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Exploring the Ethical Boundaries of Artificial Intelligence in Vocational Education: A Practice-Oriented Path to Human-Machine Symbiosis

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Abstract

Vocational education, as a key site of workforce development, faces two major challenges in the age of artificial intelligence : technological integration and ethical governance. As AI becomes increasingly embedded in educational practices, a collaborative model between AI tutors and human teachers is reshaping approaches to skilled workforce development. Within the theoretical framework of "human–machine symbiosis," this paper explores some core ethical issues arising from AI's involvement in vocational education, including boundaries of authority, attribution of responsibility, building of trust, and educational equity. The analysis suggests that AI's capacity for personalized services complements the value-based guidance provided by human teachers. Clarifying AI's authority, building a shared accountability system, strengthening trust between humans and machines, and ensuring fairness in using technology are essential for developing a modern, technically skilled workforce. This study offers a novel perspective on the design of human-centered, AI-enhanced training systems for advanced technical professionals.

Keywords: *Human–Machine Symbiosis, Artificial Intelligence, Vocational Education*

1. Introduction

With the rapid development of artificial intelligence (AI) technologies, intelligent systems—driven by big data and natural language processing—are becoming more and more integrated into all aspects of education. AI has been widely applied in education management, personalized learning, and virtual simulation training, enhancing instructional efficiency and assessment precision. The emergence of the concept of 'AI tutor' indicates that artificial intelligence functions not only as an auxiliary tool for

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knowledge delivery, but also increasingly assumes instructional roles traditionally performed by human teachers. Given vocational education's emphasis on practical training and the cultivation of professional craftsmanship educators are expected to serve not only as transmitters of technical knowledge but also as mentors in moral and professional values. Consequently, the collaboration between AI and human educators must address not only the practical efficacy of technological integration, but also a range of ethical concerns. These include the redefinition of pedagogical authority, ambiguities in responsibility attribution, the restructuring of human–machine relationships, and potential threats to educational equity.

Despite the growing use of artificial intelligence in education, the existing research remains largely focused on its effectiveness, overlooking the ethical issues arising from interactions between AI and human teachers. To address this gap, this study introduces the concept of human–machine symbiosis. Drawing on educational ethics and vocational education theory, the study proposes a theoretical framework for joint talent cultivation by AI tutors and human instructors. It further explores how ethical boundaries are established in AI-enhanced education, aiming to offer a new pathway for high-quality talent development amid the ongoing transformation of vocational education driven by AI.

2. Literature Review

Although notable progress has been made in integrating AI with vocational education, research is still lacking in key areas, including the development of a theoretical framework for human–machine collaborative education, the delineation of ethical boundaries, and the establishment of institutional safeguards. The construction of an ethical analytical framework grounded in human–machine symbiosis helps promote the ethical and sustainable development of AI-driven educational technologies, offering value-based guidance and institutional support for cultivating highly skilled professionals.

2.1 Applications of AI in Vocational Education

In vocational education, AI now empowers the full cycle of teaching, learning, assessment, and training, progressively reshaping conventional pedagogical and competency-based models of talent development. Recent scholarship has paid growing attention to the effectiveness of AI applications, particularly in areas such as virtual simulation training, automated skill assessment, personalized learning trajectories, student behavioral analytics, and learning outcome prediction [1]. In recent years, AI technologies have become deeply embedded in educational practices worldwide, serving as a critical catalyst for the ongoing transition toward "smart education." Studies have shown that AI-driven simulation systems are widely applied in the training of high-risk skills—such as surgical procedures or industrial machinery operations—while virtual apprenticeship platforms support students in immersive, experiential learning contexts. Intelligent assessment tools are also deployed at both secondary and higher vocational levels to improve the objectivity and accuracy of skill evaluation [2].

The adoption of AI has significantly enhanced instructional efficiency, improved the learner experience, and contributed to the reorganization of teaching models [3]. However, most existing research has concentrated on technological efficacy, implementation frameworks, or feedback mechanisms, while giving insufficient attention to the ways in which AI redefines educational relationships, reconfigures teacher–student dynamics, and influences the normative foundations of educational goals and values. In particular, ethical considerations—such as algorithmic bias, student autonomy, and data privacy—remain notably underexplored.

