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Design of Course Goal Achievement System based on OBE Concept

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Abstract

Under the background of promoting the reform of world-class undergraduate education and engineering education, the scientific construction of the quality evaluation system of personnel training has become an important starting point to improve the quality of education. To this end, this study is based on Outcome-Oriented Education (OBE).By integrating MATLAB high-performance computing engine and Electron cross-platform framework, it can provide teachers with multi-dimensional teaching feedback by using simple Web applications, and support the closed-loop continuous improvement of teaching quality. The system not only adopts modular architecture design, but also integrates data acquisition, intelligent analysis, visual presentation and evaluation report generation, which can be flexibly configured according to the individual needs of different institutions, thus providing a scalable technical solution for OBE education model.

Keywords

OBE Education Concept; Course Goal Achievement; MATLAB; Web Development; System Design.

1. Introduction

Optimizing the evaluation of education quality is the key to the reform of higher education. At present, most colleges and universities still rely on the summative evaluation system based on the final examination, which is difficult to fully reflect the development process of students'abilities, and has not yet established a dynamic monitoring mechanism for curriculum objectives and graduation requirements. The traditional evaluation system has the defect of "emphasizing knowledge and neglecting ability", especially in the evaluation of high-level objectives such as complex engineering problem solving and team cooperation.In addition, the fragmentation of multi-source educational data leads to the inefficiency of curriculum goal achievement analysis, and it is difficult for teachers to quickly locate the weak links in teaching.

Based on the limitations of the traditional evaluation system, the concept of OBE (Outcome-Based Education), as a new outcome-oriented education paradigm, is being widely introduced into the education industry. This model constructs the curriculum system through reverse design, and establishes a continuous improvement mechanism, aiming at systematically improving the quality of education. Shaoyun Song and Hong Shi (2007) [1] implemented the Matlab Web Server in the construction of a mathematics laboratory to facilitate intuitive understanding of abstract higher mathematics concepts, which aligns with the practical application of the OBE (Outcome-Based Education) philosophy. By establishing a virtual laboratory architecture, students could more effectively grasp mathematical theories. However, challenges remain in the actual implementation of OBE, including difficulties in integrating multi-dimensional assessment data and the lack of automated analysis tools.

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In view of the above problems, this study proposes an OBE-based course goal achievement analysis assistant system, whose technical strategy includes three innovations: firstly, it integrates MATLAB numerical calculation engine and Electron cross-platform framework by using front-end and back-end separation architecture, and realizes automatic collection and standardized processing of teaching data through RESTful API; Secondly, a dynamic visualization module based on Web is developed.The Echarts and Highcharts toolkits are used to generate the histogram of course goal achievement degree and the trend line chart of professional achievement degree, which supports teachers to diagnose the multi-dimensional teaching effect; Finally, a grading evaluation algorithm system is constructed, and the automatic generation from the original data to the course improvement suggestions is realized by establishing a double-layer framework of the course score threshold calculation model and the overall goal achievement analysis model.The experimental results show that the system greatly reduces the workload of teachers' manual data analysis and makes the evaluation work more efficient. The cross-platform features and standardized evaluation process of the system not only solve the problem of multi-source education data integration, but also provide a scalable technical solution for engineering education certification.

2. Research Background and Theoretical Basis

2.1. Engineering Education Reform and the Rise of OBE Concept

In the context of the wide spread of the global engineering education accreditation system, the learning outcome-oriented education model has become the main trend of engineering education reform. Through the principle of reverse design, the concept of OBE forms a closed-loop system of graduation requirements, course objectives and teaching evaluation (as shown in Figure 1). The principle of "student-centered" and "continuous improvement" proposed by the concept effectively aims at the defects of "focusing on knowledge imparting and neglecting ability training" in traditional engineering education.The American Association for Accreditation of Engineering Education (ABET) has fully adopted the OBE model in its accreditation efforts. Since China joined the Washington Agreement in 2016, although the concept of OBE has been gradually introduced into the reform of engineering education in Colleges and universities, there are still many difficulties in technology implementation and concept transformation. But there are still people doing this practice, such as Hongxiu Liu and Peng He (2023)[2] .In the reform of talent training mode of big data management and application specialty based on OBE-CDIO concept, the strategy of building a unique teaching and talent training system of big data management and application specialty is put forward. This shows that the concept of OBE has a wide range of applicability and practical value in the training of talents in different professional fields.

