Data-Driven Curriculum and Curriculum Design in Management and Physical Education Science

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ABSTRACT With the rapid deployment of smart wearable devices and wireless sensing technologies, multimodal physiological and behavioral data have become increasingly available for intelligent educational applications. This study investigates a data-driven curriculum design framework for management and physical education science by integrating learning analytics with wearable sensing and adaptive decision-making mechanisms. A multidimensional data acquisition architecture is established to collect academic performance, behavioral trajectories, and biometric information from smart textile sensors, while standardized data processing and visualization strategies are employed to support evidence-based curriculum optimization. The proposed framework further incorporates teacher data literacy enhancement and a closed-loop feedback mechanism to continuously refine instructional objectives, content organization, and evaluation strategies. By combining real-time monitoring with quantitative learning assessment, the framework enables dynamic adjustment of teaching intensity and personalized intervention according to learner characteristics. In addition, structured data governance and cross-departmental collaboration improve the consistency and reliability of curriculum management. Rather than relying solely on traditional experience-based instructional design, the proposed methodology establishes an adaptive information-processing architecture that integrates multimodal sensing, continuous feedback, and intelligent decision support. This framework provides valuable engineering references for wearable electromagnetic sensing systems, wireless educational monitoring platforms, distributed information acquisition, and human-centered communication networks in next-generation smart learning environments.

INDEX TERMS data-driven curriculum design, smart textile sensors, wearable electromagnetic sensing, wireless educational monitoring, multimodal learning analytics

I. INTRODUCTION

BIG data and artificial intelligence are reshaping education by enabling data-driven decision-making based on performance metrics from smart textile wearables and digital manufacturing simulations [1]. Centering on data allows for the precise optimization of educational practices, particularly in training personnel for the automated textile and intelligent garment industries. In fields such as educational science and physical education science, traditional curriculum design is generally based on teachers' experience and theoretical reasoning, lacking the support of objective data and failing to accurately grasp student needs and teaching effectiveness. Data-driven curriculum design uses learning analytics to formulate objectives, optimize content, and refine instructional methods, thereby enabling personalized and precise teaching. Especially in textile industry management education and physical education science, integrating analytics-informed methodologies can enhance the empirical validity of curriculum design.

II. THE SIGNIFICANCE OF DATA-DRIVEN CURRICULUM DESIGN IN MANAGEMENT AND PHYSICAL EDUCATION SCIENCE

A. ENHANCE THE SCIENTIFIC RIGOR AND PRECISION OF CURRICULUM DESIGN

Data-driven curriculum design relies on the systematic collection and analysis of data on students' learning behavior. To demonstrate this, consider a case study in Physical Education where students wore smart textile shirts embedded with heart rate and respiration sensors during a high-intensity interval training (HIIT) module. Data mining revealed that 40% of students reached peak fatigue levels 15 minutes earlier than the curriculum's theoretical model predicted. By identifying these physiological thresholds, instructors were able to precisely recalibrate recovery intervals and intensity spikes, replacing subjective observations with objective biometric feedback to address specific performance deficiencies [2].

B. PROMOTING TEACHING EFFECTIVENESS EVALUATION AND CONTINUOUS IMPROVEMENT

The data-driven concept provides quantitative tools and methods for evaluating teaching effectiveness. By continuously tracking and analyzing students' learning outcomes and process evaluation data, teachers can promptly identify instructional shortcomings. For instance, when biometric data from textile sensors indicated a significant drop in engagement during specific management simulation lectures, the curriculum was adjusted to include more interactive, data-visualized case studies. This evidence-based approach ensures the identification of instructional shortcomings through quantitative physiological metrics rather than post-course surveys [3]. The evaluation system captures both learning outcome and dynamic learning process, thereby providing a comprehensive measure of teaching effectiveness. At the same time, data accumulation and comparative analysis provide a reliable basis for teaching improvement [4].

