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Teaching Research and Practice of "Data Analysis and Visualization" Course Based on OBE-CDIO Concept in the Context of Interdisciplinary Integration

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Abstract: This paper explores the teaching reform and practice of the "Data Analysis and Visualization" course based on the OBE-CDIO concept in the context of interdisciplinary integration. First, a three-tier progressive practical teaching system—basic practice, professional practice, and comprehensive practice—is established to meet the needs of different disciplines and industries, cultivating students' data analysis and interdisciplinary application abilities. Second, a four-dimensional teaching organization model, including demonstration-based, design-based, inquiry-based, and entrepreneurship-based approaches, is developed to enhance students' practical skills and innovative thinking through case demonstrations, visualization design, problem exploration, and business applications. Additionally, a diverse data analysis toolset, incorporating Excel, Power BI, R, and Python, is constructed to support business data analysis education. Furthermore, an interdisciplinary data analysis and visualization teaching database is developed, providing real-world business data to improve students' data application capabilities. Finally, a business-oriented data analysis methodology and model library, including regression analysis, clustering algorithms, and time series analysis, is established to help students master the complete process from data cleaning to decision optimization. This study provides an effective framework for cultivating high-quality business and technology professionals with expertise, technical skills, and innovation capabilities.

1. Background

In September 2023, the concept of "new quality productive forces", has emphasized its crucial role in driving China's high-quality economic development and regional coordination. These new quality productive forces not only include traditional production factors such as labor, capital, and technology but also integrate emerging elements such as information technology, artificial intelligence, the digital economy, green industries, and institutional innovation. These factors contribute to higher production efficiency, sustainability, and innovation. Consequently, higher

education institutions face new requirements in cultivating interdisciplinary talents equipped with both managerial and technical capabilities.

The cultivation of interdisciplinary talents has become essential in meeting this demand. Data analysis requires not only technical skills—such as data mining, modeling, and visualization—but also business acumen and industry insights to effectively apply data to real-world problems and support decision-making. As a result, interdisciplinary professionals with both technical and business expertise are in high demand, as a single-discipline background in either technology or management is no longer sufficient to meet the diverse needs of enterprises. The integration of data science with management, economics, marketing, and other disciplines has become a crucial approach to developing high-quality data analysis professionals.

According to the "National Standards for Teaching Quality in Undergraduate Programs of General Higher Education Institutions," business education aims to cultivate applied, interdisciplinary, and innovative professionals. This requires students to develop interdisciplinary application capabilities throughout their education. The interdisciplinary "Data Analysis and Visualization" practical teaching model is designed to cultivate students' intelligent thinking, digital literacy, and data competency, enabling them to apply digital technologies in business practice to analyze and solve complex commercial problems effectively.

Furthermore, interdisciplinary experiments and training enhance students' ability to integrate knowledge across different disciplines, helping them master business theories while also gaining insights into psychology, sociology, and computer science, thus broadening their intellectual horizons. In terms of innovation, the course incorporates entrepreneurship education and academic competitions, stimulating students' creative thinking and equipping them with hands-on skills in entrepreneurial and innovative projects. This comprehensive teaching model prepares students with multi-dimensional competitiveness for future career success.

2. Relevant Concepts and Current Status

2.1 Relevant Concepts

The OBE-CDIO educational approach integrates Outcome-Based Education (OBE) with the Conceive-Design-Implement-Operate (CDIO) teaching model. This framework is designed to guide teaching practices by focusing on clearly defined student learning outcomes. OBE emphasizes that the ultimate learning outcomes of students should be the core objective of education, prioritizing the development of students' practical and application-oriented abilities[2]. Meanwhile, CDIO provides a project-driven practical teaching framework, covering the entire process from conceiving, designing, implementing, to operating, thereby reinforcing hands-on experience and innovation skills[1].

A new practical teaching model based on OBE-CDIO overcomes the limitations of traditional teaching methods by focusing on students' comprehensive competencies. It strengthens the integration of foundational education, professional development, and practical training, effectively addressing the demand for high-quality, interdisciplinary, and innovative talents in the digital era. This model promotes a balanced approach to theory and practice, as well as capability and competency development, advancing teaching methodologies to better align with the evolving industry landscape.

