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Opportunities and Challenges of Educational Evaluation in the Metaverse

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Abstract: As an emerging technological form, the metaverse provides innovative transformations for all levels of education—including scenarios, resources, and models—through its highly immersive and powerful social interaction characteristics. Educational evaluation is core to assessing teaching effects and improving teaching strategies. With the technical support of the metaverse, challenges in traditional educational evaluation can be addressed, and comprehensive multi-dimensional portraits of individuals and collectives can be depicted, effectively enhancing teaching outcomes. Therefore, it has important value and untapped potential. This paper first analyzes the characteristics of educational evaluation in the metaverse context, discusses possible opportunities and challenges, then explores comprehensive practical paths from macro, meso, and micro levels, providing suggestions for the reform of educational evaluation in the metaverse environment.

Keywords: Metaverse; Educational evaluation; Implementation path

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1. Introduction

Educational evaluation is based on goals and standards, aiming to assess teaching effects and promote teaching quality and student development [1]. Traditional evaluation methods, such as standardized tests, surveys, and observations, combine qualitative and quantitative approaches to assess academic performance and behavior. The Overall Plan for the Reform of Educational Evaluation in the New Era issued by the State Council in 2020 calls for modern evaluation models to promote student growth and innovation [2]. Meanwhile, the rise of the metaverse has accelerated the application of technologies such as VR, AR, and 3D modeling, providing immersive educational experiences. In these environments, students' behaviors, emotions, and participation can be tracked to support comprehensive evaluation [3,4]. This transformation requires rethinking evaluation frameworks and methods to establish systems suitable for the mixed reality of modern learning.

2. Two new opportunities for educational evaluation in the metaverse environment

2.1. Diversity and comprehensiveness: A new evaluation framework emphasizing abstraction and concreteness, knowledge and emotion, teachers and students alike

Constructivism holds that the best way to learn is to construct knowledge through practice. In metaverse scenario design, high-level human-computer integration is achieved—cognitive integration, physiological integration, and environmental integration—to serve this goal [5]. This facilitates the application of knowledge in real-world problems and deeper understanding of complex concepts, requiring evaluation methods that can integrate multiple types of information, including sign language, language, gaze, and EEG data. Transcending traditional measurement methods, this approach can effectively analyze emotional and thinking states, potentially enabling “flow” experiences [6]. Additionally, blockchain and security technologies ensure data integrity and authentic authentication. Thus, metaverse learning evaluation should also reflect real-life performance, include analysis of cognitive-emotional relationships, and aim to encourage students’ self-reflection and evaluation. This represents a comprehensive student-centered educational view that recognizes diverse multi-sensory channel dialogues and evolves into a partnership between teachers and students.

2.2. Continuity and dynamism: New evaluation technologies requiring remote, multimodal, and in-depth participation

Learning is a dynamic process, and mastering knowledge [7] stems far more from continuous engagement than exam scores. However, traditional evaluation technologies, constrained by technical limitations, hardly provide instant feedback. With metaverse support, new technologies like 5G, VR, AR, and MR can break geographical barriers for continuous learning and knowledge mastery [8]. Applications of IoT RFID, sensors, and brain-computer interfaces can record individual behaviors and emotional fluctuations, while cloud computing creates conditions for storage and analysis. These establish a cyclic feedback mechanism between humans and the environment to monitor students’ performance, behaviors, and cognitive conditions in real time, enabling spiral evaluation based on feedback to improve “how to teach” and facilitate long-term tracking of knowledge storage, ability transfer, and educational effectiveness.

2.3. Personalization and precision: Achieving new evaluation results that supplement both individuals and groups

Traditional evaluation models often ignore individual differences. This personalized evaluation mechanism can address problems through instant feedback and self-correcting learning paths, using multi-source data evaluation to formulate appropriate teaching strategies, thereby improving learning efficiency and promoting educational equity. However, individual evaluation cannot fully replace group evaluation—personal information can be aggregated to provide collectives with more contextual understanding. The metaverse environment is well-suited for group tasks, enabling continuous tracking of group progress, communication, and collaboration effectiveness, thus enhancing the fairness of group evaluation.