TABLE 1. Statistics on the Application Value of Data-Driven Curriculum Design in Management and Physical Education Science

Application Dimension	Data collection indicators	Application effect	Coverage
Scientific nature of curriculum design	Biometric load data (HRV, VO2 max proxies), learning behavior, and knowledge acquisition	Empirical recalibration of training intensity and cognitive load	Course design process
Teaching effectiveness evaluation	Learning outcome data, formative assessment data, feedback data	Achieve dynamic monitoring and improvement	Each stage of teaching implementation
Teaching model transformation	Teaching resource data, teaching process data, decision support data	Facilitating adaptive and data-informed instruction	Teaching organization and management

C. PROMOTING THE MODERNIZATION OF MANAGEMENT AND PHYSICAL EDUCATION

Data-driven curriculum design exemplifies the integration of informatics into high-level pedagogy. Incorporating data-driven ideas into the fields of management education and physical education science facilitates a transition from traditional knowledge-centric instruction to evidence-based, adaptive learning frameworks [5]. The adoption of data technology transforms curriculum design methods, teaching concepts, and organizational models. The construction and application of data platforms enables the optimal allocation of teaching resources, intelligent management of instructional process, and data-driven support for pedagogical decision-making [6].

III. PROBLEMS IN THE APPLICATION OF DATA-DRIVEN MANAGEMENT AND PHYSICAL EDUCATION SCIENCE

TABLE 2. Analysis of the main problems in data-driven applications of management and physical education science

Problem Categories	Specific Manifestations	Degree of Impact	Entities Involved
Insufficient data acquisition technology	Limited data coverage; outdated collection technologies; low level of data standardization	High	Educational institutions; technology departments
Insufficient teacher data literacy	Weak data awareness; lack of analytical competence; absence of systematic training mechanisms	High	Frontline teachers; teacher training institutions
Lack of an integration mechanism	Fragmented workflows; absence of data-to-decision transformation pathways; limited cross-departmental collaboration	Moderate	Administrative department; teaching units

A. INSUFFICIENT APPLICATION OF DATA ACQUISITION AND ANALYSIS TECHNOLOGIES

At present, the data collection methods in the fields of management education and physical education science are singular, mainly relying on traditional test scores, attendance records and other limited data sources, lacking comprehensive collection of data on students' entire learning process, behavioral characteristics, and emotional attitudes. Regarding the latter, current methods often fail to bridge the gap between subjective sentiment and objective measurement, requiring the integration of physiological indicators–such as heart rate variability (HRV) or skin conductance–to provide a reliable proxy for emotional state. Data collection technology in most existing institutions is backward, and the adoption of intelligent platforms remains low, preventing the recording of valuable pedagogical data. The model introduced in subsequent sections is designed to address the lack of structured pedagogical data by implementing specialized sensor-based acquisition protocols [7]. Many institutions lack advanced analytical tools, and data processing remains limited to descriptive statistics rather than in-depth mining or predictive analysis. Suboptimal data standardization and poor structural integrity prevent interoperability between disparate systems, resulting in isolated data repositories [8].

B. TEACHERS LACK DATA LITERACY AND APPLICATION SKILLS

Data-driven curriculum design has put forward new requirements for teachers' data literacy. However, many teachers in the fields of management education, physical education and science lack the necessary data awareness and data application ability. Some teachers do not have a good understanding of the data-driven concept, are used to traditional experience-based teaching, do not have a deep understanding of the value of data, and rarely use the results of data analysis in curriculum design [9]. Even if they have the willingness to use data, due to the lack of basic knowledge and skills in data analysis, they do not know how to collect, organize, analyze and interpret data, and cannot transform data into effective teaching decisions. The content of data literacy in the teacher training system is relatively weak,

TABLE 3. Implementation Framework of Data-Driven Curriculum Design Strategy

Implementation Strategy	Key Measures	Technical Support	Expected Results
Multi-source data collection and analysis system	Expanding data collection dimensions, introducing advanced tools, and establishing standards and specifications.	Learning management system, intelligent platform, visualization tools	Creating a comprehensive student profile and improving data quality
Teacher capacity building	System training, technical support, incentive mechanisms, and communication platforms	Data analysis tools and teaching research platforms	Enhancing data literacy and promoting teaching innovation
Data feedback loop mechanism	Standardize design processes, establish multi-level feedback mechanisms, and promote cross-departmental collaboration.	Data monitoring system and evaluation platform	Achieve continuous improvement and optimize course quality

and there are very few training programs specifically for data-driven curriculum design [10].

