of student-centered education and human-computer collaborative teaching mode will be further developed; and in the talent cultivation

of new engineering education, it focuses on the development of engineering majors driven by the integration of industry and education and emerging technologies, and cultivates composite and high-quality talents with a broad vision, interdisciplinary knowledge, practical and innovative ability and digital literacy.

The rapid development of digital intelligence technology and its extensive use in the field of higher education provide a broad space for digitally empowered higher education change and modernization of the higher education system.[1]The construction of new engineering discipline is first of all a major change of talent cultivation mode, which is the source of vitality and growth for the formation of emerging industries. As a result, the construction of new engineering discipline focuses on five things: theoretical foundations, specialized disciplines, curriculum design, structural optimization, and integrated development.[2] Digital intelligence technology drives the development and change of the new engineering education model, from the conceptual level down to the practice, the future of the new engineering construction will be inseparable from the leadership of digital intelligence technology.

As a new talent training "leader" of the new engineering education, first of all, we should start from the updating of the teaching content. The engineering education in the era of digital intelligence is no longer confined to the traditional teaching of a single piece of knowledge, but needs to integrate professional knowledge with the application of cutting-edge technology, and on this basis, docking industry update changes in order to dynamically update and adjust the professional knowledge. Additionally, it is necessary to update and adjust the professional knowledge dynamically in response to the changes in the industry, and at the same time, the teaching content needs to pay more attention to the cultivation of students' practical and innovative abilities. Secondly, the most profound influence of digital technology in the teaching process is the change of education method. Digital intelligence technology breaks the one-way teaching mode of the traditional "teacher-student" interaction, which is dominated by the teacher, and makes the classroom teaching become more open and diversified. Teachers and students become equal participants in the "teacher-student-machine" interaction, deepening students' learning experience through ubiquitous and whole process interaction.[3] With the help of big data and artificial intelligence, personalized teaching programs and learning paths will become easier to achieve, while digital intelligence technology promotes new methods of human-computer collaborative teaching, and builds a new "teacher-machine-student" trinity of education and teaching framework. Finally, digital intelligence technology realizes dynamic tracking and evaluation of the whole process of student learning, making way for full-process, multi-dimensional, and multi-subject evaluation systems. Data-driven evaluation and feedback will assist teachers in making teaching decisions.

The ultimate foothold of the reform of the new engineering education model is the cultivation of talents, so the new engineering education promoted by digital technology will pay more and more attention to the integration of industry, academia and research, and the introduction of digital technology is no longer confined to classroom teaching in colleges and universities, but also penetrates more into the industry or the industry. In the "teacher-student-machine" triadic interaction process, teachers and students will be more familiar with the use of digital technology, not only in the teaching of the full use of digital technology, but also to help students in the industrial practice of the rational use of digital technology.

The study introduces relevant theories in the field of human-computer interaction, explores the "teacher-student-machine" triadic interaction in new engineering under the era of digital intelligence, and accelerates the transformation of the traditional "teacher-student" to "teacher-student-machine" teaching structure by human-computer cooperative education system. The educational system of human-computer collaboration accelerates the transformation of traditional "teacher-student" to "teacher-student-machine" teaching structure, forming the "human-computer co-teaching" mode of human-computer coexistence and multidimensional interaction.[4] The innovative use of human-computer interaction theory has certain application value for the improvement of teaching efficiency in new engineering education, the improvement of students' personalized experience, the construction of a new ecology of intelligent education, as well as educational governance and decision-making. Meanwhile, with the rapid development of digital technology, the new engineering education is facing subversive changes, and the complex problems of human-computer collaboration in the teacher-student relationship, as well as the cultivation and output of future talents, and the ethical and sustainable development of education, urgently need the theoretical expansion and practical improvement of the research related to the triadic interaction of "Teacher-Student-

Machine".

2.Theoretical Framework

Due to the intervention of digital technology, the teacher-student interaction relationship in new engineering education in the era of digital intelligence has gradually changed from the traditional "teacher-student" dichotomy to the "teacher-student-machine" triadic interaction structure. This innovative paradigm shift is conducive to the improvement of the teacher-student relationship in new engineering education, and strengthens the role of teachers on the basis of guaranteeing the personalized development of students. At the same time, the introduction of "machine" can stimulate the innovation and creation of education, expand the boundaries of education, and improve the efficiency and quality of new engineering education.

