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**RESEARCH ARTICLE**

# A Hybrid Approach to Personalized Learning in the Educational Metaverse: "Data and Knowledge" Driven for Vocational Art and Design Students

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**ABSTRACT**

This study aims to explore the development and application of "data-driven and knowledge-driven" in personalized learning video recommendation technology within the educational metaverse. By mining the learning profiles of vocational art and design students, including their degree of knowledge acquisition and learning depth, and based on their potential learning interests, personalized video recommendations are made. The research first investigates how to construct a knowledge graph-based teaching video association network in the field of art and design education and how to utilize this network for personalized video recommendations. The research content encompasses the tagging of teaching videos, the construction of a knowledge graph-based video association network, the establishment of student profiles, the analysis of complex recommendation scenarios, and the study of intelligent video recommendation algorithms. The study results indicate that video recommendation technology based on the "data-driven + knowledge-driven" approach can significantly enhance students' learning abilities and motivation, providing an efficient online education pathway for digital creative talent cultivation in the Guangdong-Hong Kong-Macao Greater Bay Area. The contribution of this research lies in advancing the process of personalized development in the educational metaverse and offering an important reference for future online education recommendation systems.

## 1. INTRODUCTION

With the rapid development of information technology and the popularization of the internet, educational models are undergoing profound transformations, particularly in the field of online education (Wang, 2013). The concept of the educational metaverse is gradually emerging, not only altering traditional educational practices but also providing new possibilities for personalized learning. The educational metaverse constructs a virtual video learning environment through emerging information technologies, enabling immersive learning for students. In this context, how educational platforms can efficiently recommend learning resources to learners has become an important research topic. Personalized learning video recommendation technology aims to recommend learning videos based on students' identity tags and individualized needs, thereby improving learning efficiency and experience. Currently, most online learning platforms' recommendation systems are primarily based on data-driven methods, which analyze students' behaviors and preferences through big data to make resource recommendations. However, this method neglects the associations between knowledge points and the construction of systematic knowledge, failing to fully meet students' needs for systematic learning.

This study aims to explore the development and application of the "data-driven and knowledge-driven" in personalized learning video recommendation technology within the educational metaverse. By delving into the identity tags and learning profiles of vocational undergraduate students majoring in art and design, the research intends to recommend personalized and systematic video knowledge based on students' potential learning interests. The ultimate goal of this research is to provide an efficient online education pathway for digital creative talent cultivation in the Guangdong-Hong Kong-Macao Greater Bay Area, thereby advancing the personalization of the educational metaverse.

## 1. The challenges of personalized learning video recommendation technologies in educational metaverse platforms

Online university courses have gradually become a new mode of learning, and scholars have conducted some research on the development and application of recommendation systems. Kuo & Tu (2005) utilized Adaptive Resonance Theory (ART) neural networks and K-means clustering to analyze web browsing paths and determine user browsing preferences. Wang et al. (2019) adopted embedded representations to model the semantic representations of entities and relationships and used recurrent neural networks (RNNs) to model the path sequences of entities and relationships, achieving explainable recommendation results through weight pooling operations. Du (2019) proposed utilizing external information to assist recommendations, such as item attributes, knowledge graphs, and user social networks. Zhou et al. (2004) optimized traditional collaborative filtering methods by calculating the influence between users based on the temporal order of their ratings on commonly rated items. Deng et al. (2003) employed a novel similarity metric method to compute the nearest neighbors of a target user to alleviate the data sparsity problem. Lin et al. (2005) segmented users into content-based and collaborative-based categories, comprehensively analyzed the impact of both categories on users, and used Fisher discrimination analysis to recommend text to users.

In the field of online education, the research and development of recommendation systems have had a significant impact on the advancement of educational informatization. Wang & Li (2007) proposed that e-learning systems can intelligently push relevant learning resources to users based on their characteristics. Li (2018) suggested utilizing learning paths to recommend learning resources by generating personalized learning paths for users. Karampiperis & Sampson (2005) introduced a sorting model that recommends resources of interest to learners through a fitness function. Meng & Yang (2018) and others positioned resources within courses based on users' historical learning records to make subsequent recommendations. However, in the context of the educational metaverse platform, user ratings and comments on courses are sparse, and learners' learning behavior is a dynamic and continuous growth process that requires flexibility in preference profiling, especially with respect to changes over time. Additionally, while recommendation accuracy is important, a single recommendation result may not provide psychological recognition to users.