C. THE MECHANISM FOR INTEGRATING DATA WITH CURRICULUM DESIGN IS IMPERFECT

Although data technology is increasingly widely used in education, there are still systemic obstacles to the deep integration of data and curriculum design. Many educational institutions have not yet formed a systematic data-driven curriculum design process and institutional norms. There are no unified standards and clear requirements for data collection, analysis and application, resulting in the randomness and fragmentation of data-driven practice. Furthermore, most institutions lack a rigorous ethical oversight framework and specific protocols for Institutional Review Board (IRB) approval when dealing with sensitive student data. This creates a significant gap between the technical ambition of real-time monitoring and the legal requirements for student consent and data privacy protection [11]. There is a lack of effective transformation mechanism between data and teaching decisions. Furthermore, there is a logistical tension between data-driven flexibility and instructional stability. Without a clear threshold for intervention, impulsive real-time adjustments based on fluctuating data can disrupt the pre-established learning structure, leading to confusion among students and a fragmented curriculum delivery. Most data analysis results are only on the report and cannot play a guiding role in the specific aspects of curriculum design. From an organizational perspective, there is a lack of cross-departmental collaboration mechanism. The teaching department, the technical department and the management department act independently and cannot form a data-driven synergy [12].

IV. STRATEGIES FOR DATA-DRIVEN CURRICULUM DESIGN IN MANAGEMENT AND PHYSICAL EDUCATION

To demonstrate the advantages of data-driven curriculum design, the following figure compares the differences between traditional curriculum design and data-driven curriculum design in terms of decision-making basis, data sources, evaluation methods, and improvement mechanisms (Figure 1).

A. CONSTRUCTING A DIVERSIFIED DATA COLLECTION AND ANALYSIS SYSTEM

To transition from the data-poor environment described in Section "Insufficient Application of Data Acquisition and Analysis Technologies" to a data-rich pedagogical model, the creation of a systematic collection system is essential. This paper advocates for the adoption of textile-based biometrics to fill the current void in learning behavior and physiological tracking. First, we need to broaden the dimensions and scope of data collection, including student academic performance, learning processes, and emotional attitudes. To ensure scientific rigor, emotional data must be quantified through a standardized framework that combines qualitative sentiment analysis with objective biometric data from smart textile sensors. This multi-modal approach operationalizes subjective attitudes as measurable data indicators (e.g., engagement levels and stress responses), thereby reducing reliance on purely intuitive teacher assessments. We should use learning management systems and wearable textile devices to achieve real-time tracking of student progress. The scientific validity of this approach is supported by regression analysis that correlates physiological exertion data with academic performance scores. For example, by analyzing the correlation between students' physical recovery rates (measured via textile sensors) and their subsequent performance in management theory exams, researchers can determine the optimal balance between physical activity and cognitive tasks in a dual-track curriculum. However, the implementation of real-time monitoring must be preceded by a comprehensive ethical review and the establishment of a transparent informed consent procedure. Before any data collection begins, researchers and educators must obtain formal IRB approval to ensure that the tracking of behavioral and emotional metrics adheres to national privacy laws and institutional ethical standards, thereby mitigating the risk of digital surveillance overreach. Second, we need to establish standardized data collection specifications and processes to ensure the accuracy, integrity and consistency of data, and lay a reliable foundation for subsequent analysis [13]. In terms of data analysis, we should use advanced data analysis techniques and tools, such as descriptive statistics, correlation analysis, regression analysis, cluster analysis, etc., to explore teaching data from multiple angles and in depth. We should attach importance to the application of data visualization technology, and present the complex data analysis results in an intuitive way such as charts and reports, so as to facilitate teachers' understanding and use. We should also increase the construction of data platforms,