2.1 An Overview of the Theory of "Entangled Human-Computer Interaction".

The theory of human-computer interaction (HCI) can be traced back to the 1940s, when it mainly focused on the study of information exchange between human beings and machines, emphasized on the enhancement of machine's working style and efficiency for human beings, and gradually derived a research paradigm mainly based on ergonomics. Later, along with the development of information effectiveness under the technology perspective, the coupling of emotion and action under the social and humanistic perspective, and the intervention of communication science, the subjectivity of machines was gradually established. In the development of HCI, the human-machine relationship has gone through four important stages of development: affiliation, antagonism, equivalence, and symbiosis,[5] in which the relationship between humans and machines has transitioned from human-centered, competitive game, and indispensable to intertwined and mutual embeddedness of competition and dependence.

The theory of entangled human-computer interaction(entangled HCI), first proposed by Christopher Frauenberger at TOCHI (Transactions on Computer-Human Interaction) in 2019, emphasizes the close entanglement between humans and digital technologies, exploring the ways in which virtual reality, artificial intelligence, neural implants, and ubiquitous information-physical systems produce ontological uncertainty, epistemological proliferation, and ethical dilemmas. The theory is mainly used to understand and design the complex relationship between humans and technology, which is not merely one-way tool-utilization but "symbiotic entities" formed through dynamic interactions. It transcends traditional user-centered design by emphasizing the ontological inseparability of humans and technology, focusing on the ontology of techno-human relationships, the materiality of knowledge production, and ethical responsibilities.[6]

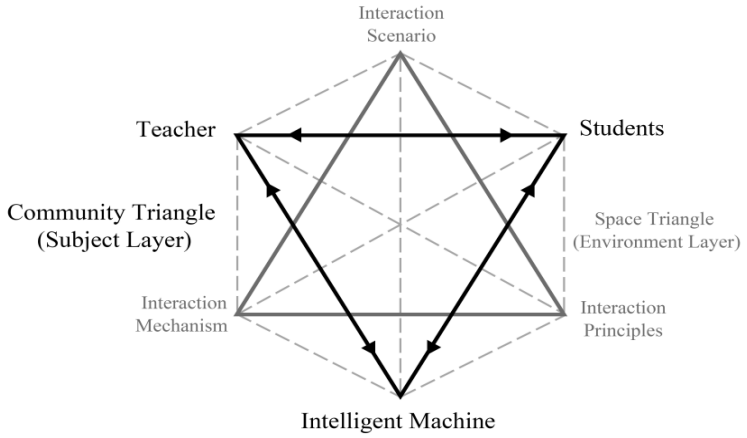
In 1960, Licklider put forward the idea of human-machine symbiosis on the basis of symbiosis theory, believing that the partnership formed between humans and machines can perform intellectual operations more effectively than humans alone in decision-making and controlling complex situations.[7] The synergistic symbiotic relationship between humans and machines also implies that humans will no longer be the only subject of learning activities, and the human-machine collaborative learning system can be regarded as a learning symbiosis composed of humans and machines.[8] Therefore, in the practice of human-machine cooperative learning in the era of digital intelligence, human cognitive activities have been inextricably linked with digital intelligence in terms of knowledge comprehension, interactive learning and intelligent services.

As computers, artificial intelligence and other digital technologies enter the field of education, the theory of HCI is slowly being applied in the field of education, resulting in the emergence of HCI education, which is aimed at improving and updating traditional education and teaching by combining education with artificial intelligence, virtual reality, augmented reality and other digital technologies, so as to provide students with a richer and more personalized learning experience. In terms of changes in teaching methods, traditional teaching methods are limited to the teacher's one-to-many classroom mode, and it is difficult for students to avoid bias in the absorption and understanding of knowledge. HCI, on the other hand, can intelligently adjust the content and form of teaching and realize personalized tutoring in the education process according to the individual needs of students and learning ability conditions and other factors. In terms of teaching mode, the introduction of digital intelligence technology can break through the traditional constraints and creatively introduce virtual reality, remote control and other technologies into classroom teaching, providing an immersive, interactive and reusable learning experience. HCI explores immersive learning, expands teaching scenarios, brings into play student subjectivity and the "entangled" symbiosis between humans and machines[9].

