The triple realm of AI-enabled education: from instrumental rationality to value reconstruction

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Abstract—Artificial Intelligence (AI) is reshaping the education ecosystem, and its development presents the triple realm of "instrumental rationality - integration rationality - value rationality". The instrumental rationality stage optimises teaching efficiency through technology, but faces the risk of alienation of teachers' roles and data privacy; the integration rationality stage emphasises human-computer collaboration to promote personalised learning and educational equity, but needs to solve the problems of technological ethics and system integration; the value rationality stage focuses on the reconstruction of the essence of education, and advocates that AI empowers moral and humanistic education, and balances technological efficiency and humanistic care. The current challenges include algorithmic bias, digital divide and lack of ethical governance, which need to be addressed through interdisciplinary integration, policy synergy and teacher capacity enhancement. In the future, AI education will evolve towards generative intelligence, lifelong learning and sustainable development, and it is necessary to build an inclusive ecosystem to ensure that technology empowers educational equity and social value.

Index Terms—Artificial Intelligence and Education; Reduce Burden and Increase Efficiency; Intelligent Teaching System.

I. The Triple Realm of AI-Enabled Education: Theoretical Basis and Relevance from Instrumental Rationality to Value Reconstruction

1.1 Background and significance of AI-enabled education

The rapid development of Artificial Intelligence (AI) technology is profoundly reshaping the ecological pattern of education. From early intelligent tutoring systems to today's generative AI tools, AI has evolved from the "instrumental rationality" stage of assisting teaching to the "value reconstruction" stage. This transformation is not only reflected in the technological breakthrough, but also in its redefinition of the nature of education. Zhang Jingjing pointed out that the intelligent education of AI should shift from "teaching" to "education", emphasising new teaching modes such as "human-machine co-teaching" and "human-machine symbiosis". It emphasises new teaching modes such as "human-machine co-teaching" and "human-machine symbiosis", and promotes the transformation of education from standardisation to personalisation, and from knowledge transfer to ability cultivation [1]. Liu Sanwu tooth, on the other hand, proposed that the two-way empowerment of AI and education needs to build a "one creation+ two concurrent+ three synergistic+ four fusion" talent training system, in order to achieve a comprehensive reconstruction of the education ecosystem [6]. These theories provide both philosophical and practical support for the triple realm of AI-enabled education.

1.2 The theoretical framework of the triple realm: from instrumental rationality to value reconstruction

The triple realm of AI-enabled education can be summarised as "instrumental rationality - integration rationality - value rationality". **The first realm** (instrumental rationality) takes technology as its core and focuses on the application of AI in teaching efficiency, learning analysis and personalised services. For example, adaptive learning platforms provide customised learning paths through algorithmic analysis of student behavioural data [11]; and intelligent tutoring systems achieve instant feedback and question-answering through natural language processing technology [7]. AI education in this stage is still dominated by "technology empowerment", and its value lies in improving teaching efficiency and learning experience. **The second realm** (integration rationality) emphasises the deep integration of AI and education, breaking through the limitations of a single tool and building a "human-machine collaboration" teaching ecology. Wang Hua proposes that AI-enabled education needs to achieve the three major features of "intelligent teaching mode", "personalized learning mode" and "open educational resources" [12], for example, through the virtual teaching assistant and teacher collaboration to achieve dynamic teaching and learning experience. For example, through the virtual teaching assistant and teacher collaboration, to achieve dynamic teaching adjustment; through big data analysis, accurate identification of students' cognitive blind spot and provide targeted intervention. **The third realm** (value rationality) goes beyond the technical level and returns to the essential value of education. Zhang Jingjing advocates that AI education should take "moral education" as the core, and through the "human-computer co-teaching" mode, transform the technical tools into the carrier of educational value, and promote students to shift from knowledge acquisition to ability cultivation and value shaping [1]. This stage of AI education is no longer limited to technical efficiency, but through the reconstruction of value, to achieve the organic

unity of educational equity, humanistic care and technical rationality.