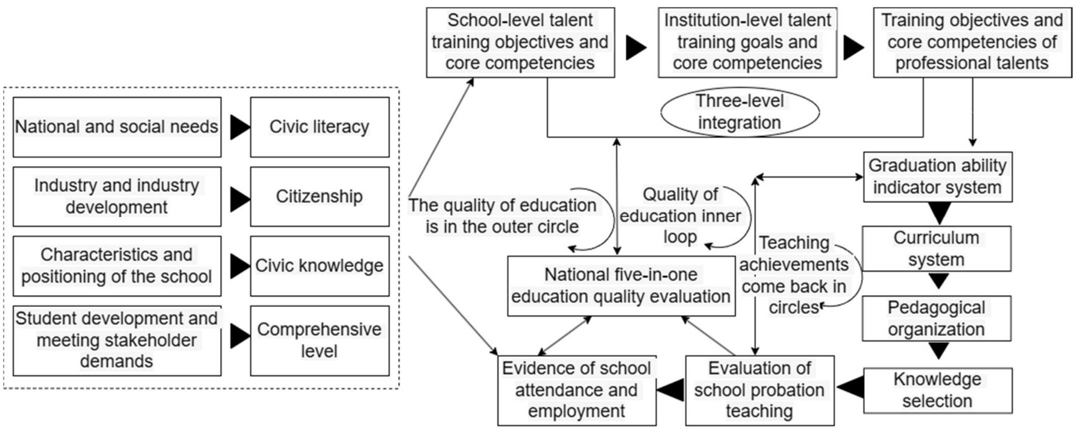

Figure1. Principle of OBE education concept

2.2. Evolution and Bottleneck of Curriculum Evaluation Method

Traditional assessment only relies on a single dimension index of test scores, which is in essential conflict with the "multi-dimensional dynamic evaluation" required by OBE.Practice at home and abroad shows that effective OBE assessment needs to integrate process data and result data, but the existing technical means face three dilemmas: first, data heterogeneity, that is, unstructured data such as classroom performance and experimental reports are difficult to quantify and analyze; second, the current schools generally use manual statistics, so it is difficult to achieve real-time control of the teaching process, which has a certain lag. Third, there is a lack of dedicated analysis system. Refer to Xiangqiang Kong(2025)[3] Constructs the multiple assessment and evaluation system of university mathematics course based on the concept of OBE, which takes the course of "Advanced Algebra Method" as an example, and realizes the comprehensive assessment of knowledge, ability and quality through the combination of process assessment and summative assessment. The system is based on this idea, which gave birth to the development of this research tool.

2.3. Differences between Domestic and Foreign Technology Paths for OBE Implementation

Through comparative study (Table 1), it can be seen that a mature OBE technology ecosystem has been formed in foreign countries. For example, the United States adopts ABET certification system, combined with cloud computing and learning analysis technology, and Australia realizes data integration through MyLO course platform and based on LTI standard. In contrast, domestic universities mainly rely on general tools such as MATLAB for local analysis, and there is a phenomenon of data islands.Therefore, this study refers to the Web-based digital resource sharing information query system designed by Zhaohui Xiao (2024) [5]to realize a unified user interface, share digital resources, interact and integrate information, and ultimately build a query system management platform.