2.2 Role Definition of AI and Human Teachers

The functional positioning of AI in education has increasingly become a subject of critical inquiry within the philosophy of educational technology, particularly in recent years. While AI is often characterized as a "technological tool," its increasing decision-making capabilities and the advent of intelligent teaching aids have enabled it to perform quasi-teaching functions [4]. In some domains—such as lesson planning, instructional assessment, and learner guidance—AI systems have, to a limited extent, begun to substitute for certain forms of human involvement.

This trend has triggered an ongoing scholarly debate over the conceptual boundaries and pedagogical legitimacy of the so-called "AI teacher". For instance, Zheng et al. (2024) argue that, despite its utility in optimizing pedagogical processes, the data-driven nature of AI remains fundamentally instrumental and therefore does not threaten the irreplaceable subjectivity of human educators [5].

Vocational education, with its dual emphasis on practical training and character formation, intensifies the ethical and relational dimensions of teaching roles. Research by Dai and Zhu (2024) suggests that although AI excels in data processing and personalized instructional delivery, it falls short in domains such as ethical modeling, emotional attunement, and complex situational judgment [6]. Human teachers function not only as transmitters of technical skills, but also as embodied role models and custodians of professional values. The educational relationships and affective bonds cultivated through personal example and mentorship embody a form of interpersonal moral agency that remains fundamentally irreplaceable. Excessive AI involvement in moral guidance or pedagogical decision-making risks eroding teacher authority, distort the educational mission, and potentially undermine students' trust in educational outcomes [7]. Therefore, clarifying the auxiliary role of AI in teaching and delineating its functional boundaries within the talent development process constitute essential ethical tasks amid the evolving integration of AI into vocational education.

2.3 Research on AI and Educational Ethics

Ethical concerns surrounding the application of AI in education have emerged as a focal point of international scholarly inquiry. Core risks—such as algorithmic bias and opaque decision-making (so-called "black-box" processes)—may unintentionally reinforce structural inequities within educational systems [8]. Growing empirical and theoretical evidence suggests that AI technologies not only transform pedagogical practices, but also exert a subtle influence on the normative values and epistemic logics that underpin educational systems. At the same time, the emergence of "digital governance" in education has introduced a new layer of ethical complexity to vocational education systems [9].

In China, existing research has been largely confined to examining AI's impact on teacher–student relationships in basic education and the ethical boundaries of AI-driven assessment systems in vocational institutions [5]. Scholars have emphasized the need to establish a dynamic balance between teacher authority and technological agency, while also advocating for multi-stakeholder

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accountability frameworks. Nevertheless, systematic research on the ethical dimensions of vocational education—which integrates practical training, skills development, and moral cultivation—remains scarce. In light of the increasingly collaborative dynamics between AI systems and human educators, future research must critically interrogate how to construct mutually reinforcing and trustworthy human–machine relationships. Clarifying the authority, agency, and scope of influence of AI within pedagogical contexts is imperative. These themes are poised to become central to the evolving discourse on AI ethics in vocational education.

3. Dimensions of Ethical Boundaries from the Perspective of Human–Machine Symbiosis

As AI technologies become more and more embedded in vocational education, a purely technological perspective is no longer sufficient to account for their complex effects on educational relationships, normative value systems, and institutional practices. Drawing on the theory of human–machine symbiosis and integrating perspectives from educational ethics, responsibility ethics, and the philosophy of technology, this study proposes a conceptual framework for examining the ethical boundaries of AI within vocational education.The framework comprises four key dimensions: boundaries of authority, attribution of responsibility, construction of trust, and safeguarding of fairness.

3.1 Authority Boundaries: Balancing Teacher Leadership and Technological Empowerment

In vocational education, teachers are more than mere conveyors of knowledge; they are also instructors of applied skills and mentors in the formation of professional values. As artificial intelligence becomes more deeply involved in areas such as curriculum planning, classroom management, student evaluation, and instructional feedback, its influence extends beyond logistical support [10]. Increasingly, decision-making functions embedded in recommendation algorithms are shaping pedagogical directions, subtly shifting the locus of authority away from educators.

This evolving dynamic underscores the importance of clearly defining the role of AI as supportive rather than directive. Adhering to the principle of teacher-led, technology-assisted instruction is not simply a matter of pedagogy, but of preserving the ethical integrity of the learning process. When educators disregard or override algorithmic outputs, tensions may arise between human expertise and machine-generated suggestions, potentially leading to issues of algorithmic dominance or value distortion. Establishing clear thresholds for AI involvement in teaching decisions is thus vital to maintaining teacher agency and safeguarding the educational mission [11].