1.3 Challenges and opportunities in current practice

Although AI-enabled education shows great potential, the realisation of its triple realm still faces multiple challenges. **At the technical level**, the "instrumental rationality" stage of AI education is prone to fall into the misunderstanding of "technology first", neglecting the humanistic attributes of education. For example, some AI systems have insufficient adaptability to disadvantaged groups due to algorithmic bias, exacerbating educational inequality [2]. **At the integration level**, the deep integration of AI and education needs to solve the problem of technical barriers and organisational inertia. Liu Sanwu teeth pointed out that the current AI education application still exists in the three major dilemmas of "difficult to deepen the application of education", "difficult to promote the system change", "difficult to improve the effectiveness of the significant" [3], for example, teachers are not sufficiently accepting of AI tools, and the teachers are not sufficiently accepting of the AI tools. For example, teachers' acceptance of AI tools is insufficient, or schools lack a mechanism for interdisciplinary integration. **At the value level**, the reconstruction of the value of AI education needs to balance the relationship between efficiency and fairness, technology and humanity. Xiao Rui and other scholars emphasise that AI education needs to avoid "technocratic tendencies" and be guided by a "big idea" to integrate AI into the core objectives of education, rather than only being used as a teaching aid [17]. However, these challenges also present opportunities. For example, the openness and scalability of AI technology provides a new path for educational equity, and through projects such as "digitalisation of enrolment" and "digitalisation of international education public services", we can break through geographical and resource constraints [15]. At the same time, the construction of the ethical framework of AI (e.g., transparency, accountability) provides an institutional guarantee for value reconstruction [16]. In the future, the triple realm of AI-enabled education needs to be broken through in the synergistic evolution of technology, education and society, and ultimately realise the paradigm leap from "instrumental rationality" to "value reconstruction".

II. The Triple Realm of AI-Enabled Education Practice Paths and Challenges

2.1 Practical Paths and Limitations of the Instrumental Rationality Stage

In the "instrumental rationality" stage of AI-enabled education, the core value of technology is to improve teaching efficiency and learning experience. Zhang Jingjing pointed out that AI analyses students' behavioural data through intelligent algorithms to achieve personalized learning path design, such as adaptive learning platforms (e.g., Knewton, DreamBox) through real-time feedback to adjust the content of the study, significantly improving learning efficiency. Liu Sanwu Dental further proposes that the application of AI in teaching support should follow the principle of "one creation+ two concurrent+ three synergy+ four integration", i.e., creating new scenarios by means of technology, focusing on the concurrent of teaching content and technology tools, and the synergistic interaction between teachers, students and AI. However, this stage of practice still faces significant limitations. Firstly, technological dependence may lead to the risk of "human-machine substitution", where the teacher's role is marginalised and students' autonomy and creativity are undermined (Hua Wang, 2022). Second, the algorithmic bias of AI systems may exacerbate educational inequalities, for example, in resource-poor areas, AI tools may not be able to effectively support disadvantaged groups due to insufficient data quality (Liu, 2023). In addition, the standardised design of technological tools may ignore the diverse needs of education, leading to a "one-size-fits-all" teaching model (Zhang Jingjing, 2021).

2.2 Synergistic mechanisms and innovative models at the stage of integrative rationality

Entering the stage of "integration rationality", the deep integration of AI and education has become the key. Wang Hua proposed that AI-enabled education needs to achieve the three major features of "intelligent teaching mode", "personalised learning mode" and "open educational resources", such as through virtual teaching assistants (such as Squirrel AI) and teachers to collaborate to achieve dynamic teaching adjustments; through big data analysis to accurately identify students' cognitive blind spots and provide targeted support. For example, through virtual teaching assistants (such as Squirrel AI) and teachers to collaborate to achieve dynamic teaching adjustment; through big data analysis, accurately identify students' cognitive blind spots and provide targeted intervention. Liu Sanwu teeth stressed that AI education needs to break through the limitations of a single tool to build a "human-computer collaboration" teaching ecology, for example, through the "dual-teacher classroom" model (teacher + AI assistant), to achieve the depth of the teaching content mining and personalised feedback. However, this stage of practice also faces challenges. Firstly, the deep integration of technology and education needs to address organisational inertia, such as teachers' lack of acceptance of AI tools, or schools' lack of mechanisms for cross-disciplinary integration (Liu Sanyu Dental, 2023). Secondly, the lack of openness and scalability of AI systems may lead to the phenomenon of "technology silos", such as poor data interoperability between different AI platforms, which restricts the sharing of educational resources (Zhang Jingjing, 2022). In addition, the synergy between technology and education needs to balance efficiency and fairness, for example, the "digital divide" problem of AI in resource allocation may further aggravate the inequality in education (Wang Hua, 2021).