Semantic mismatch issues in educational metaverse platforms arise as learners struggle to find resources that match their backgrounds and needs amidst a vast array of information, leading to a sense of disorientation and choice difficulty, which in turn diminishes learning efficiency. The lack of personalized learning guidance and systematic knowledge structure construction can cause learners to miss out on key courses. Future research should therefore focus on optimizing search mechanisms, alleviating information overload, and developing systematic, personalized learning guidance to enhance learning experiences and outcomes.

The issue of data sparsity in recommendation systems poses challenges for algorithms to accurately predict user preferences, particularly for new users or new content. In the context of online video learning platforms, user behavior is dynamic, and recommendation systems must flexibly capture evolving user preferences. Future research will explore the integration of recommendation technologies to overcome the challenges posed by data sparsity.

## 2. Developing a data and knowledge-driven framework for personalized learning video recommendations within educational metaverse environments.

The application of big data in educational metaverse platforms, while providing a wealth of information resources, does not directly equate to in-depth knowledge. Knowledge-driven management emphasizes understanding and learning of causal relationships, which is not directly provided by big data analysis. Big data provides a vast amount of data for machine learning, particularly deep learning, which has played an important role in improving the accuracy of tasks such as image recognition. However, deep learning models often rely on large-scale labeled data and have difficulty directly incorporating prior knowledge, sometimes resulting in outcomes that contradict expert knowledge. This indicates that data-driven methods may have limitations in revealing the essential laws of things.

### 2.1 Critical issues in data and knowledge-driven modeling

Construction of a data and knowledge-driven educational metaverse personalized learning video recommendation model is primarily based on two questions: how to build an associative network of teaching videos for the art and design specialty in the educational metaverse, and how to make personalized video recommendations based on the video association network. This is introduced by first incorporating research on the tagging of teaching videos, which addresses how to annotate videos with knowledge points and categories, and then by introducing a vocational education knowledge graph to link resources centered on videos, while also elucidating the relationships between different video knowledge points. Subsequently, the construction of student profiles based on big data from online education platforms and the analysis of online education scenarios are discussed, followed by research on a video recommendation mechanism based on a "data-driven + knowledge-driven" approach for video association networks, including the recommendation model and algorithm. The key issues and structure are illustrated in Figure 1.