2.2 Research Status of Domestic Scholars

The "Data Analysis and Visualization" course is a key subject offered by business schools, covering multiple disciplines such as Information Management and Information Systems,

E-Commerce, International Economics and Trade, Logistics Management, Business Administration, and Human Resource Management. The course is designed to equip students with fundamental knowledge and skills in data analysis, emphasizing a broad, interdisciplinary approach rather than a highly specialized focus. The core objective is to help students master the fundamental methods of data analysis, design, and visualization development, laying a solid foundation for careers in data science and related fields.

Although this course has been introduced in universities only recently, numerous scholars have explored its development, mainly focusing on the construction of data analysis curricula.

Wang Jingjuan (2023) proposed a tiered teaching model, structuring the course into four levels: data recognition, data storage, data preprocessing and analysis, and data visualization.

Yang Yanxia (2021) adopted a case-based teaching method, enabling students to gain a deeper understanding of the complete data analysis and visualization process. These studies contribute to the continuous improvement of data analysis education in higher institutions, promoting effective teaching models that combine theoretical knowledge with real-world applications.

3. Major Issues in Existing Teaching Content

1) Lack of Practicality and Progression

Traditional data analysis courses often focus heavily on theoretical instruction, lacking systematic practical training, which results in students having insufficient hands-on skills. This paper establishing a three-tier progressive teaching system—basic practice, professional practice, and comprehensive practice—can gradually enhance students' practical abilities. This ensures that students acquire skills that align with real-world job requirements at different learning stages[4], strengthening their capability to solve practical problems effectively.

2) Limited Teaching Methods, Lack of Multi-Dimensional Thinking Development

Conventional teaching methods primarily emphasize fixed analytical techniques, neglecting the cultivation of students' innovative thinking, problem-solving skills, and real-world application abilities. This paper introducing a four-dimensional teaching model—demonstration-based, design-based, inquiry-based, and entrepreneurship-based approaches—can break the constraints of a single teaching method, fostering interdisciplinary thinking and enhancing students' ability to analyze data and make decisions in complex business environments.

3) Limited Use of Data Analysis Tools, Inadequate Support for Different Disciplines

Traditional courses rely heavily on basic tools (such as Excel), which fails to meet the diverse needs of different disciplines and professional fields[5]. This study establishing a diverse data analysis toolset can offer students a broader selection of tools tailored to specific disciplinary and business needs, improving their ability to conduct data analysis across various scenarios and enhancing their technical proficiency with different software solutions.

4) Lack of Interdisciplinary Data Analysis and Visualization Teaching Resources

Existing data analysis courses often focus on single-domain datasets, lacking interdisciplinary teaching resources. This limits students' ability to apply data analysis and visualization skills in interdisciplinary contexts. This study developing an interdisciplinary data analysis and visualization teaching database can provide students with datasets[6] from multiple fields, supporting comprehensive cross-disciplinary analysis and visualization. This will enhance their ability to integrate knowledge across disciplines and solve complex real-world problems.

4. Main Teaching Content of the "Data Analysis and Visualization" Course Based on the OBE-CDIO Approach

This project adopts a multi-domain perspective to develop a comprehensive practical framework, covering five key data analysis scenarios:

(1)Customer Value Analysis for Airlines

(2)Retail Shopping Basket Mining

(3)Public Opinion and Sentiment Analysis of Events

(4)Cross-Border E-Commerce Data Interpretation

These projects deeply integrate theory with practice, utilizing Python, Power BI, and Excel to build a complete framework that includes data collection and preprocessing, data analysis and visualization, and results interpretation and application. The goal is to cultivate big data thinking and hands-on skills for students across different disciplines, guiding them to extract valuable insights from large datasets, apply data mining algorithms and visualization techniques, strengthen logical reasoning and problem-solving abilities, and contribute to digital transformation across industries[3].

4.1 Customer Value Analysis for Airlines

In the era of big data, businesses have shifted their marketing focus from product-centric to customer-centric strategies, making Customer Relationship Management (CRM) a core business concern. This project leverages customer data from an airline company to Classify customers into different segments, analyze the characteristics of each customer segment and compare their value, develop personalized services and marketing strategies tailored to different customer groups to maximize revenue[4].

Key Steps in Airline Customer Data Analysis

(1)Data Exploration and Preprocessing:

Load customer transaction data for a specific period. Conduct exploratory data analysis (EDA), including handling missing values and outliers, data cleaning, feature engineering, and standardization.

(2)Customer Segmentation Using the RFM Model:

Implement RFM (Recency, Frequency, Monetary) analysis to assess customer behavior. This model uses the K-Means clustering algorithm to segment customers into meaningful groups.