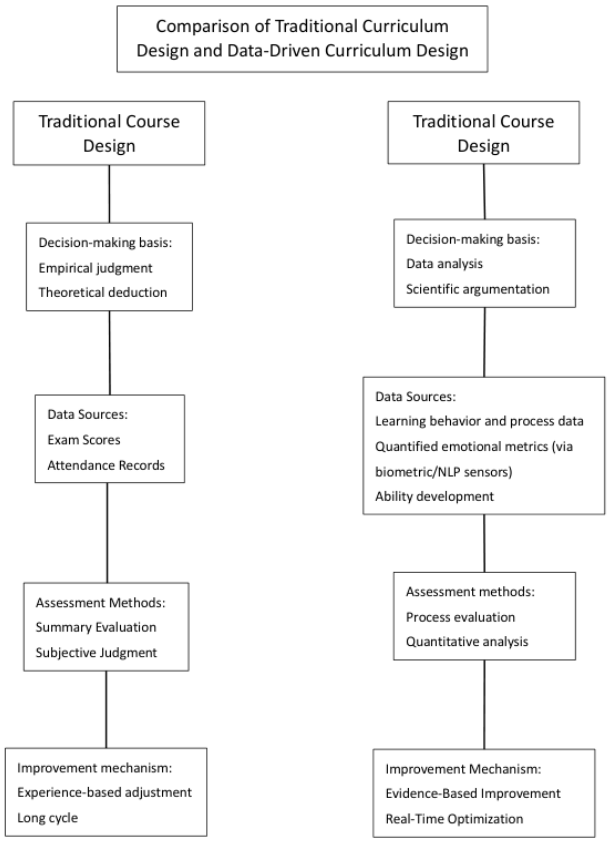

FIGURE 1. Comparison between Traditional Curriculum Design and Data-Driven Curriculum Design

break down data barriers between systems, realize data integration and sharing, and improve data utilization [14].

B. ENHANCING TEACHERS' DATA APPLICATION ABILITY AND TEACHING INNOVATION

Teachers are the key subjects of data-driven curriculum design, and it is essential to improve teachers' data literacy and application ability. First, teachers should be systematically trained and data literacy training should be incorporated into the teacher professional development system. Various forms such as special lectures, workshops, and practical training should be used to help teachers establish data awareness and master the basic methods of data collection, analysis, and application. The training content should be linked to the characteristics of management education and physical education science disciplines, and should be practical and operable. Second, teachers should be provided with necessary technical support and resource guarantees, and professional data analysis personnel or teams should be provided to help teachers process and analyze data, thereby reducing the technical threshold for teachers. Simple and easy-to-use data analysis tools and templates can be developed so that teachers can quickly get started. Teachers should be encouraged to apply the data analysis results to the curriculum design process and integrate the data-driven thinking into all aspects such as the determination of teaching objectives, selection of teaching content, design of teaching methods, and improvement of teaching evaluation. A teacher data application incentive mechanism should be established to affirm and reward teachers who have achieved significant results in data-driven curriculum design. At the same time, a teacher exchange platform should be built so that data-driven curriculum design experience can be shared and promoted, thereby forming a good practical atmosphere [15].

C. ESTABLISH A COURSE OPTIMIZATION MECHANISM WITH DATA FEEDBACK LOOP

Establishing a sound data feedback loop mechanism is essential for continuous course improvement. First, a standardized data-driven course design process must be established, defining the role and application methods of data in each stage of course design: pre-design analysis, mid-term monitoring, and post-design evaluation. At the outset, teaching objectives and content should be scientifically determined based on historical teaching data and student characteristic data. During implementation, real-time data monitoring should be used to identify areas for improvement. However, to maintain curriculum coherence, instructional adjustments should be categorized into micro-