Table 1. Differences between domestic and foreign technology paths

Country/region	Typical Tool	Technical features	Application case
America	ABET Certification System	Cloud computing technology arc hitecture, with its powerful capabil ities, provides support for massive data storage and in-depth analysis; integrated learning analysis techn ology realizes dynamic evaluation and feedback.	The Mechanical Engineering and Computer E ngineering programs at the Michigan College of Shanghai Jiao Tong University have been succes sfully accredited by ABET. The college's training program places a high emphasis on competenc y development and places practical projects in a key position.
Australia	MyLO course platfom	LTI standard is adopted to realiz e multi-platform data exchange an d compatible with third-party tool access.	Monash University and other universities rea lize cross-system sharing of curriculum resourc es through LTI integration
China	MATLAB+ Web Customization Systm	MATLAB deals with complex cal culations (such as course goal achi evement degree modeling); Web te chnology is used to support cross-t erminal interaction and graphical d isplay	The course of Fundamentals of Manufacturin g Engineering in Changsha University of Science and Technology is analyzed by MATLAB, which needs to be supplemented by manual statistics.
International use	FATE Federal Lear ning Framework	Privacy-preserving computation (homomorphic encryption); suppo rts multi-party data collaborative modeling without revealing the ori ginal data	Industry-grade federated learning applicatio ns for cross-school education data Federation

2.4. Theoretical Feasibility of Technology Integration

This project builds an organic collaborative technical architecture through MATLAB algorithm engine and Web technology system: the front-end uses React + Electron to achieve cross-platform interactive interface, through WebSocket and Node.The JS back-end is linked in real time to ensure the dynamic update of data; the back-end relies on MATLAB Web Server to complete the modeling and visual calculation of the achievement degree of course objectives, and its mathematical analysis ability effectively supports the complex formula analysis in the OBE multi-dimensional evaluation model; MySQL database realizes the distributed management of educational big data through the sub-database and sub-table strategy, and the read-write separation mechanism ensures the response efficiency in high concurrency scenarios. Anfu Zhang(2024)[4]In the evaluation of course objectives, graduation requirements and achievement of training objectives based on OBE concept, the importance of evaluation system and implementation methods are emphasized. Therefore, the architecture inherits the maturity of MATLAB in the field of educational data analysis (such as dynamic threshold calculation, learning trajectory modeling).The standardization of evaluation process and the real-time output of results are realized through Web technology, which makes the technical tools and OBE education theory form a closed loop in data collection, algorithm adaptation, visual feedback and other links, and verifies the theoretical feasibility of technology integration in education evaluation scenarios.

3. System Requirement Analysis

3.1. Educational Scenario Requirements

At present, curriculum evaluation in colleges and universities faces three main problems: First, the way of data collection is scattered. Although OBE mode needs to integrate 12 kinds of process data such as attendance, experiment and project defense, the existing system can only deal with simple data such as examination results, forcing teachers to manually organize Excel.For example, the course of Digital Signal Processing in North China University of Technology needs to check 26 test data of 116 students manually, which is inefficient. Secondly, the evaluation method is too single. The survey shows that 78% of the courses are still based on the final examination, which makes it difficult to evaluate the ability indicators such as "engineering ethics" and "teamwork". Finally, the feedback of evaluation results lags behind seriously, usually taking 1-2 months, which makes teachers unable to adjust the teaching plan in time.

3.2. Technical Requirements

The analysis of course goal achievement involves high-order mathematical modeling such as dynamic weight allocation and multi-dimensional data aggregation, and the traditional programming tools have significant bottlenecks in real-time and calculation accuracy. Therefore, it is necessary to introduce a mathematical computing engine supporting matrix operation, statistical modeling and visual output, and basically achieve the millisecond processing standard of complex models through its built-in optimization solver and parallel computing capabilities. However, the technical implementation level still needs to overcome the challenges of teaching scenarios.The mainstream computer systems on the market are generally Windows and macOS, so teachers generally have cross-platform operation needs, and the Electron + React technology stack can meet the cross-platform needs. At the same time, facing the processing pressure of a large number of teaching behavior data, the system needs to design a high-concurrency database architecture.Based on MySQL database and table division strategy and read-write separation mechanism, it has the ability of fast transaction processing, and combines with cache layer optimization to stabilize the response time of data query within the threshold of 1 second. This architecture design not only breaks through the performance bottleneck of traditional single database, but also supports the dynamic expansion of terabyte-level data through distributed storage scheme, which provides sustainable technical support for the increasing demand for data precipitation in Colleges and universities year by year.