2.2 "Teacher-student-machine" triadic interaction Model

Based on the theory of "entangled HCI", the "teacher-student-machine" triadic interaction model of new engineering education is based on the theory of dynamic entanglement, which aims to break through the unidirectional interaction logic of the traditional HCI and propose a "double triangle inter-embedded" model in response to the challenges of the fuzzy subject of education in the age of digital intelligence, the complexity of the scene, and the prominent ethical risks. In response to the challenges of blurred educational subjects, complex scenarios, and prominent ethical risks in the digital age, we propose the "dual triangular inter-embedded" model, in which the external triangle is the spatial triangle consisting of the interaction mechanism, the interaction scenario, and the interaction principle, and the internal triangle is the community triangle consisting of the teacher, the student, and the intelligent machine. The spatial triangle creates an interactive environment for education, and collaborates with the internal community triangle to realize efficient and intelligent "teacher-student-machine" in-depth interaction.

Figure 1: "Teacher-student-machine" triadic interaction Model



In this model, the core is the synergistic subject composed of the teacher, the student and the intelligent machine, forming three interoperable interaction chains, and each of the three in turn influences the third interaction relationship through the interaction chain related to itself. Each subject element in the triadic interaction model has its own role to ensure the smooth operation of the interaction. Teachers act as guides and coordinators; students are the main body of learning and the center of the triadic interaction. In the "teacher-student-machine" triadic interaction model constructed based on "entangled HCI", the intelligent machine is no longer an auxiliary tool in the traditional teacher-student interaction relationship, but an important side of the interaction model, supporting the stability of the triadic interaction model.

As the triangle in the external space of the model, the efficient interaction between the community triangle is realized through the dynamic synergy between the interaction mechanism, interaction scene and interaction principle. The interaction mechanisms include role division of labor, task-driven and closed-loop feedback, etc., which are not independent of each other but require cooperation and mutual assistance to support the operation of the "teacher-student-machine" triad; the interaction scenarios, i.e., the application scenarios of the "teacher-student-machine" triad, are the most effective way to realize the interaction between the triads in the actual teaching and learning. Interaction scenarios are the application scenarios of the "teacher-student-machine" triadic interaction model in actual teaching, such as the combination of virtual and real teaching environments, the use of generative AI tools, and the use of digital teaching tools as "auxiliary teachers", etc; Interaction principles are the inevitable needs of the new engineering education to adapt to the digital transformation of education, such as the principle of human-centeredness, the principle of assisting teaching with digital technology, and the principle of ethics and norms. The construction of the spatial triangle is not only the underlying support for the triadic interaction of "teacher-student-machine", but also the educational environment necessary for promoting the intelligent transformation of the new engineering education and cultivating innovative talents to meet the needs of the future society.

3.Implementation Strategies for the "teacher-student-machine" Triad of Interaction

3.1 Changes in the Role of "Teacher-student-machine"

3.1.1 Changes in the Role of Teachers

The role of teachers in the "teacher-student-machine" triadic interaction has changed profoundly, and this change in role puts forward new requirements for teachers' development. Firstly, in traditional teaching and teacher-student interaction, teachers are mainly responsible for the transmission of knowledge, but under the influence of digital intelligence technology, the channels of knowledge acquisition have become more diversified and convenient, and the role of teachers has gradually shifted from knowledge transmitters to thinking guides. Secondly, with the diversification of students' access to knowledge, teachers' knowledge authority status is challenged by digital intelligence technology, and they gradually become partners and guides in the process of teacher-student interaction to learn from Ho Sang. Thirdly, from a single pedagogue to a personalized tutor. Digital intelligence technology for teachers to provide personalized teaching programs, teachers no longer need to students in the form and content of the unified teaching, can use digital tools for each student to provide targeted tutoring. Fourthly, with the support of digital intelligence technology, teaching evaluation has become more diversified and scientific, and educational supervision and feedback have become more convenient with the help of intelligent technology, so teachers have changed from single evaluators to comprehensive evaluators.[10]

As an important element in the "teacher-student-machine" ternary community of interacting subjects, along with the change in their roles, teachers should also change or adopt appropriate coping strategies in their interactions with students and intelligent machines. First of all, teachers need to improve their ability to apply AI, master the operation and functions of digital tools, and integrate them creatively into curriculum design. But teachers also need to pay attention to the ethical and moral issues brought about by digital intelligence technologies, and discipline themselves while guiding students to correct technological values. Secondly, teachers should maintain the attitude of lifelong learning. With the rapid development of digital intelligence, teachers need to keep learning, update their knowledge system, and adapt to the "invasive" entry of new knowledge into the field of education and teaching. In addition, teachers should actively explore new teaching methods and approaches, and integrate the innovation of digital intelligence technology into education and teaching, in order to create a more interactive and interesting teaching environment. However, when using methods such as flipped classroom and distance learning, teachers should also pay attention to the development of students' thinking and should not neglect the growth of students' abilities, and can cultivate students' critical thinking about digital intelligence technology by designing inspiring questions and guiding students to question. Finally, teachers need to clarify their roles in the "teacher-student-machine" interaction, and on the premise of not interfering too much in the "student-computer" interaction, they should fully fulfill the tasks within the scope of their identities, and at the same time, properly deal with the relationship between the three interactions, so as to prevent ethical and moral risks and technological crises in education. Ethical and moral risks and technological crises in education can be prevented.