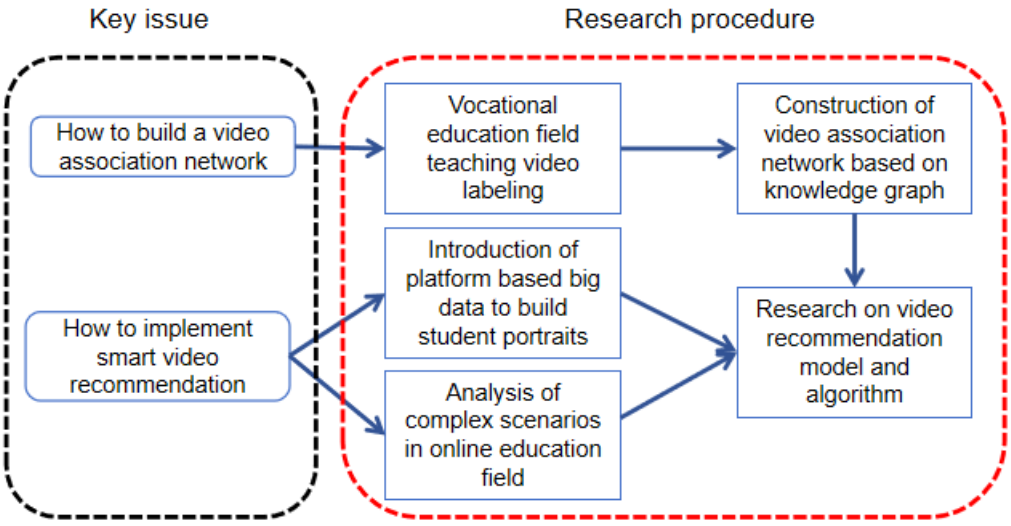


**Figure 1: Key issues of education meta-universe personalized learning video recommendation**

**Step 1:** Tagging Teaching Videos in Vocational Education and Art Design Discipline. Analyze and describe the attributes of teaching videos, such as video types, teaching instructors, and video knowledge points. Due to the particularity of teaching videos, whether knowledge points overlap, and whether they cross disciplines, there are more relationships and patterns among videos than general videos. All these need to be mined, analyzed, and tagged.

**Step 2:** Constructing a Video Association Network Based on Knowledge Graph. Art design knowledge should be systematic and comprehensive. This study is based on the rich course data provided by the Product Design major teaching resource library and the Design Education Cloud platform of

Guangdong University of Light Industry. Video tasks are an important part of achieving an immersive learning experience, providing students with a simulated real-world learning environment, thereby enhancing the interactivity and practicality of learning. Through video content, students can intuitively learn and understand the key knowledge points taught by teachers. Therefore, all resources need to be associated with videos at the center, studying how to use knowledge point graph models to associate videos, with points on the graph representing videos that explain the knowledge points, and also explaining the relationships between various knowledge points.

**Step 3:** Introducing Student Profiles in Vocational Education and Art Design Based on Platform Big Data. Online learning platforms achieve normalized classroom applications, and the massive data generated constitutes multi-dimensional educational big data involving teachers, students, and managers, covering multiple aspects of the pre-class, in-class, and after-class teaching process.

**Step 4:** Analyzing Complex Online Education Recommendation Scenarios. In the field of education research, the relationships among students, teachers, and knowledge within the education system are nonlinear. Therefore, the complexity of learning needs to be fully considered. At the same time, online learning systems should be guiding, identifying the scenarios in which recommendations should be triggered during learning.

**Step 5:** Research on Intelligent Video Recommendation Algorithms. Combining the video association network, research on how to intelligently guide students in learning video resources at different levels, establish a knowledge system, cultivate learning habits, and help students gradually learn and master knowledge and skills.

### 2.2 Construction of a data and Knowledge-driven framework

The data- and knowledge-driven educational metaverse personalized video recommendation model consists of five steps, as shown in Figure 2. Step 1: Video Tag Prediction; Step 2: Complex Scenario Analysis; Step 3: Constructing Student Profiles; Step 4: Building a Video Association Network Based on Knowledge Graph; Step 5: Implementing Video Recommendation Models and Algorithms. The video association network, based on the knowledge graph, involves the automatic annotation of knowledge points and difficulty levels, as well as intelligent analysis in complex scenarios, such as topic-to-topic and video recommendations. These technologies collectively support the construction of personalized learning paths and the enhancement of learning efficiency. Student profiles include: fundamental data and behavioral data to construct data tags, and capability and effort level tags based on student assignments (performing similarity evaluations of student assignments and generating effort level tags), professional, job competency tags, and more. A knowledge graph containing general, foundational, and professional knowledge points is constructed and associated with video resources. Intelligent recommendation algorithms are studied, such as adaptive learning and personalized recommendations, to accommodate the learning paths and habits of different students. These algorithms will optimize the learning experience and assist students in systematically constructing their knowledge systems.