2.3 Ethical Reflection and Future Prospects of the Value Rationality Stage

In the "value rationality" stage, the core goal of AI education shifts from technical efficiency to the reconstruction of educational value. Xiao Rui and other scholars pointed out

that AI-enabled education needs to avoid "technocratic tendencies", and needs to be guided by the "big idea" to integrate AI into the core objectives of education, such as through the "human-machine co-teaching" model, which transforms technical tools into carriers of educational value, and promotes students' transformation from knowledge acquisition to competence to reconstruction. For example, through the "human-machine co-teaching" model, the technical tools are transformed into carriers of educational value, and students are promoted to shift from the acquisition of knowledge to the cultivation of abilities and the shaping of values (Zhang Jingjing, 2023). Liu Sanwu Dental further proposes that the reconstruction of the value of AI education needs to build a breakthrough path of "difficult to deepen the application of education", "difficult to promote the systematic change" and "difficult to improve the effectiveness significantly", for example For example, through the "digitalisation of enrolment and study" and "digitalisation of international education public services", we can break through the geographical and resource restrictions (Liu, 2023). However, the practice of at this stage still faces ethical challenges. Firstly, the "black box effect" of AI in education may lead to a crisis of trust, for example, students and parents have doubts about the transparency of AI decision-making (Wang Hua, 2022). Second, the "algorithmic bias" of AI in education may exacerbate social division, for example, AI may discriminate against disadvantaged groups due to data bias in the process of enrolment and evaluation (Zhang Jingjing, 2021). In addition, the value reconstruction of AI education needs to balance the relationship between technology and humanities, for example, through the "ethical framework of education" (e.g., transparency, accountability) to provide institutional protection for AI education (Xiao Rui, 2023).

2.4 Articulation and Future Trends in the Triple Realm

The triple realm of AI-enabled education does not exist in isolation, but is gradually promoted through the synergistic evolution of technology, education and society. From "instrumental rationality" to "integration rationality" to "value rationality", the practical path of AI education needs to establish a dynamic balance between technological breakthroughs and educational concepts. For example, Zhang Jingjing points out that the "value reconstruction" of AI education needs to take the "moral education" as the core, and through the "human-machine co-teaching" mode, the technical tools should be transformed into the carrier of educational value (Zhang Jingjing, 2023). (Zhang Jingjing, 2023). Liu Sanya emphasises that the future of AI education needs to achieve a comprehensive restructuring of the education ecosystem through the breakthrough path of "difficult to deepen the application of education", "difficult to promote the systematic change" and "difficult to improve the effectiveness" (Liu Sanya, 2023). Comprehensive reconstruction of the education ecosystem (Liu Sanwuya, 2023). The construction of "education ethics" to ensure the sustainable development of AI education.

III: Ethical Challenges and Governance Paths for AI-Enabled Education

3.1 Ethical dilemmas of AI in education

While the widespread use of AI in education has brought many conveniences, it has also raised a series of ethical challenges. Firstly, **privacy and data security** issues are becoming increasingly prominent: AI systems rely on a large amount of student data for personalised learning and assessment, but the collection, storage and use of such data may infringe on students' privacy rights. For example, Zhang Jingjing pointed out that the "black box effect" of AI in education may cause students to feel uneasy about the opacity of data use, which in turn affects their sense of trust [1]. Secondly, the problem of **algorithmic bias** is also a cause for concern, as AI systems often make decisions based on historical data, which may contain biases such as gender, race, and economic background, leading to unfair educational outcomes. For example, Wang et al. point out that the application of AI in education may lead to "algorithmic discrimination", which may exacerbate social inequality [5]. In addition, **the alienation of teachers' roles** is also one of the important ethical issues, and the introduction of AI may weaken the dominant position of teachers, lead to the alienation of teacher-student relationships, and even affect students' social skills and emotional development [16].