4. System Design

4.1. Overall Architecture Design

In order to achieve an efficient, stable and easy-to-expand analysis platform for the achievement of course objectives, the system adopts a front-end and back-end separation architecture and is divided in combination with modular functions (as shown in Figure 1), aiming at improving the scalability of the system.The front-end uses Electron + React technology stack, which is responsible for user interface display and interaction logic, and supports the deployment of Windows, macOS, Linux and other platforms to ensure the wide applicability of the system, which can serve most people.The back-end is based on Matlab Web Server, which is responsible for core computing and data processing, and communicates with the front-end through RESTful API to achieve efficient data interaction.

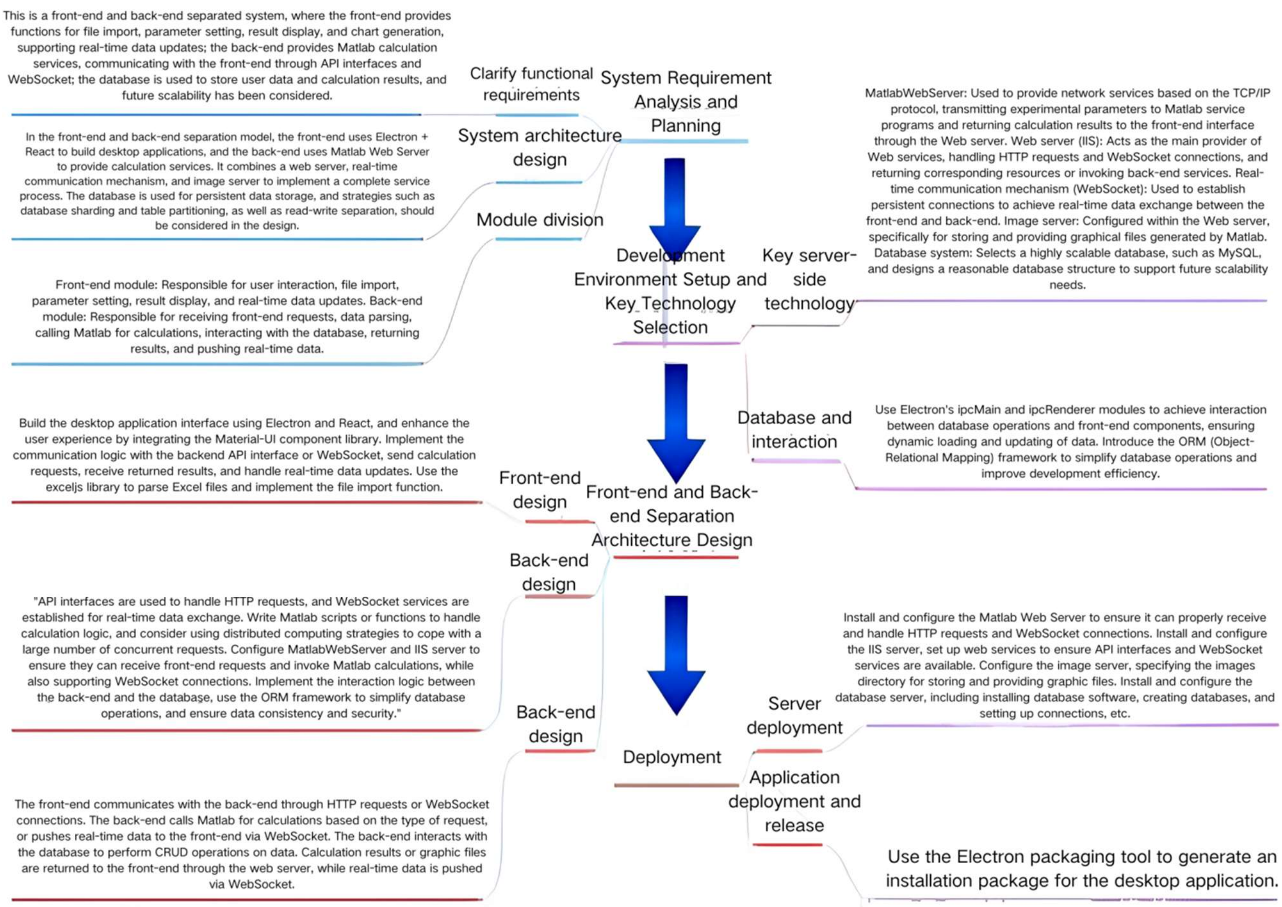

Figure 2. Design and Technology Selection of System Front-end and Back-end Separation Architecture

