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Exploring Innovative Teaching Approaches for 3D Real-Time Engine Courses in the Context of Digital Education

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Abstract. With the rapid development of digital technologies, there is an urgent need to modernize traditional educational models and teaching content for emerging technology courses. This paper explores innovative teaching approaches for the 3D Real-Time Engine course, which plays a vital role in cultivating students' technical competence and creative capabilities in digital media and film technology programs. Given the complexity and fast-evolving nature of 3D engine tools, conventional teaching methods face challenges such as outdated content delivery, insufficient integration of practical case studies, and limited personalization. To address these issues, this study proposes an application-oriented hybrid teaching model structured across four dimensions: teaching objectives, course content, instructional methodologies, and assessment systems. The model integrates online self-directed learning with in-class interactive instruction and post-class project-based practice, supported by high-quality digital resources and real-world examples. A tiered evaluation system is introduced to accommodate diverse student needs, focusing on work attitude, innovation, technical complexity, and completeness. This research contributes to the ongoing transformation of digital education by offering a replicable and adaptable framework for teaching emerging technologies.

Keywords: 3D engine technology, hybrid teaching model, digital education

1. Introduction

Digital technology, as a key driving force in contemporary education, has significantly promoted the innovation and development of educational models. Among these innovations, hybrid teaching represents a novel instructional approach that has gained prominence with the maturation of the Internet plus education paradigm and advancements in digital technologies. This model integrates the strengths of online and offline instruction to construct a composite educational framework characterized by a digital-physical hybrid structure. The concept of hybrid teaching is multidimensional, not only encompasses the fusion of teaching formats but also involves the integration of pedagogical theories, instructional methods, and organizational forms. By combining diverse educational resources and tools, this model maximizes the instructor's guiding role in the teaching process while highlighting the student's central role in learning. Its ultimate goal is to optimize learning outcomes and promote students' comprehensive development in knowledge, skills, and overall competence.

In parallel, three-dimensional (3D) real-time engines have become instrumental in supporting cultural digitization and metaverse-related technological innovation, offering immersive, interactive visual simulations of complex real-world scenarios. These engines are increasingly vital across various domains, including film production, virtual cinematography, simulation training, and game development. As a sophisticated system engineering domain, 3D real-time engines draw on interdisciplinary knowledge from computer science, mathematics, physics, and computer graphics. Prominent examples such as Unreal Engine and Unity not only dominate the digital entertainment industry but are also widely adopted in fields such as education, military training, healthcare, and industrial digital transformation. Academic research continues to explore core aspects of 3D engine technologies, including real-time rendering, natural human-computer interaction paradigms, and physics engine optimization.

With the rapid growth of the digital media industry and the increasing maturity of 3D technologies, there has been a rising demand for professionals skilled in 3D real-time engine development. Currently, many higher education institutions offer courses titled 3D Real-Time Engine Technology within programs related to film and television technology or digital media. These courses typically combine theoretical instruction with hands-on practice to cultivate students' foundational understanding and practical capabilities in engine development. Such coursework plays a crucial role in deepening students' technical proficiency, fostering cross-disciplinary innovation, and enhancing problem-solving abilities in real-world project development. Nevertheless, challenges persist in the effective delivery of this rapidly evolving subject. On one hand, the fast-paced updates in 3D engine technologies—such as new versions, tools, and functionalities—require instructors to frequently revise curricula to keep pace with emerging trends, resulting in considerable teaching pressure. On the other hand, given the highly practical nature of the course, students often seek to deepen their understanding through application-oriented case studies aligned with their personal interests and career aspirations. Consequently, there exists a strong demand for high-quality instructional materials and diversified exercise platforms to support personalized and competency-based learning.