3.2 Responsibility Attribution: Coordinating Ethical Accountability Among Diverse Stakeholders

The integration of artificial intelligence into vocational education has created a complex web of accountability that extends across developers, institutional administrators, educators, and learners. When instructional failures or algorithmic biases emerge, traditional notions of singular or linear responsibility fall short. This is largely due to the semi-autonomous nature of AI systems, which are neither fully independent agents, nor mere passive tools. As Chen and Chen (2024) argue, this ambiguity calls for a restructured model of responsibility attribution: (1) at the technical level, AI systems should comply with standards that ensure transparency, interpretability, and evaluability; (2) institutionally, responsibility should be clearly distributed among developers (design responsibilities), institutional overseers (supervisory responsibilities), and frontline users such as teachers (operational responsibilities); and (3) at the humanistic level, all stakeholders should be encouraged to cultivate ethical awareness in both technological and pedagogical contexts [7].

To translate these responsibilities into practice, a contract-based governance mechanism is advised, with clearly defined liabilities for each stakeholder. In particular, the degree of AI's decision-making influence should be quantitatively defined to avoid responsibility being obscured under the pretext of algorithmic opacity—the so-called "black box" problem. From the standpoint of practical ethics, a dynamic responsibility-tracing system is more effective than static attribution. This may include ethical impact assessments during system design, controlled deployment trials (e.g., double-blind testing), and the implementation of log-tracing mechanisms in daily educational use. A compelling analogy can be drawn from the three-tier liability model in healthcare. In this model, developers are held accountable for algorithmic integrity (such as biases in training data), administrators are responsible for ensuring system operability (such as addressing failure in risk alerts), and teachers ultimately carry the responsibility for pedagogical decisions (such as the misapplication of AI-generated suggestions). In addition, regulatory models such as the European Union's Artificial Intelligence Act (2021) provide a risk-based framework for AI accountability [12]. This model imposes stricter liability standards for high-risk educational applications—such as intelligent assessment systems—than for low-risk tools like digital assistants. Such stratified accountability models help balance the pursuit of technological innovation with the ethical imperative of educational equity and justice.

3.3 Trust Construction: Reconfiguring Trust Dynamics in Human–Machine Collaboration

Trust serves as the cornerstone effective teaching and learning. With the integration of AI, the traditional binary trust relationship between teacher and student evolves into a triadic one that includes AI as a key participant. As Kou et al. (2025) suggest, the trustworthiness of AI systems depends on their transparency, explainability, and predictability [13]. If students distrust AI-generated learning recommendations due to the "black box" effect, and teachers find it difficult to reconcile AI's instructional advice with their professional judgment, the educational process risks destabilization As noted by Ahn et al., the trustworthiness of AI systems relies on transparency, comprehensibility, and predictability. Explainability frameworks—such as logged decision paths and decision trees—form the foundation of system transparency, which in turn underpins trust.

Based on the Human-in-the-Loop (HITL) principle, teachers can oversee machine outputs and intervene when necessary. Ethical scholars Dai and Zhu, referenced earlier, emphasize that ultimate decision-making authority should reside with teachers, with machines serving not as guides but as supportive tools. Rebalancing the power dynamics between humans and machines is essential for fostering trust. This dual-track strategy—integrating transparency and human primacy—forms the basis for establishing a sustainable and resilient trust framework in vocational education [6]. Concurrently, students should be encouraged to develop critical thinking regarding the implications of science and

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technology, enabling them to effectively utilize artificial intelligence without compromising their own judgment [14].

3.4 Fairness Protection: Ethical Safeguards for Justice in Technology-Driven Education

Students in vocational education often come from diverse backgrounds, particularly from rural areas targeting for revitalization. Many face challenges related to socioeconomic status, geographic isolation, or limited digital access. These are crucial factors that contribute to unequal opportunities in AI-supported learning. Threats to educational fairness stem from the following three main sources: (1) Data bias, such as an overreliance on samples from urban institutions; (2) Algorithmic design, which may incorporate default assumptions tailored to high-resource environments; and (3) Hardware distribution, including disparities in regional access to AI infrastructure [15]. If left unaddressed, these factors may exacerbate the "Matthew Effect" in educational resource distribution, deepening algorithm-driven digital divides. At the policy level, mandatory fairness audits should be enforced. In addition to disclosing the level of diversity in their datasets, developers should be required to submit reports on diversity metrics, such as statistical parity and equal opportunity, and undergo independent audits to ensure that these measures are implemented inclusively.