level pedagogical tuning (e.g., pacing and supplementary resources) and macro-level structural changes. The latter should be deferred to the next course cycle to maintain the continuity of the current learning path, while real-time adjustments must be implemented with caution and clear communication to students. After the course concludes, data analysis should be used to comprehensively evaluate teaching outcomes, supporting the next round of course design. Second, a multi-level feedback system should be created, including immediate, periodic, and summative feedback, ensuring data can be quickly communicated to relevant decision-makers or implementers. Emphasis should be placed on collecting and analyzing student feedback data. Rather than relying solely on raw subjective feedback, the system should employ Natural Language Processing (NLP) to categorize and weight student interviews and questionnaires. By triangulating these results with real-time physiological data collected during physical education or management simulations, the framework generates an objective emotional index that validates student evaluations against their biological responses. A system to ensure continuous course quality improvement should be established. This system must include a stability buffer protocol that evaluates whether a proposed data-driven adjustment justifies potential disruption to the semester's logical flow. By prioritizing incremental optimization over radical mid-term restructuring, the feedback loop can enhance teaching quality without sacrificing the structural integrity of the management or physical education science programs. Furthermore, it is essential to raise awareness of data security and privacy protection, formulate ethical guidelines for data use, and effectively supervise data collection and use. This process must move beyond passive protection to active ethical compliance. It involves the mandatory implementation of data anonymization protocols, the right for students to opt-out of real-time emotional tracking without academic penalty, and the continuous monitoring of data usage by an independent ethics committee to ensure that the collection of high-frequency behavioral data remains strictly for pedagogical optimization rather than unauthorized profiling. Data-driven curriculum design is a systematic and cyclical process that encompasses multiple stages, including data collection, analysis, design, implementation, and evaluation, and achieves dynamic optimization of the curriculum through continuous feedback (see Figure 2).

V. CONCLUSION

Data-driven curriculum design offers a new approach for reforming scientific teaching in management and physical education, specifically by integrating performance analytics from intelligent textile sensors to optimize the instructional methodologies used in technical textile engineering. This methodology enables the precise alignment of educational content with the functional requirements of high-performance fiber applications, ensuring students master the intersection of data science and advanced textile technology. By creating a diversified data collection and analysis system, strengthening teachers' data application capabilities, and forming an optimization mechanism based on data feedback loops, the scientific rigor and accuracy of curriculum design can be effectively improved, promoting continuous improvement in teaching quality and driving the modernization of education. However, the practice of data-driven curriculum design still faces challenges in terms of technology, capabilities, and significant ethical and logistical hurdles related to student consent and IRB standards. Addressing these requires not only technical innovation but also the construction of a robust legal and ethical framework that balances the benefits of data-driven precision with the fundamental rights of student privacy. Future research should focus on strengthening the application of data-driven concepts in curriculum design by exploring effective paths for integrating smart textile sensor analytics and functional fiber performance data, thereby providing strong support for cultivating high-quality professionals in textile management and sports engineering. This integration ensures that future experts are equipped to utilize intelligent textile technologies to optimize physical education outcomes and drive innovation within the technical textile sector.

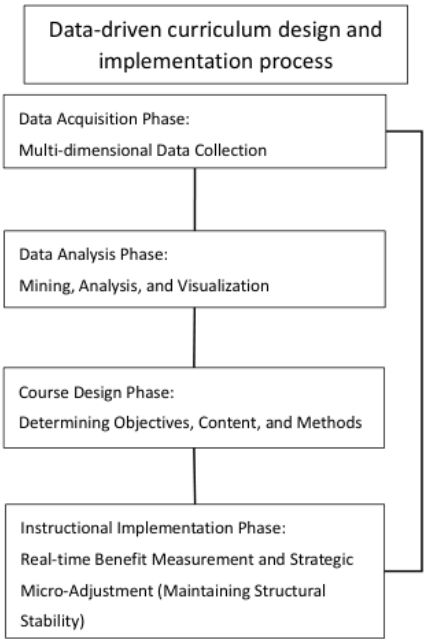

FIGURE 2. Flowchart of Data-Driven Curriculum Design Implementation

AUTHOR CONTRIBUTIONS

Junzhi Zhou designed, collected and analyzed the data, and drafted the manuscript. Junzhi Zhou conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be pub-li shed. Junzhi Zhou participated fully in the work, take pu blic responsibility for appropriate portions of the content,an d agreed to be accountable for all aspects of the work in ens uring that questions related to the accuracy or integrity of a ny part of the work are appropriately investigated and resol ved.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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