4.2. Function Module Design

Data integration and management module is responsible for processing teaching data from classroom records, network teaching platform, examination system and other channels. The module supports teachers to manually upload data files in common formats such as Excel and

CSV, and ensures the accuracy and consistency of data through format verification and preprocessing. Storing the consolidated data in a MySQL database facilitates subsequent analysis.

Intelligent analysis module is the core of the system. Based on the powerful data analysis ability of MATLAB, it realizes the calculation and analysis of the achievement degree of curriculum objectives. The module completes the analysis through the following steps:

(1) Data preprocessing: The readtable function of MATLAB is used to import the data, and the cleaning, normalization and missing value processing are carried out.

(2) Mathematical modeling: According to the relevant calculation formula of the achievement degree of curriculum objectives, a mathematical model is constructed to calculate the achievement degree of each sub-objective and the overall.

(3) In-depth analysis: With the help of MATLAB's statistical analysis and visualization module, intuitive and clear analysis charts are generated.

Through Echarts and Highcharts component libraries, the visualization module displays the analysis results in the form of histograms, line charts, pie charts, etc., to help teachers quickly understand the achievement of curriculum objectives. The report generation module can output the analysis results to PDF, Word or Excel format, which is convenient for teachers to save and distribute.

The real-time feedback module realizes the real-time communication between the front end and the back end through the WebSocket technology to ensure that the back-end calculation results can be pushed to the front-end interface in real time, and teachers can view the latest analysis results in real time.

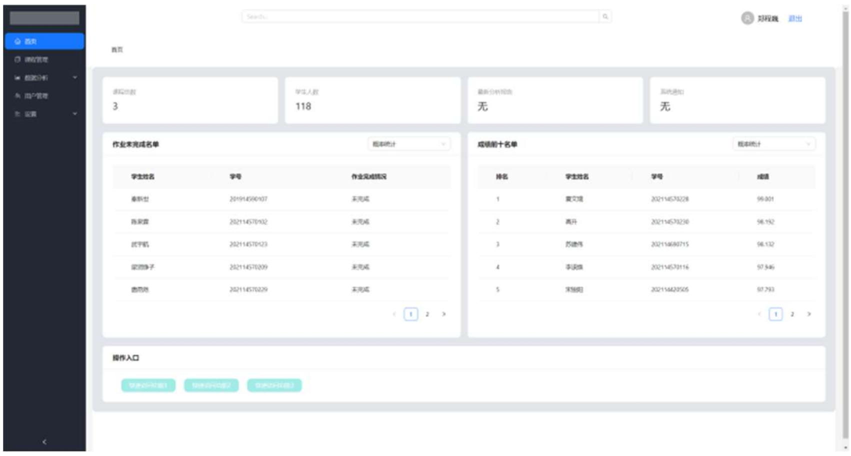

Figure 3. Display of system front-end interface and function module

4.3. Algorithm Support

The system is embedded with the standardized calculation method of the achievement degree of the course objectives of North China University of Science and Technology, which provides a set of scientific and efficient evaluation tools for teachers. At the same time, the system also supports different colleges and universities to customize algorithms according to their own needs to meet the needs of personalized evaluation.