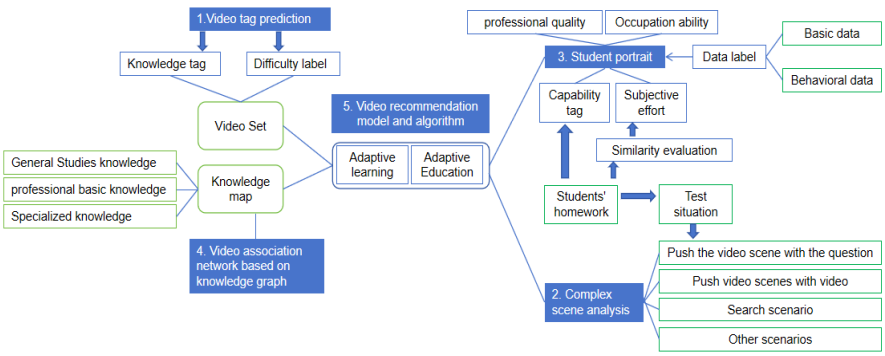


**Figure 2: Data-and knowledge-driven education meta-universe personalized learning video recommendation framework**

## 3. Evaluation of data and knowledge-driven personalized learning video recommendations in educational metaverse

This study focuses on 60 students from the Product Art Design major of the 2022 cohort at Guangdong University of Light Industry, aiming to evaluate the practical effectiveness of the personalized video recommendation system in the educational metaverse, which is data- and knowledge-driven. Two sets of data were used for evaluation and analysis:

Survey Response Information: We distributed a survey to students in the Product Art Design major of the 2022 cohort at Guangdong University of Light Industry, aiming to collect their feedback on personalized and systematic video recommendations for learning. A total of 60 questionnaires were distributed, with 59 successfully collected, resulting in an effective recovery rate of 96.7%. This high recovery rate ensures the representativeness and reliability of the feedback data.

Academic Performance Indicators: In addition, we collected academic performance data from students' mid-term exams, final exams, assignments, and class quizzes to objectively measure whether the personalized recommendation system helps improve learning outcomes.

Through these two aspects of data, we will comprehensively evaluate the application effects of the personalized and systematic video recommendation system in the educational metaverse environment, with the hope of providing empirical support for optimizing the learning experience and enhancing learning outcomes.

**Table 1: Survey feedback results on the evaluation of data and knowledge-driven video recommendation learning effectiveness.**

| Question | Level of Agreement | | |
|---|---|---|---|
| | Strongly Agree | Agree | Disagree |
| 1. Knowledge Graph Visualization: Data and knowledge-driven visualization techniques that clearly reveal knowledge associations, accelerating the construction of a systematic framework and enhancing learning efficiency and depth. | 45 | 13 | 1 |
| | 76.3% | 22% | 1.7% |
| 2. Optimized Knowledge Sharing and Retrieval: Data and knowledge-driven enhancements that improve sharing and management efficiency, facilitate the discovery of related knowledge, and significantly increase the precision of resource retrieval. | 36 | 22 | 1 |
| | 61% | 37.3% | 1.7% |
| 3. Intelligent Analysis of Learner Information: A data and knowledge-driven video system that accurately comprehends learner needs, improving the accuracy of resource recommendations and enhancing personalized learning. | 30 | 21 | 8 |
| | 50.8% | 35.6% | 13.6% |
| 4. Flexible Dual-track Learning Mode: Data and knowledge-driven learning content and pathways ensure goal attainment, enabling efficient learning experiences. | 49 | 9 | 1 |
| | 83.5% | 15.3% | 1.7% |
| 5. Enhanced Personalized Learning Services: Data and knowledge-driven resources and pathways that stimulate interest and promote the development of personalized skills. | 38 | 15 | 6 |
| | 64.4% | 25.4% | 10.2 |
| 6. Intelligent Adaptive Learning Experience: Data and knowledge-driven video recommendations that optimize processes, cater to diverse needs, and create efficient and enjoyable learning experiences. | 42 | 12 | 5 |
| | 71.2% | 20.3% | 8.5% |

In Table 2, the first three questions survey students' feedback on the adoption of a mixed method driven by data and knowledge. The results show that students have given very high evaluations. Ninety-eight point three percent of students agree that video recommendations based on a mixed

method driven by data and knowledge improve learning effectiveness, ninety-eight point three percent agree that such recommendations optimize knowledge sharing and retrieval, and eighty-six point four percent agree that using a mixed method driven by data and knowledge to describe learner information enhances the efficiency of personalized learning. These data indicate that students are willing to learn the recommended video knowledge.