3.2 The Necessity and Practical Path of AI Ethics Education

In the face of the above ethical challenges, AI ethics education has become an important issue in the field of education.AI ethics education not only involves ethical design at the technical level, but should also be integrated into the core objectives of education, such as developing students' critical thinking, moral judgement, and digital literacy. For example, Jason Borenstein and Ayanna Howard point out that AI developers need to be ethically aware to ensure the appropriate use of technology [10]. In addition, AI ethics education should be integrated throughout the educational process, including curriculum design, teaching methods, and assessment systems. For example, Fajar Alamin and Sofyan Sauri emphasised that AI ethics education should be centred on "building moral values", and that students' and teachers' ethical awareness should be enhanced through curriculum reform and teacher training [16].

At the practical level, AI ethics education can be realised in a number of ways. First, **curriculum design** should incorporate AI ethics content into the teaching of various disciplines, for example, by introducing AI ethics modules in computer science, social science and humanities programmes. Second, **teacher training** should enhance teachers' understanding of AI ethics so that they can effectively guide students to think about the moral implications of AI. For example, Hu et al.

proposed that a guide to ethical norms for educational AI should be prepared and their intelligence education literacy should be enhanced through teacher training [14]. In addition, **student engagement** is also an important part of AI ethics education. For example, Sara Saylam et al. stated that educators should guide students to understand the potential impacts of AI and develop their ethical awareness and digital citizenship [9].

3.3 Framework and Policy Recommendations for Ethical Governance of AI

In order to effectively address the ethical challenges of AI in education, it is necessary to construct a sound framework for the ethical governance of AI. First, **policymaking** should clarify the ethical boundaries of AI in education, for example, through legislation that ensures the privacy protection of student data and regulates the fairness of AI systems. For example, Afshan Bibi et al. suggest that student rights protection should be strengthened, algorithmic and data biases should be addressed, and the impact of AI on educational equity and inclusion should be monitored [6]. Second, **technology governance** should focus on the transparency and interpretability of AI systems, for example, through algorithmic auditing and publicising the decision-making process to enhance students' and teachers' trust in AI. For example, Liheng Yu and Zhonggen Yu pointed out that AI ethics should include principles such as transparency, justice, fairness, impartiality, harmlessness, responsibility, and privacy [7]. In addition, **interdisciplinary cooperation** is also an important direction for AI ethics governance. For example, Ana María Alonso-Rodríguez emphasised that AI ethics should integrate scientific, technological and cultural-social factors to guide the application of AI in education [11].

At the policy level, governments and educational institutions should develop appropriate ethical norms for AI and promote their implementation in educational practices. For example, Celalettin Çelevi et al. pointed out that a guide to ethical norms of AI in education should be prepared and students' ethical awareness should be promoted through public interest learning resources [12]. In addition, **international co-operation** is also an important direction for AI ethical governance. For example, the draft proposal for AI ethics proposed by UNESCO emphasises the unification and coordination of AI ethical standards globally [1].

IV. Future Trends and Interdisciplinary Integration Paths of AI-Enabled Education

4.1 Generative AI-driven paradigm shift in education

Generative AI is becoming the core force driving the change of education paradigm.Hao Yu and Yunyun Guo (2023) pointed out that generative AI can dynamically generate personalized learning content based on students' learning data and behavioral patterns through natural language processing and deep learning technology, realizing the accurate teaching and learning according to students' abilities [5]. " precision teaching [5]. For example, AI can generate customised learning paths based on students' interests or provide immersive experimental experiences through virtual labs, thus breaking through the time and space constraints of traditional classrooms. In addition, generative AI can enhance learning motivation through gamification design, for example, combining augmented reality (AR) technology to construct interactive learning scenarios to visualise abstract concepts and enhance students' cognitive engagement [5].