3.1.2 Changes in the Role of Students

In the "teacher-student-machine" triadic interaction, students' roles and learning styles have changed significantly. When intelligent machines enter the teacher-student interaction and reconstruct a new "teacher-student-machine" interaction model, students should take the initiative to face the changes in the interaction in order to promote their own stable development. In terms of role change, firstly, in the traditional classroom and teacher-student interaction, students mainly receive knowledge passively through the teacher's lectures. In the "teacher-student-machine" triadic interaction, students are able to actively utilize intelligent tools and technologies to acquire knowledge, thus transforming into active learners. Secondly, students are no longer isolated learning subjects in traditional teaching, but learning subjects in cooperative interaction with teachers and intelligent machines. Students are able to integrate knowledge and enhance higher-order thinking skills through interaction with intelligent tools.[9]In terms of learning mode, the "teacher-student-machine" triadic interaction enables the role of intelligent machines to be played, thus transforming the learning mode of students. Among them, personalized learning, blended learning and problem-oriented learning are the main ones. Intelligent machines can provide personalized learning resources and feedback according to the students' learning progress and characteristics; learning through the combination of online and offline, using online courses, virtual labs and other resources to expand the learning space; students analyze the problems, integrate knowledge and propose solutions around the high-level tasks designed by the teacher through the

interaction with the intelligent tools.[11]

In order to better integrate into the "teacher-student-machine" triadic interactive educational environment, students need to develop their abilities and literacy in the digital age on the basis of adapting to their new roles and changes in learning styles and methods. First of all, they need to master the basic knowledge and skills of digital technology and use intelligent tools to facilitate learning, such as online learning platforms and generative AI tools. Secondly, it is necessary to cultivate and develop learning abilities in the digital age, such as independent learning ability and higher-order thinking ability. Students should learn to make personalized learning plans in line with their own development through the "teacher-student-machine" triad, and make full use of intelligent machine tools for self-assessment and critical reflection. At the same time, students need to think about the problems in the learning process and whether they can obtain suitable and feasible solutions through the "teacher-student-machine" interaction relationship, so as to cultivate problem-solving ability and innovative thinking. Finally, students need to establish a correct learning concept to adapt to the learning mode in the era of digital intelligence, recognize the functions and roles of intelligent tools, and avoid over-reliance.

3.1.3 Roles and Functions of Intelligent Machines

Intelligent machines are able to generate educational resources independently in the teaching process of new engineering, providing diversified learning materials for education and teaching; through the operation tools mainly based on generative AI technology, they can interact with teachers and students in real time to broaden the education and teaching ideas and realization paths; in addition, they can assist in the supervision of education management through data analysis, provide teachers with the feedback of students' learning situation, assist teachers in making decisions on teaching, and help students to knowledge sorting and thinking expansion.[12] In the process of introducing intelligent machines to optimize the traditional teacher-student interaction relationship, intelligent machines improve the "teacher-student-machine" triad interaction experience through multiple ways, such as providing virtual practice, handwriting and touch control and other diversified interaction modes to enhance the sense of reality and interactivity in classroom participation; incarnating as intelligent teaching assistants or learning companions to participate in the teaching process. It gives teachers and students a diversified experience and provides instant interactive feedback and value-emotional support; intelligent machines support a variety of interaction modes, such as text, voice, image, etc., and can provide personalized interaction experience according to the needs.

3.2 "Entangled" Symbiotic Educational Models

3.2.1 Theoretical Connotation of "Entangled" Symbiosis

"Entangled" symbiosis implicitly draws on both the theory of entangled HCI and the theory of symbiosis, which, while focusing on the relationship between human beings and technology as well as the ethical notion of responsibility, considers that human beings no longer act as the only subject in the interaction system, and emphasizes that human beings and machines act as different subjects and form a community relationship of "entangled symbiosis" with each other through the formation of digital and intellectual technologies. It emphasizes that human and machine act as different subjects and form a mutual "entangled and symbiotic" community relationship through digital and intellectual technologies.[13] The "entangled" symbiosis in the new engineering education is manifested in the interaction between "teacher-student-machine". Teachers use intelligent machines to generate teaching resources, optimize teaching design, and interact with each other in real time in the classroom to achieve complementary advantages; students obtain personalized learning paths through intelligent tools, complete project tasks, and improve their independent learning ability with the assistance of machines.[14] In the "entangled" symbiosis mode, teachers and students participate in the knowledge creation process, and students, teachers and intelligent machines interact in ternary to spontaneously complete the exploration and solution of problems.