The last three questions in the table survey students' acceptance of personalized video resource recommendations. The results show that eighty-three point five percent of students prefer the ability to customize their learning content and paths, as well as to follow system-recommended resources and paths. Eighty-nine point eight percent of students agree that personalized and systematic learning services supported by the system improve learning motivation, and ninety-one point five percent are willing to learn in a system that provides personalized and systematic support. Student feedback suggests that data- and knowledge-driven personalized video resource recommendations have a positive impact on learning motivation and autonomous learning abilities, helping to enhance the learning quality on the metaverse platform.

## 4. DISCUSSION

The results of this study underscore the important role played by the hybrid method in personalized learning experiences, which leverages both data and knowledge. By combining student profiles, including knowledge mastery and learning depth, with advanced video recommendation algorithms, we have achieved significant improvements in learning outcomes, engagement, and satisfaction among students in vocational art and design. This research emphasizes the critical role of data and knowledge-driven hybrid methods in enhancing personalized and systematic learning experiences. The method combines students' knowledge mastery and learning depth data with advanced video recommendation algorithms, resulting in marked improvements in student learning outcomes, engagement, and satisfaction in the field of art and design education at vocational and technical universities.

**(1) Enhanced learning outcomes:** The results indicate that the data and knowledge-driven hybrid recommendation system has greatly improved learning outcomes. This is consistent with previous research findings that personalized learning environments better meet the needs of individual students, thereby promoting deeper understanding and knowledge retention. The new learning video recommendation system has facilitated a significant increase in students' learning outcomes, highlighting the effectiveness of combining data-driven insights with knowledge graphs to create customized educational experiences.

**(2) Increased student engagement:** The data and knowledge-driven hybrid recommendation system has significantly increased student engagement, as evidenced by higher numbers of videos watched and longer durations of learning activities. This finding supports the notion that personalized recommendations can create more attractive learning environments by presenting content that aligns with students' interests and learning needs. In the context of online education, increasing engagement is crucial.

**(3) Improved user satisfaction**: Personalized and systematic video recommendation systems have shown a significantly higher level of user satisfaction compared to traditional systems. Students appreciate the relevance and suitability of recommended videos, which are tailored to their learning profiles. This feedback aligns with previous research, emphasizing the importance of personalization and systematization in enhancing user satisfaction and the overall learning experience. Qualitative data from student interviews further reinforces these findings, indicating that personalized recommendations not only meet educational needs but also make learning more enjoyable.

The successful application of the data and knowledge co-driven hybrid method in personalized learning experiences holds significant implications for the development of the educational metaverse. As the digitalization and immersive characteristics of the learning environment become

increasingly prominent, providing personalized learning experiences has become key to enhancing educational quality. This study provides an effective framework for integrating data-driven and knowledge-driven personalization and systematization in the metaverse, which is instrumental in enabling educational platforms to better support the diverse learning needs of students and promote more effective and inclusive educational practices. Although the research results indicate promising prospects, future studies should consider the representativeness of the sample and the assessment of long-term impacts, as well as the universality of this method across different disciplines and educational levels in vocational education.

## 5. CONCLUSION

In conclusion, this study has demonstrated the effectiveness of a hybrid method that combines data and knowledge in personalized and systematic learning within the educational metaverse, specifically in product design, contributing a cutting-edge theoretical perspective and practical guidance to the field of educational technology. Through rigorous empirical analysis, we not only validate the significant effects of the data-knowledge hybrid method on enhancing learning outcomes but also uncover its unique advantages in promoting student engagement and satisfaction. These findings enrich the theoretical framework of personalized learning and provide operational guidance for the design and application of the educational metaverse.

This study utilizes a method of argumentation based on quantitative analysis to ensure the comprehensiveness and depth of the research findings. We have quantified the effectiveness of personalized learning strategies and gained insights into learners' subjective experiences in the educational metaverse, providing valuable perspectives for future research.

In the future, the integration of personalized learning technologies with the educational metaverse will be a key trend in educational innovation. However, some limitations should be noted. Firstly, the current research is focused on students in vocational education, specifically in product design, and may lack generalizability. Future studies should expand to other disciplines and educational levels to test the effectiveness of such hybrid methods. Secondly, long-term research is necessary to continuously assess the true impact of personalized recommendations on students' learning outcomes and engagement.

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