4.2 New Pathways for Equitable and Inclusive Development in Education

The popularity of AI technology provides technical support for educational equity, but its application still needs to address the uneven distribution of resources and the digital divide. Hu Xiaoyong et al. (2022) proposed that high-quality educational resources should be sunk into remote areas through projects such as "digitisation of enrolment" and "digitisation of public services in international education", so as to realise the equalisation of educational opportunities [13]. For example, AI-driven distance learning platforms can provide rural students with the same quality of curriculum resources as urban students, and at the same time break down language barriers and promote multicultural integration through voice recognition and real-time translation technology [15]. However, technological empowerment needs to be synergised with policy design, such as the establishment of "Guidelines for Ethical Regulation of AI in Education", to ensure the universality and safety of technological applications [15].

4.3 Interdisciplinary Integration and Reconstruction of Educational Ecology

The deep integration of AI and education needs to break through the disciplinary barriers and build a new educational ecology of "human-machine collaboration". Liu Bangqi and He Sheng (2021) proposed that a multi-level AI education system should be constructed with the framework of "one goal, four levels, and two types of training", covering the differentiated needs of basic education, vocational education and higher education [14]. For example, in the basic education stage, AI can assist teachers in designing interdisciplinary curricula (e.g., STEAM education), and integrating maths, science and art content through knowledge mapping technology; in higher education, AI can provide researchers with intelligent literature analysis and experimental design support to promote academic innovation [17]. In addition, the combination of educational robots and virtual teachers can provide personalised support for special education groups, e.g. identifying students' emotional states and adjusting teaching strategies through affective computing technologies [17].

4.4 Policy synergies and global governance frameworks

The sustainable development of AI-enabled education depends on policy guidance and international cooperation. Huang Ronghuai et al. (2021) emphasised that the government should adopt the proposition of "two-way empowerment of science

and technology and education" to formulate the development plan of AI education, for example, setting up a special fund to support the research and development of AI education products , and establishing a collaborative mechanism of "government-enterprise-academia-research" to promote the technology to the ground [7]. [7]. Meanwhile, the draft AI ethics proposal (2023) proposed by UNESCO provides a reference for global governance, such as avoiding technological monopoly and data barriers through standardised data sharing agreements [15]. In the future, the governance of AI in education needs to take into account technological innovation and humanistic care, such as building a dynamic simulation system of educational data through the "digital twin strategy" to achieve risk warning and decision optimisation [4].

4.5 Challenges and Opportunities in the Education 4.0 Era

Education 4.0 (Education 4.0), as the future form of AI and education integration, faces the uncertainty of technology iteration, but also contains unlimited possibilities.João Fernando Costa Júnior et al. (2023) pointed out that AI education needs to address the core issues of "algorithmic bias" and "data privacy", such as protecting student data privacy through federated learning technology, and improving model generalisation ability by using transfer learning [17]. João Fernando Costa Júnior et al. (2023) pointed out that AI education needs to address core issues such as "algorithmic bias" and "data privacy", for example, by protecting student data privacy through federated learning techniques, and by using transfer learning to improve the generalisation of models [17]. In addition, Education 4.0 needs to reconfigure the role of the teacher, so that it is transformed from a "knowledge transmitter" to a "learning guide", through AI tools to assist in the design of inquiry-based learning tasks, to cultivate students' critical thinking and innovation [12]. Ultimately, the triple realm of AI-enabled education will move from "instrumental rationality" to "value rationality", and achieve a comprehensive reconstruction of the education ecosystem through the synergistic evolution of technology, education and society [1].

V. The Future Picture and Sustainable Development Path of AI-Enabled Education

5.1 A systematic summary of the three realms of AI education

The triple realm of AI-enabled education - from "instrumental rationality" to "value reconstruction" - is not only the inevitable result of technological evolution, but also a deep mapping of educational philosophy and social values. It is not only the inevitable result of the evolution of technology, but also a deep mapping of educational philosophy and social value. Zhang Jingjing (2021) pointed out that the "value reconstruction" of AI education needs to take "moral education" as the core, and through the "human-machine co-teaching" mode, the technical tools are transformed into carriers of educational value, promoting students from knowledge to education. Through the mode of "human-machine co-teaching", the technological tool is transformed into a carrier of educational value, and students are promoted to shift from knowledge acquisition to ability cultivation and value shaping [1]. Liu Sanwuya (2023) further proposes that the "trilogy" progression pattern of AI education - technological empowerment, technological innovation, and technological reshaping - reveals the transformation of the education ecology from "standardisation" to "standardisation". "standardisation" to "personalisation" to "ecology" [16]. This process not only relies on technological breakthroughs, but also requires the innovation of educational concepts and the synergy of social systems.