2. Related Works

As early as 1993, the concept of "educational informatization" was formally proposed, aiming to utilize information technology as a key approach for educational reform, enabling students to access vast educational resources and alleviate the contradiction between the supply and demand of educational information [1]. In book The World Is Open: How Web Technology Is Revolutionizing Education, Curtis J. Bonk pointed out that hybrid learning integrates face-to-face teaching with computer-assisted learning, thereby overcoming the limitations of both approaches [2]. With the advent of the Internet plus education era, blended teaching approach has evolved beyond the simple integration of online and in-person teaching, emphasizing the blending of pedagogical strategies and teaching methods, as well as the optimization of students' learning experiences [3]. The application of hybrid teaching model fully leverages the advantages of both online and offline teaching, aiming to address longstanding issues in traditional classroom settings such as low student engagement, insufficient cognitive participation, and limited development of innovative talents, ultimately offering more flexible and diverse learning approaches [4].

The rapid advancement of digital technologies has accelerated the transformation of teaching models and learning behaviors in higher education. Notably, the emergence of generative artificial intelligence technologies, represented by ChatGPT, is reshaping the educational landscape and driving profound changes in instructional practices, presenting both significant opportunities and challenges for higher education [5]. Currently, research and practice related to hybrid teaching models are flourishing [6]. Sung et al. [7] designed a multimedia e-book learning system, and their research found that project-based learning can bridge the gap between theory and practice, fostering learners' multiple cognitive skills and problem-solving abilities. Liu et al. [8] explored the innovation and application of blended teaching approach in foundational mechanical engineering education, aiming to enhance students' learning efficiency and comprehension. By conducting a comparative analysis of the differences in student performance between traditional and blended teaching approaches, they validated the superiority of the blended teaching approaches in foundational mechanical courses. Li et al. [9] constructed a research framework based on Bourdieu's theory of field, and from the three dimensions of teaching field, learning field, and auxiliary teaching field, investigated the factors influencing blended teaching cognition in the context of higher engineering education. Gamage et al. [10] argued that to effectively cultivate undergraduate competencies, fundamental reforms are urgently needed in teaching strategies, instructional and learning behaviors, classroom facility upgrades, and curriculum design, especially for remote teaching. These studies indicate that current scholarly attention has shifted toward the practical application effects of hybrid teaching models and how these models can enhance students' higher-order thinking and learning capabilities [11][12].

Although existing research has extensively explored the theoretical foundations and broad applications of hybrid teaching models across various disciplines, their implementation in highly specialized and technically demanding fields, such as 3D real-time engine education, remains underdeveloped. Most studies have focused on general pedagogical strategies or foundational subjects, leaving a gap in how hybrid approaches can effectively address the unique challenges of teaching complex and rapidly evolving technologies. Building upon previous research, we first analyze the core challenges faced by 3D real-time engine courses, and then proposes an innovative hybrid teaching model specifically designed for 3D real-time engine instruction, aiming to enhance both technical mastery and student engagement in this critical area of digital education.

3. Challenges in 3D Real-Time Engine Courses

Based on the characteristics of the tools and the limitations of traditional teaching methods, the traditional setting of 3D Real-Time Engine courses currently faces three primary challenges.

The first issue is that the course content remains largely traditional, with limited integration of cutting-edge application areas, which results in insufficient motivation and engagement among students. When learning 3D engine tools, students often spend a significant amount of time familiar with interface operations and programming languages. Particularly at the introductory stage, the content is information-dense and includes numerous tedious and fragmented topics such as function shortcuts and basic commands. The conventional lecture-based approach to teaching tool-oriented courses fails to effectively stimulate student interest, leaving learners unprepared to tackle real-world application problems.

The second issue is that the functional modules of 3D engines are highly complex and demand strong systematic and modular thinking skills from students. 3D engine technology constitutes a complex system science, encompassing multiple functional modules such as animation, physics, rendering, user interfaces, and artificial intelligence. Each module contains unique operational procedures and algorithmic knowledge, and there exist intricate interdependencies among them. Moreover, new features and modules continue to emerge. As a result, within a limited number of class hours, students are required to learn how to manage and understand multiple modules and their collaborative interactions, while also developing the ability to adapt to continuous technological evolution.