3. Three major challenges of educational evaluation in the metaverse context

3.1. Macro perspective: New challenges in policies and standards

The policy and standard system for metaverse educational evaluation urgently needs improvement. Although some local governments have issued relevant policies, gaps remain in the top-level design, legal norms, and ethical guidelines for virtual spaces. Due to the complexity of educational evaluation itself, it is often overlooked, making the construction of a metaverse evaluation system a long-term and arduous task. Evaluation work faces multiple challenges: On the one hand, the adaptability of evaluation content to teaching content needs urgent resolution. The diversity of disciplines and professional courses makes designing a single course evaluation system quite difficult, not to mention building an interdisciplinary overall evaluation framework. The innovation of teaching methods and the diversification of metaverse resources further exacerbate this contradiction. On the other hand, the fragmentation of the technical ecosystem is prominent. The metaverse consists of diverse platforms with different data formats and interaction modes, making it difficult to unify standardized evaluation indicators, data interoperability mechanisms, and cross-platform evaluation systems. Additionally, the complexity of learners' behavioral data poses a challenge. Learners' dual activities in real and virtual spaces generate multi-dimensional behavioral data, and establishing scientific evaluation models (such as index weight formulas, threshold settings, dimension division, etc.) covering all disciplines and educational stages is extremely difficult, leading to dual technical and theoretical bottlenecks in constructing standardized evaluation frameworks.

3.2. Meso perspective: New challenges in design and integration

The metaverse deeply integrates "people" and "objects" through digital twin technology [9], capable of simulating complex real-world social networks. Here, "people" exist in two forms: real individuals and digital avatars, whose recognition in evaluation needs to be implemented at both individual and institutional levels. Teachers and students must trust the teaching evaluation capabilities of digital avatars to ensure objective and fair evaluation; meanwhile, it relies on institutions to establish consensus and norms, granting avatars credible evaluator identities. "Objects" include evaluation systems, content, participants, and intelligent data tools. In a hybrid real-virtual environment, these objects need continuous iteration and upgrading to maintain evaluation efficiency and accuracy [10]. However, affected by platform diversity and technical integration challenges, designing and implementing such systems is fraught with difficulties. An ideal metaverse evaluation system needs to integrate virtual reality hardware, immersive content, cloud platforms, and advanced computing facilities to achieve interoperability of multi-sensory data, requiring not only deep technical integration but also substantial investment in human resources and funds. However, the global development of such support systems is currently lagging, and the complexity of teaching design and technical integration has become an important obstacle to implementing personalized and dynamic evaluation methods. Solving these problems requires continuous strengthening of infrastructure construction, institutional capacity enhancement, and increased resource investment, undoubtedly a global long-term challenge.

3.3. Micro perspective: New challenges for learners and educators

Learners and educators are the core of evaluation, but the metaverse brings technical and cognitive challenges. From the learner's perspective, adapting to virtual environments and embodied tools can affect learning performance. Emotions are based on the body, and changes in physical or digital states can alter cognitive outcomes [11]. Differences in the quality of virtual content, equipment, and compatibility with human perception may hinder cognitive expression, thus affecting evaluation. Furthermore, virtual identities may encourage role-playing behaviors to achieve ideal results, compromising the authenticity and seriousness of evaluation.

Although educators benefit from rich dynamic data, they face challenges in effectively collecting, analyzing, and using this data to guide evaluation. The complexity of such tasks may lead to over-reliance on technology and increase the risk of evaluation bias. Digital avatars may provide assistance—students can use peers for self-evaluation, and educators can delegate routine tasks to AI. However, achieving this human-machine collaboration model requires significant cognitive shifts and methodological reforms. This transition process is slow, difficult, and time-consuming. For example, teachers must balance roles with digital avatars, create personalized evaluations, monitor learning progress, and provide individual feedback. Unless AI reaches a more advanced level, achieving these outcomes will remain a major challenge.

4. Comprehensive practice paths for metaverse educational evaluation teaching

4.1. Top-level guidance: Policy-driven and balanced development

Policies and funds are key drivers for addressing emerging technologies to promote educational reform. Despite increasing global efforts, metaverse applications remain in an immature stage, and policies in various fields lack clear implementation standards. Educational institutions should participate in formulating metaverse-related policies—including technical, legal, and ethical frameworks—to protect data privacy, intellectual property, and educational equity [12]. Governments should increase investment in evaluation tools, platforms, and immersive educational content, and provide training support.

Since 2020, more than 40 provinces and cities in China have introduced metaverse policies. The Three-Year Action Plan for Innovative Development of the Metaverse Industry (2023–2025) jointly issued by five national ministries and commissions in 2023 emphasizes the educational application of metaverse technology and implementation funding support. The metaverse can transcend time and space constraints, promoting resource sharing and educational equity. National strategies must coordinate with local governments to integrate technical, economic, and educational policies, balancing innovation and equity to avoid exacerbating inequalities.