5.2 Challenges and Directions for Breakthroughs in Current AI Education Practices

Although AI education shows great potential, its development still faces multiple challenges. First of all, the issues of **technology ethics and data security** are prominent.Neil Selwyn (2022) emphasises that the application of AI in education needs to be alert to risks such as "algorithmic bias", "data privacy", "social inequality", etc. [4]. "For example, generative AI may discriminate against disadvantaged groups due to biased training data [4]. Secondly, the realisation of **equity in education** still needs a breakthrough. The UNESCO report points out that AI education needs to narrow the education divide between urban and rural areas, regions and groups through strategies such as "inclusive data systems" and "open sharing of digital resources" [12]. In addition, **the transformation of teachers' roles** and the "human-machine trust crisis" are also key challenges. Huang Ronghuai et al. (2021) suggest that teachers need to transform from "knowledge transmitters" to "learning facilitators", and the "black box effect" of AI tools may weaken the depth of teacher-student interaction [18]. The "black box effect" of AI tools may weaken the depth of teacher-student interaction [18].

5.3 Sustainable Paths for the Future of AI Education

For the future, the sustainable development of AI education needs to be promoted from the three aspects of technology, education and society. **On the technical level**, the transparency and interpretability of AI systems should be strengthened, for example, through "explainable AI" (XAI) technology to enhance the trust between teachers and students [20]. Meanwhile, the cultivation of "emotional intelligence" and "AI literacy" of generative AI should be the focus of research to address the cognitive and ethical challenges in human-computer interaction [14]. **At the education level**, a new teaching ecology of "human-computer collaboration" should be constructed, for example, through the mode of "dual-teacher classroom" and "virtual teacher", to achieve the balance between personalised learning and social-emotional development [3]. Balance of personalised learning and social-emotional development [3]. **At the social level**, it is necessary to establish an education-technology-policy linkage mechanism, for example, through the "Code of Ethics for AI

in Education" and "Open Platform for Digital Resources", to promote the universality and fairness of AI education [4]. The social level needs to establish an "education-technology-policy" linkage mechanism, for example, through the "code of ethics for AI in education" and "open platform for digital resources" to promote the universality and fairness of AI education [12].

5.4 Future Research Directions and the Future Picture of Policy

Future research on AI education should focus on the following directions: first, interdisciplinary integration, for example, combining education, psychology and computer science to explore the application of AI in special education, lifelong learning and other fields [16]; second, ethical governance, to build a global standard covering data privacy, algorithmic fairness and social impacts [12]; and third, educational equity, to optimise resource allocation strategies through the "digital twin" technology to simulate different educational scenarios [19]. Third, educational equity, through "digital twin" technology to simulate different educational scenarios and optimise resource allocation strategies [19]. At the policy level, initiatives such as "education AI special fund", "teachers' AI literacy training" and "education data open platform" should be promoted to ensure the sustainable development of AI education [17]. The triple realm of AI-enabled education is not only a leap in technology, but also a reconstruction of the nature of education. From "instrumental rationality" to "value reconstruction", AI education needs to adhere to the humanistic care in the technical empowerment, and achieve fairness and justice in the systematic change. In the future, only through the synergistic evolution of technology, education and society can we build a new ecosystem of AI education that is "high-quality and warm", and truly realise the educational ideal of "making people moral" [16].

VII. Conclusion

With the continuous development of artificial intelligence, its application fields continue to expand, and will be more widely used in primary and secondary school teaching in the future, artificial intelligence will be more deeply integrated into the field of primary and secondary school teaching, and artificial intelligence will develop towards intelligence, personalization and fairness. As a tool for teachers to carry out teaching work, artificial intelligence can tailor personalized learning plans for students, and to a certain extent, it can also promote the balanced allocation of educational resources and contribute to the fair development of educational resources. In the face of the development of AI technology, the education sector should seize the opportunity to tap the potential of AI technology to achieve sustainable development of primary and secondary education.

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