It is also essential to educate both the public and the students on how to recognize and prevent discrimination in the application of artificial intelligence. Ensuring fairness requires prioritizing the integration of digital and educational resources into underserved and marginalized regions [16]. Only through a comprehensive governance strategy—combining technical regulation, equitable resource allocation, and institutional capacity-building—can the education sector harness the transformative potential of AI for the benefit of all learners. For instance, when AI is applied in admissions or evaluation processes, mechanisms for appeal and revision must be established to safeguard educational fairness.

4. Practical Pathways for Human-AI Collaboration in Education

To ensure that education remains both human-centered and value-driven, it is essential to delineate the ethical boundaries between artificial intelligence and human educators. The integration of AI and human teaching roles has emerged as a defining trajectory in the evolution of education. On this basis rests the moral integrity of future vocational training.

This study explores an ethical framework for human–AI collaboration in vocational education through four core dimensions: (1) clarifying the supportive function of AI; (2) regulating the distribution of authority between humans and machines; (3) constructing robust accountability mechanisms; and (4) fostering sustainable trust systems. Together, these dimensions constitute a normative foundation for the ethically grounded and intelligent transformation of vocational education.

4.1 Defining the Role of AI in Instruction

Empirical research indicates that while artificial intelligence serves as a powerful tool for learning analytics and recommending learning paths, it still has limitations in value alignment, emotional engagement and the cultivation of creativity [17]. Accordingly, the integration of AI in education should adhere to the principle of augmentation—leveraging its strengths in data processing and personalized instruction, while safeguarding the teacher's central role as a moral and pedagogical guide. Vocational training, which is inherently both practice-oriented and socially embedded, carries the dual responsibility of imparting technical proficiency and fostering ethical character. This dual mission calls for a more precise delineation of functional roles in human–AI collaboration. In current educational technology discourse, AI functions are often classified into three hierarchical levels: a foundational level responsible for data collection and processing; an intermediate level focused on predictive modeling and learning analytics; and an application level that supports instructional decision-making [18].

To maintain alignment with ethical standards, robust monitoring mechanisms are essential. In vocational education specifically, AI should primarily be deployed within the foundational and intermediate levels therein its strengths in efficiency and scale can be best utilized. In contrast, higher-level responsibilities—such as instilling values, making pedagogical judgments, and fostering human relationships—must remain under the purview of human educators.This functional division not only capitalizes on the technological benefits of AI, but also preserves the humanistic core of the educational process. Periodic evaluative frameworks should be established to assess whether AI applications remain within the ethically appropriate boundaries [19]. AI should be positioned explicitly as an "intelligent assistant"—capable of supporting tasks like data analysis, personalized feedback, and automated grading—yet excluded from making high-stakes educational decisions or conveying normative content. Lastly, thoughtful application of educational technologies should be guided by the goal of empowering both teachers and learners to access, interpret, and benefit from expanded knowledge ecosystems—without compromising critical judgment or pedagogical integrity. The pedagogical function of vocational training, characterized by its practical and social dimensions, lies in fostering the technical and moral education of the students.

4.2 Regulating Authority Boundaries in Human–AI Collaboration

In intelligent learning environments, institutional mechanisms must be established to ensure that educators retain ultimate authority over instructional decision-making. Clearly delineating the boundary between human educators and intelligent systems is vital to safeguarding the quality and integrity of education. In high-stakes areas such as intelligent assessment and instructional resource recommendation, a two-tiered mechanism should be systematically implemented—whereby AI generates suggestions, and human educators make the final decisions. Zhao and Yang (2024) have observed that in cases of asymmetrical human–machine collaboration, excessive reliance on AI systems may erode teachers' professional judgment [19]. To mitigate this risk, intelligent systems must be explicitly designed to support—not supplant—human educators. For example, when evaluating or selecting learning materials, AI-generated recommendations should be subject to human review and adjustment, based on pedagogical objectives and student-specific needs. In educational practice, AI should function strictly as an assistive tool, rather than as the primary driver of curricular decisions. Mechanisms must be introduced to prevent disproportionate algorithmic influence on the content, direction, and ethos of instruction.