(3)Visualization and Interpretation:

This project utilizes Matplotlib and Seaborn to visualize analysis results. Display distribution of different customer groups, and analyze customer lifetime value, profitability, and loyalty.

(4)Business Strategy Development:

Based on clustering results, categorize customers by value and loyalty. This project design targeted marketing strategies and personalized service plans to optimize customer engagement and maximize profits.

Through this project, students gain practical experience in data-driven decision-making, customer analytics, and business intelligence, equipping them with interdisciplinary problem-solving skills essential for real-world business applications. The experimental results are shown in the figure 1.

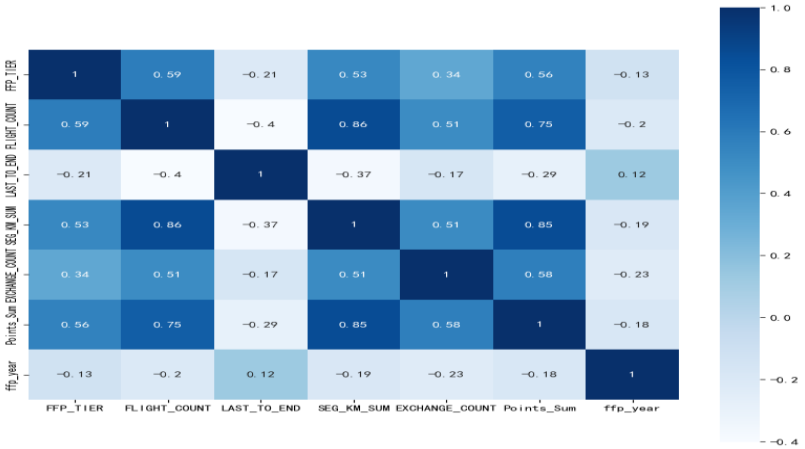

Figure 1: Correlation Analysis

4.2 Retail Product Basket Analysis

Project Overview

This project focuses on retail transaction data to mine product association rules using association analysis. By collecting and cleaning multi-source sales data, the Apriori algorithm is applied to calculate support, confidence, and lift to identify strong association rules, such as the common pairing of milk and bread. The results are visualized using Matplotlib to help retailers optimize shelf layouts, design bundled promotions, and increase customer purchase volume and sales revenue[7].

Key Steps in Retail Basket Association Rule Mining

(1)Exploratory Data Analysis:

This project analyzes sales data to examine product popularity and the overall product structure.

(2)Data Preprocessing:

Transform the data into a suitable format for the Apriori algorithm.

(3)Association Rule Mining with Apriori Algorithm:

This project applies the Apriori algorithm to generate product association rules, adjusting model parameters as needed.

(4)Visualization and Result Analysis:

This project use Matplotlib to visualize the results of the association rule analysis. Based on the insights, provide sales recommendations to optimize product pairings and marketing strategies.

The experimental results are shown in the figure 2.

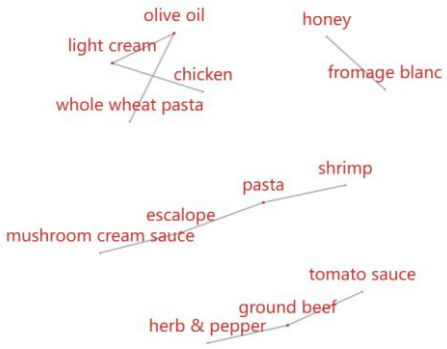

Figure 2: Apriori Association Rules for Shopping Basket

4.3 Public Opinion and Sentiment Analysis of Sudden Public Events

In the age of information overload, sudden public events are frequent, and their associated public opinion can have a significant impact. This project collects public opinion data related to such events from social media, news sources, and other channels. After data preprocessing, relevant analysis methods, such as TF-IDF weighting and the LDA topic model, are applied to visualize and analyze the sentiment tendencies of public opinion. The goal of this project is to provide valuable insights for decision-makers and assist in crisis management, ultimately contributing to social stability.

Key Steps in Public Opinion Sentiment Analysis

(1)Data Crawling:

This project Use Python web scraping tools (such as the Scrapy-Redis framework) or Power BI to collect and integrate data.

(2)Data Cleaning and Preparation:

This step clean the collected data by removing noise and irrelevant information, then tokenize the text, perform part-of-speech tagging, and remove stop words.

(3)Sentiment Analysis of Comment Data:

This step applies sentiment dictionaries and the LDA topic model to identify high-frequency terms and analyze the frequency of sentiment-laden words, helping to uncover the focus of public opinion.