As education steps into the digital age, human-computer collaborative learning has become a kind of natural learning form in the present and even in the future human society.[15] As the ideal state or mode of "teacher-student-machine" triadic interaction in new engineering in the future digital age, "entangled" symbiosis has the significance of promoting knowledge innovation, building a smooth channel for technology application, promoting human-machine reciprocal development and improving the quality of education, etc. In the construction and development of new engineering education, it has the significance

of promoting knowledge innovation, building a smooth channel for technology application, promoting the reciprocal development of human-machine and improving the quality of education.[16]

The "teacher-student-machine" triadic interaction needs to realize the effective collaboration among teachers, students and intelligent machines through the theoretical framework and practical path of "entangled" symbiosis. First of all, the community constructed by the three elements needs to clarify their respective roles and their roles and functions. Secondly, we need to adopt project-type and problem-oriented teaching methods, design tasks under the background of real situations, and guide students to accomplish the learning objectives with the collaborative support of teachers and intelligent machines.[17] Furthermore, the data analysis function of intelligent machines is utilized to construct a multi-dimensional, whole-process evaluation system. Teachers can adjust the teaching strategy and optimize the educational means and measures according to the data feedback in order to improve the teaching effect.[18] Finally, it is necessary to build a three-party intelligent teaching platform to coordinate the communication and cooperation among teachers, students and intelligent machines, so as to provide a suitable space for the "entangled symbiosis" of "teacher-student-machine".

3.2.2 Paths to the Implementation of the "Entangled" Symbiosis Model

In the era of digital intelligence, the new engineering education has gradually changed from the traditional "teacher-student" binary structure to the "teacher-student-machine" triadic interaction mode.[19] However, there are still many problems in the practice of this interaction mode. For example, the division of labor between teachers and machines as the main body of collaborative education and teaching is not clear enough, which leads to duplication of work or shirking of responsibilities in the teaching process; students may not use intelligent machines properly when interacting with machines due to insufficient technological literacy, leading to a decrease in their independent learning ability and enthusiasm for learning. In addition, when providing teaching support, machines may not be able to accurately meet teaching needs due to technological limitations, which affects the teaching effect.[20]

In order to solve the dilemmas and problems of "teacher-student-machine" triadic interaction in the era of digital intelligence, it is urgent to synthesize the theory of entangled HCI and symbiosis, and to promote the development of "teacher-student-machine" triadic interaction mode from pure HCI to "entangled" symbiosis, so as to realize the development task of training high-quality talents to meet the future social needs in the new engineering education. Firstly, clarify the role positioning and build a collaborative symbiosis mechanism. Teachers, students and intelligent machines in the "entangled" symbiosis need to correct their positions, clarify the division of labor, and build a stable community triangle. Secondly, to improve the technical literacy of teachers and students, and enhance the ability of human-computer interaction. The development of cutting-edge technology and the digital transformation of education in the era of digital intelligence require the dual subjects of traditional teacher-student interaction to develop technological literacy, acceptance and efficient use of intelligent machines in order to realize "entangled" symbiosis. Thirdly, adjusting machine technology to enhance teaching adaptation. On the one hand, the digital technology should be developed and designed according to the teaching scenarios and students' needs, or be reasonably and appropriately adjusted for education; on the other hand, teaching should monitor the applicability of the machine technology, and the educational application of the digital technology is different from the industrial use, and should not be blindly and directly applied. Fourthly, construct a cooperative game mechanism to realize the ternary dynamic balance. In the process of carrying out the cultivation of new engineering talents, construct the cooperative game mechanism between humans and machines, realize the dynamic balance between teachers, students and machines through the cooperation and game in the interaction process of the two, and improve the efficiency and quality of teaching.[21] Fifthly, strengthening practical teaching and promoting "entanglement" symbiosis. Practical teaching is an important part of new engineering education, and it is also the key to realize the "entangled" symbiosis education interaction mode. In the process of practical teaching, the "teacher-student-machine" triad strengthens the "entanglement" symbiosis of interaction through teaching design and cooperative learning. Sixthly, establish the support of teaching environment to promote the new mode of interaction. Colleges and universities need to increase resource investment in intelligent education technology and cooperate with high-tech industries to create a supportive teaching environment for the realization of the "entangled" symbiosis education interaction mode, and provide guarantee for the implementation of the "teacher-student-machine" triad interaction

mode.