The third issue is that the existing teaching model is relatively uniform and fails to support student-centered, personalized learning. The *3D Real-Time Engine* course serves students majoring in film and television technology and digital media, who are expected to pursue careers in diverse fields such as broadcasting, new media production, and game development. Given this heterogeneous student population, traditional classroom instruction struggles to accommodate individual learning needs within constrained class hours. Students may lose motivation due to either insufficient foundational materials or prior familiarity with certain concepts, and some may feel discouraged by assessments that are perceived as overly challenging. Furthermore, limitations in the breadth and depth of available teaching resources hinder differentiated instruction and innovation-driven learning, making it difficult to monitor and evaluate students' progress and learning outcomes in a timely and effective manner.

4. Application and Design of a Hybrid Teaching Model for 3D Real-Time Engine Course

Currently, research on hybrid teaching models is gradually shifting from a focus on technological aspects to pedagogical innovation design and the enhancement of students' learning capabilities. In response to the key challenges identified in the 3D Real-Time Engine course, we propose an application-oriented design of a hybrid teaching model, focusing on three core dimensions: instructional objectives, course content, and teaching methodology.

4.1. Improvement of Teaching Objectives

The *3D Real-Time Engine* course aims to equip students with the fundamental concepts and core modules of 3D real-time engine technology, as well as practical application skills based on a mainstream engine platform. By integrating systematic theoretical instruction with a variety of hands-on case studies, the course guides students in transitioning from mastering basic operational details of the engine to acquiring the ability to solve real-world problems. The teaching objectives are structured into three hierarchical levels.

(1) At the knowledge level, students are expected to master the fundamental concepts and core modules of 3D real-time engines and acquire the ability to operate a general-purpose engine effectively.
(2) At the competency level, students should develop capabilities in constructing virtual scenes and writing logic scripts, enabling them to independently design and develop digital media projects.
(3) At the application level, students are encouraged to apply engine knowledge as an innovative and productive technological tool, analyzing case studies and solving practical engineering problems from an interdisciplinary and cross-module perspective.

4.2. Innovation in Teaching Content

In the teaching design of courses focused on emerging technologies, the introductory phase plays a critical role in capturing students' attention and stimulating their interest. As a highly practical course, *3D Real-Time Engine* has broad applications across cutting-edge domains such as film production, game development, and stage simulation. Therefore, incorporating high-quality, recently released, and widely recognized case studies into the initial teaching materials can significantly enhance student engagement. For example, the famous game *Black Myth: Wukong*, developed using advanced 3D real-time engine technology, showcases detailed character rendering, realistic lighting effects, grand-scale environmental design, and fluid combat mechanics, which are all made possible by the powerful capabilities of modern engines. Similarly, the animated feature film *Ne Zha: The Rise of the Devil Child* utilized real-time rendering technology powered by 3D engines, allowing the production team to adjust camera angles and lighting effects within virtual environments to ensure visual accuracy and detail in the final output. These cases are visually compelling, culturally resonant, and easily recognizable, making them ideal for facilitating student comprehension and visual memory, thereby drawing their focus toward the functionalities and potential of 3D real-time engines.

Furthermore, the development of digital course resources—including official project files and excellent student works from previous cohorts can serve as valuable learning materials. By analyzing their design philosophies, implementation processes, and practical outcomes, students can gain deeper insights into various technical modules of the engine while exploring the interplay between design concepts and cultural narratives. This approach not only enhances students' intrinsic motivation and curiosity but also promotes self-directed learning.

4.3. Optimization of Teaching Models

The hybrid teaching model constructs a composite instructional structure by integrating the strengths of both online and offline education, forming a digital-physical hybrid approach. In the context of the *3D Real-Time Engine* course, implementing this model requires designing course content based on the complexity and importance of engine modules, restructuring teaching materials for both online and offline delivery, and developing high-quality online learning resources and practical platforms. This leads to a personalized teaching pathway characterized by pre-class online learning, in-class focused instruction, and post-class practical training. By closely integrating online self-directed learning with in-class in-depth explanation, as well as online practice management with offline theoretical instruction, a hybrid pedagogical approach is established that effectively combines knowledge acquisition with practical application.