(4)Word Cloud and Theme Analysis:

This step visualizes the analysis results with a word cloud and performs theme analysis to draw conclusions about public sentiment.

The experimental results are shown in the figure 3.

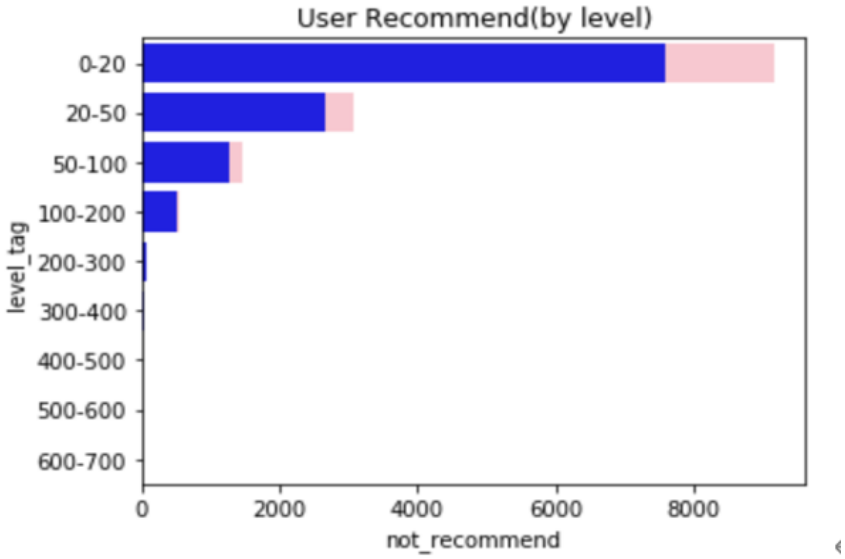

Figure 3: Visualization of User Suggestions Participation

4.4 Cross-Border E-commerce Data Analysis

With the acceleration of globalization and the widespread use of the internet, cross-border e-commerce has become an integral part of global trade. In this project, for understanding the operations of cross-border e-commerce and improve sales efficiency, this project uses tools such as Power BI and Excel to analyze cross-border e-commerce data from multiple dimensions, including

users, members, orders, and products. This analysis covers basic information, transactions, and reviews, providing support for accurately targeting customers, optimizing marketing strategies, and efficiently allocating resources. Ultimately, this helps businesses enhance their competitiveness and achieve sustainable growth.

Power BI in Data Analysis and Visualization

This project uses Power BI for data analysis and visualization. Power BI is a professional tool for analyzing and visually presenting business data. It integrates several features such as Power Query, Power Pivot, Power View, and Power Map, enabling fast data connection, modeling, and analysis.

(1)Power Query (Data Acquisition and Cleaning):

This module imports cross-border e-commerce data and performs data preprocessing tasks, such as replacing null values, removing outliers, and handling duplicate values.

(2)Power Pivot (Data Modeling and Analysis):

This module builds models and performs data calculations. It allows for the creation of multi-dimensional data models and deep data mining using DAX functions to calculate key indicators and perform complex aggregation analysis. For example, analyzing user purchase frequency and spending distribution can precisely classify customer value levels, providing core decision support for targeted marketing and segmented operations.

(3)Power View (Data Visualization):

This module is an interactive chart tool that visualizes the results using various chart formats like bar charts, line graphs, pie charts, and heat maps. It helps present key information such as sales trends, product popularity, and customer regional distribution, supporting data-driven decision-making.