4.2. Framework design: Multimodal evaluation in spatial dimension, whole-process evaluation in time dimension, and nonlinear evaluation in spiral dimension

The educational metaverse constructs a complex virtual ecosystem, urgently requiring an updated evaluation framework. Guided by situational learning and embodied learning theories, evaluation should be redesigned in three dimensions: space (multimodal), time (process-oriented), and spiral (nonlinear feedback).

In terms of the spatial dimension, the framework should integrate multi-sensory evaluation, using hardware, protocols, and cross-domain tools (such as psychology, affective computing, quantitative indicators, etc.) for evaluating emotions and actions. Multimodal data should be logically organized and expanded to add data for extracurricular success, establishing diversified learner profiles.

From the time dimension, monitoring should focus on the learning process rather than superficial activities. The true process should be embodied through dynamic monitoring of learners' states based on time and environment. Instant feedback is ideal but costly, so it is necessary to reduce the feedback cycle for feasibility; as data scale increases, AI automated interpretation becomes an important and serious issue—while also bringing strong privacy concerns.

In the spiral asymptotic learning process, students' ways of understanding and acting differ from others [13], requiring management through a spiral evaluation model of "evaluation-revision-re-evaluation." However, effective information is a prerequisite for assistance, and to make it practical, standard processes for the taught subjects or environments must be set. Inspired by metacognitive theory [14], students should also actively conduct self-evaluation and reflection on their learning to enhance autonomy.

4.3. Empowering participants: Role transformation, capacity enhancement, and competence improvement

In addition to technological innovation, the metaverse will also transform traditional teaching models to some extent, shifting learning from passive acceptance to active learning, requiring multi-dimensional and innovative teaching methods. Meanwhile, changing evaluation methods will also focus on core skills such as innovative design, teamwork, and practical application, which is also advocated by the core idea of experiential learning, the "learning pyramid" [15]. Furthermore, learners should enhance skills such as emotional management, self-observation, and time management. Additionally, teachers need to conceptually adapt to the metaverse teaching model, which emphasizes experience and data. This requires learning diversified tools, creating meaningful content, and controlling digital teaching assistants [4]. When digital teachers perform routine teaching activities, human teachers need to reserve time for intellectually demanding tasks that rely on humanity. Meanwhile, they need to have data awareness, identifying improvement directions from learning analysis. Metaverse practice evaluation also requires teachers and students to possess certain digital literacy, namely technical capabilities (data analysis, metaverse virtual collaboration), communicative abilities (metaverse cross-cultural communication), and personal capabilities (identity recognition, data privacy).

4.4. Collaborative ecosystem: Unified standards and open cooperation

With the development of metaverse technology, interactivity provided by Web2.0 cannot be avoided, but the lack of unified standards in existing systems limits data sharing between devices, affecting evaluation effectiveness. Therefore, widespread acceptance of open specifications and compatibility are means forward. For example, UNESCO's initiative supporting open teaching materials demonstrates how shared architectures can strengthen the entire evaluation environment. The development of digital property is too broad due to closed structures, and overly expensive and difficult connections make open collaboration using shared resources a more sustainable requirement, contributing to scalable and efficient testing. It is necessary for governments and international organizations to play a leading role in establishing a globally compatible collaborative virtual learning environment.

5. Conclusion

The innovation of metaverse educational evaluation is not a total negation of the traditional system but an iterative upgrade of the evaluation paradigm through technological empowerment. Despite current challenges such as vague policy standards, technical integration barriers, and subject capacity gaps, its multi-dimensional evaluation framework (multimodal in spatial dimension, whole-process in time dimension, nonlinear in spiral dimension), subject empowerment mechanism (reconstruction of teacher-student roles and capacity enhancement), and ecological collaboration model (unified standards and open cooperation) have outlined a clear development blueprint. In the future, it is necessary to balance technological innovation and educational ethics through policy driven, optimize the accuracy and adaptability of evaluation with data intelligence, and ultimately construct a three-dimensional educational evaluation ecosystem of "technology-empowered, data-driven, and multidisciplinary collaboration" to provide sustained impetus for cultivating innovative talents adapted to the intelligent era. This process not only requires collaboration between technology developers and educational researchers, but also the active participation of policymakers, schools, and society to maximize the release of educational value in the metaverse.

Disclosure statement

The authors declare no conflict of interest.

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