In the teaching process of 3D real-time engine tools, the pre-class, in-class, and post-class phases are systematically interconnected, forming an integrated instructional system. The pre-class phase serves as a preparatory stage to engage students in the learning process. Based on students' cognitive levels and disciplinary backgrounds, instructors utilize generative artificial intelligence technologies to design and deliver course-relevant learning materials, thereby stimulating students' curiosity and motivation for exploration. The in-class phase based on students' prior preparation, foundational knowledge is delivered through a combination of lectures and case analysis, while advanced topics are explored through specialized discussion sessions aimed at deepening conceptual understanding. In the post-class consolidation and enhancement phase, teachers conduct comprehensive reviews and analyses of students' learning progress, identifying strengths and areas for improvement. Based on these insights, teaching strategies can be promptly adjusted, and personalized extension projects can be designed to facilitate the effective transfer and application of acquired knowledge. Through this progressive pedagogical approach, students are guided to establish a foundational framework for understanding basic engine modules. Combined with hands-on project-based training, this model cultivates students' cross-module thinking and problem-solving abilities, fundamentally addressing the challenges associated with mastering complex systems.

4.4. Development of the Evaluation System

To better monitor and enhance teaching effectiveness, it is essential to establish a diversified and comprehensive evaluation system, which is able to assess both students' academic achievements and their developmental potential. Strengthening formative assessment and feedback mechanisms constitutes a crucial component of this evaluation framework. By setting key milestones at critical points in the learning process, timely feedback can be provided at the end of each stage, enabling students to make necessary adjustments in a prompt manner. In addition, peer assessment mechanisms are introduced to promote collaborative learning and knowledge exchange among students. Through group discussions, each member gains insights from diverse perspectives and receives constructive professional feedback. Moreover, open and frequent communication channels between instructors and students should be established, such as designated office hours and the use of instant messaging platforms, to ensure that questions and concerns are addressed promptly and effectively.

The evaluation system primarily encompasses four key dimensions: work attitude, innovation, technical complexity, and completeness. Work attitude assesses students' ability to independently resolve issues using online resources and their punctuality in completing assigned tasks. Innovation evaluates originality in creative ideation and user experience design. Technical complexity considers the sophistication and professionalism of the technical skills applied. Completeness examines the overall integrity of the project, including functional implementation and interface aesthetics. To accommodate varying student performance levels, differentiated instructional strategies are implemented. For Level A (excellent) students, advanced technical guidance and support are provided, along with encouragement to explore online resources independently. For Level B (good) students, the focus lies on reinforcing foundational skills and unlocking latent potential. For Level C (needs improvement) students, additional one-on-one assistance is offered, including supplementary tutoring sessions and customized online learning materials. This tiered approach ensures that all students receive targeted support tailored to their individual learning needs, thereby promoting equitable and effective learning outcomes.

5. Conclusion

We first highlight the significance of digital education and emerging courses on 3D real-time engine technologies. By analyzing the current state of teaching and identifying key pedagogical challenges, we explore the design of a hybrid teaching model tailored to the specific needs of this course. Throughout the pre-class, in-class, and post-class phases, the teaching design closely aligns with student needs and learning objectives. High-quality digital teaching resources are introduced to support a hybrid approach that integrates online and offline theoretical and practical instruction, effectively addressing the complexities of technical content and the limitations of existing resources. This approach helps students identify their individual interests and application directions, ultimately achieving the instructional goals of strengthening foundational engine knowledge and emphasizing student-centered, personalized learning. Thus, this model not only improves technical competency in 3D engine development but also serves as a reference for teaching other emerging technologies in digital education. The optimization of this teaching model holds profound implications for bridging the gap between educational practices and industry demands, fostering the development of high-caliber professionals equipped to meet the challenges of the digital age.

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