The experimental results are shown in the figure 4

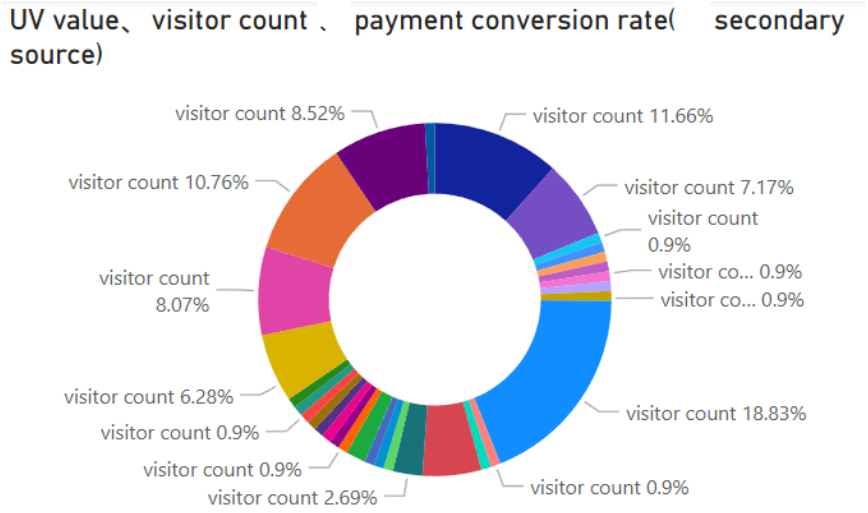

Figure 4: User Perspective Visualization Chart

5. Innovations

(1)Establishment of a Three-Level Progressive Practical Teaching System (Basic, Professional, and Comprehensive Practice)

This teaching system is designed based on students' cognitive development and the needs of different majors and industries. The practical teaching is divided into three levels:

Basic Practice focuses on industry awareness and basic skills development, helping students understand suitable data analysis tools and methods for their major through experiments.

Professional Practice allows students to use data analysis and visualization tools to analyze business data, enhancing their professional capabilities by refining industry-specific metrics during operations.

Comprehensive Practice involves interdisciplinary projects, where students combine business data with analysis results to create clear reports and effectively present insights through charts and visualizations, providing actionable optimization suggestions for real-world business problems. This approach nurtures high-quality business and technical talent with expertise in both professional and interdisciplinary fields.

(2)Establishment of a Four-Dimensional Teaching Organization (Demonstration, Design, Exploration, and Entrepreneurship)

Demonstration Teaching: Teachers display practical cases and step-by-step operations to help students understand basic concepts and skills in data analysis and visualization.

Design Teaching: Focuses on students' creativity and design abilities during the data analysis and visualization process, including designing charts and dashboards and learning how to effectively convey information through visual means.

Exploration Teaching: Emphasizes combining theory with practice, exploring the application of knowledge in real-world problems, promoting interdisciplinary integration, and developing comprehensive skills. It encourages students to actively explore solutions to data analysis problems, fostering critical thinking and analytical skills.

Entrepreneurship Teaching: Focuses on cultivating students' ability to apply data analysis and visualization skills to entrepreneurship and business practices, encouraging them to support business decisions with data and even develop new business models.

(3)Establishment of a Diversified Data Analysis Tool Library Based on Discipline and Business Needs

The tool library includes spreadsheet management software, data collection tools, data storage tools, data analysis, and visualization tools. The focus is on usability, fast decision-making, large-scale data analysis and visualization, and tight integration with business operations. Tools such as Excel, Power BI, R (and RStudio), and Python (Pandas, Matplotlib, Seaborn) are used in the teaching process to support data analysis and reporting.

(4)Establishment of an Interdisciplinary Data Analysis and Visualization Teaching Database

This teaching database integrates data from multiple disciplines, providing cross-disciplinary practice data for teaching purposes. It supports data analysis and visualization while offering interdisciplinary analytical perspectives and skills training. The aim is to prepare students to analyze data from a variety of fields, enhancing their ability to integrate knowledge across disciplines.

(5)Establishment of a Data Analysis Methods and Models Library for Business Majors

The course includes a library of analysis methods and models specifically for business students, helping them master the complete analysis process from data cleaning to decision optimization. Methods covered include:

Descriptive statistics (e.g., mean, standard deviation, correlation analysis) to help students understand data characteristics; Regression analysis (e.g., linear regression, logistic regression) for prediction and trend analysis; Classification and clustering algorithms (e.g., decision trees, K-means) for customer segmentation and market positioning; Association rules (e.g., Apriori) for market basket analysis to uncover relationships between products.

6. Conclusions

In conclusion, this teaching framework offers a comprehensive and interdisciplinary approach to data analysis and visualization education. By incorporating a three-level practical teaching system,

students are exposed to foundational skills, professional applications, and interdisciplinary projects, ensuring they are well-prepared for real-world business challenges. The four-dimensional teaching organization fosters creativity, critical thinking, and entrepreneurial skills, while the diversified tool library and interdisciplinary teaching database provide the resources necessary to support complex data analysis tasks. Additionally, the methods and models library equips students with the analytical tools to solve problems across various business domains. This holistic approach not only enhances students' technical capabilities but also nurtures their ability to integrate knowledge across disciplines, ultimately preparing them for dynamic careers in business and technology.

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