4.Challenges and Prospects

4.1 Practical Challenges

In the actual process of implementing the "teacher-student-machine" triad of interaction, the unpredictability of digital intelligence and the lack of depth of cutting-edge technologies in the field of education in the digital age may lead to many challenges and problems. For example, in the "teacher-student-machine" triad, digital technologies need to be deeply integrated with teaching content, teaching objectives and teaching methods. However, the level of technology application in many educational institutions varies, and some teachers and students may lack the necessary technological literacy to effectively utilize the intelligent tools,[22] while the digital intelligence technology itself, due to the limitations of its development, suffers from insufficient stability and lack of interactivity, thus affecting the consistency and effectiveness of the educational process.

In the "teacher-student-machine" triadic interaction model, big data technology has been introduced and used to collect and analyze educational data, including students' learning behaviors, grades, personal information, and so on. The collection and use of data need to comply with clear laws and regulations, but the boundaries of data and the authority to use them are still unclear.[22] And as the demand for open sharing of educational data increases, the difficulty of data privacy protection is also increasing.

With the advent of the digital age, the new engineering education is faced with the challenge of new ethical issues, and also challenges the implementation of the "teacher-student-machine" triad interaction. For example, in the "teacher-student-machine" triad, the role of the machine is gradually changing from an auxiliary tool to a teaching subject. Excessive intervention of machines may lead to students' over-reliance on technology, affecting normal communication between people, leading to humanistic and ethical considerations of teachers and students, and weakening their ability to learn independently and think critically. In addition the unequal access and use of data in the process of educational data collection, which leads to the unfair distribution of educational resources, as well as the excessive monitoring and analysis of data may have a negative impact on the mental health of students.[23]

4.2 Future Prospects

In the era of digital intelligence, the new engineering education model based on "entangled human-machine interaction" is showing far-reaching development potential and innovation space. In the future, the new engineering education will fully implement the new model of human-machine collaborative development, and teachers and intelligent machines will complement each other's strengths in teaching, and jointly build an efficient and personalized education and teaching environment.[24] At the same time, with the in-depth development of the construction of new engineering disciplines, interdisciplinarity has become an important direction of change in new engineering education, in order to build a comprehensive education ecology and cultivate students' comprehensive ability to solve complex problems.[25] In addition, intelligent machines design personalized learning programs by accurately analyzing students' development needs and learning results feedback, so that teachers have more energy to pay attention to the cultivation of students' critical thinking and innovation ability. This new "entangled symbiosis" "teacher-student-machine" triadic interaction mode promotes the transformation of education from "universalization" to "precision".

Future research in the development of theory and practice will focus on placing the ethical and fairness issues of HCI to ensure the fairness of intelligent machines in teaching and learning. At the same time, research on the interpretability of intelligent educational systems will be key in order to enhance teachers' and students' trust in intelligent systems.[25] In addition, the development of educational data protection technology, the design of interdisciplinary teaching methods, and the research on the intelligence of educational governance will become the core topics to promote the development of new engineering education in the future.

In conclusion, the new engineering education model based on the theory of "entangled HCI" will continue to explore new development paths under the dual impetus of technological innovation and conceptual innovation, providing strong support for the cultivation of high-quality engineering and technical talents needed by the future society.

5.Summary

“Entangled HCI” breaks the inertia of the traditional “human-centered” concept, and regards intelligent technology and machines as the participating subjects in the education and teaching process, so that they can form a two-way learning and constructive relationship with teachers and students. In the new engineering education, the optimized and updated “teacher-student-machine” triadic interaction model based on this theory can optimize the allocation of teaching resources, improve teaching efficiency, and provide students with a more personalized and immersive learning experience. In addition, this theory provides a new perspective for the study of “teacher-student-machine” triadic interaction, clarifies the role of machines in education, and promotes the “teacher-student-machine” triadic interaction in education and teaching from “simple human-machine interaction” to “human-machine interaction”. It has promoted the transformation of “teacher-student-machine” triad from “simple human-machine interaction” to “human-machine entangled symbiosis” in education and teaching.

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