The regulation of authority boundaries must proceed on both technical and institutional fronts. Technically, intelligent tutoring systems should incorporate role-based access control, assigning differentiated permissions to distinct user groups. For example,

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enabling teachers to modify AI-generated content while restricting students to viewing access only. Institutionally, education authorities should issue comprehensive guidelines that define the standards for human–AI collaboration across diverse teaching scenarios. In this regard, the Ethical Guidelines for the Use of Artificial Intelligence in Education issued by the European Centre for the Development of Vocational Training (2023) serve as a valuable reference.Tailored to the particular context of China's vocational education system, such policies should aim to balance innovation with pedagogical oversight—avoiding both excessive automation and overdependence on intelligent systems [20]. It is imperative that policymakers articulate a detailed framework specifying the roles, responsibilities, and operational limits of AI systems throughout different phases of instruction. Such a framework would serve to preserve the educator's leadership role in the teaching enterprise, and to contain algorithmic overreach, ensuring that technological advancements remain aligned with the foundational values of education.

4.3 Enhancing the Collaborative Mechanism for Human–AI Mutual Trust

Building a robust foundation of mutual trust between human educators and intelligent systems is essential for fostering meaningful collaboration in educational contexts. This trust is shaped by two critical factors: the transparency of AI system operations and educators' digital literacy. Empirical studies have shown that when teachers possess a clear understanding of how intelligent systems function—particularly their decision-making logic, they are more likely to adopt these tools and use them effectively in pedagogical practice [21]. Therefore, both transparent system design and sustained professional development in digital competencies are fundamental to cultivating a trustworthy environment for technology-enhanced education.Trust between teachers and students also hinges on the responsible integration of AI. It is vital that teachers understand the underlying principles, functional scope, and practical applications of intelligent systems in order to avoid uncritical reliance on technology. Effective use of AI tools in instructional settings ultimately depends on both the trust and technological literacy of educators.

From a design perspective, explainable AI should serve as a foundational principle. To enhance transparency, system outputs should include visualizations of decision pathways and clear explanations of the variables influencing those decisions. A multi-tiered strategy is needed to systematically strengthen trust. First, AI literacy should be incorporated into mandatory teacher training programs. Such programs should cover core concepts of AI, common use cases, and methods for identifying algorithmic bias. Second, feedback mechanisms should be established to encourage teachers to report on system performance, share best practices, and recommend improvements. Third, practical, hands-on initiatives—such as "human–machine collaboration demonstration classes"—can provide educators with experiential learning opportunities that deepen their understanding of AI-supported instruction [22].

Furthermore, students must also be guided to critically engage with intelligent systems. Instruction on how AI systems work, their limitations, and their ethical implications is essential to avoid blind deference to algorithmic outputs. A sustainable and healthy human–AI relationship in education can only emerge when both teachers and learners develop the capacity to interact with intelligent tools thoughtfully and responsibly.

5. Conclusion

This study examines the ethical challenges associated with the increasing integration of intelligent technologies in vocational education. It proposes a conceptual framework encompassing four critical dimensions: function definition, authority delimitation, responsibility allocation, and trust construction. The analysis reveals that although AI has significantly improved teaching efficiency and allowed for more tailored learning experiences, it also brings ethical dilemmas—such as weakening the role of human educators and blurring lines of accountability [23]. In response, this study proposes a collaborative educational model based on the principle of human–machine symbiosis, aiming to bridge technological advancement with the core values of education.

This study contributes to the existing literature in three main respects (1) it clarifies the supportive role of intelligent technologies in vocational education; (2) it advances a principled framework for delineating authority in human–AI collaboration; and (3) it constructs a systematic ethical accountability structure. From a practical standpoint, the study outlines a multi-pronged strategy for driving educational transformation through institutional regulation, teacher development, governance and oversight mechanisms, equitable distribution of educational resources, and cross-sector collaboration.

Nonetheless, the study remains primarily theoretical in nature and is subject to several limitations, including a lack of empirical validation, insufficient attention to disciplinary variation, and a limited incorporation of student perspectives. Future research should strengthen interdisciplinary collaboration and empirical inquiry, develop context-specific solutions tailored to different industries, and place greater emphasis on the developmental characteristics and behavioral patterns of learners. Ensuring educational equity should remain a fundamental guiding principle in the deployment of emerging educational technologies.

Through thoughtful institutional design and coordinated resource allocation, the rights of vulnerable groups can be safeguarded. As AI technologies advance, it will be imperative for the vocational education sector to establish a routine risk assessment mechanism to support the development of a more inclusive, equitable, and ethically grounded intelligent educational ecosystem.

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