(1) Curriculum Sub-goal Achievement Threshold Calculation Model

This model is based on the following formula: $Y_{mi} = \frac{\sum(A_i \times B_i \times 0.01 \times \mathrm{Assessmentitemcorrespondingvalue})}{T_i}$

Where: Y_{mi}: Achievement threshold for curriculum sub-goal A_i: Weight of the assessment item

B_i: Minimum achievement value of the assessment item

T_i: Corresponding value of the curriculum sub-goalKey Features:

Dynamic weight allocation and threshold calculation ensure objectivity and consistency in evaluation results.

(2) Overall Goal Achievement Evaluation Model

Calculated using the weighted sum method:

$$D_{zm} = \sum_{i=1}^{m} (D_i \times Z_i)$$

Where: D_i: Achievement degree of the curriculum sub-goal

Z_i: Weight of the sub-goal within the overall goal

Purpose: Provides a comprehensive evaluation from sub-goals to the overall goal, offering a holistic perspective for teaching improvement.

4.4. Database Design

In order to cope with the growth of data volume and performance bottlenecks, the system adopts the strategy of sub-database and sub-table. It is stored in different databases according to data types (user data, teaching data and analysis results), and tables with large data volume (such as grade tables) are stored in different tables according to time range or student ID, so as to improve the reading and writing performance of the database. The database designs core data tables such as users, courses, assessment items, scores and calculation results to ensure the consistency and integrity of the data.The database design is shown in the figure, which shows the field structure of each table and its association. It includes the detailed design of core tables such as users, courses, students, course objectives (course _ objectives) and student achievement (student _ achievements).

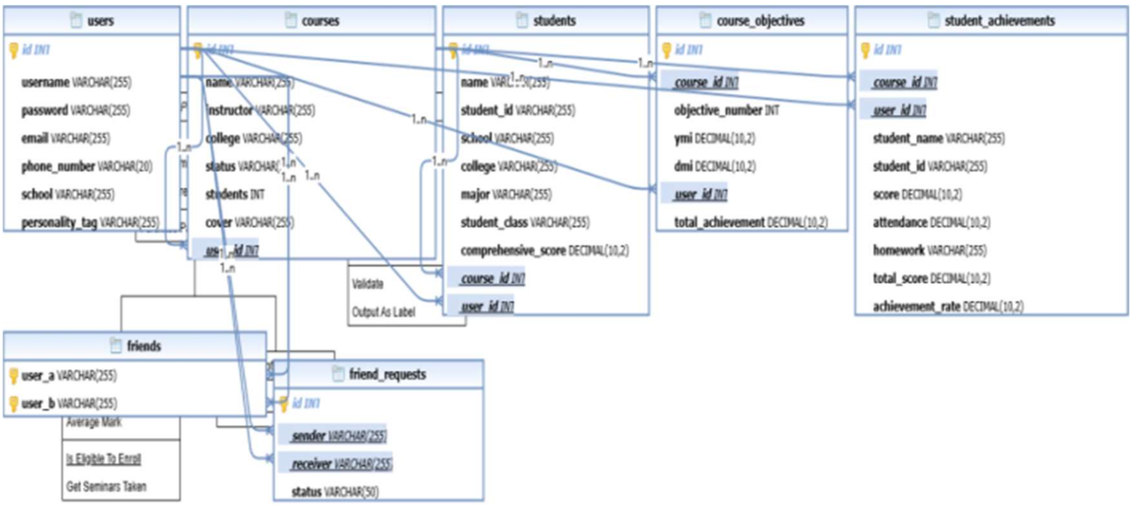

Figure 4. Database architecture and table relationship design

5. Experimental Verification

5.1. Experimental Design

In order to verify the effectiveness of the system, the course of "Digital Signal Processing A" in North China University of Science and Technology (autumn semester 2023, 116 students) is selected as the experimental object.The laboratory data includes 26 chapter tests, 12 assignments, 1 outward bound training, and 1 final examination, totaling 40 items of assessment data. The efficiency, accuracy and user experience of traditional manual analysis (Excel + manual statistics) and system automation analysis are compared.

5.2. Efficiency Improvement Verification

By comparing the time-consuming of manual processing and system automation processing, the effect of efficiency improvement is quantified:

Table 2. Efficiency Comparison: System vs. Manual Processing

Task	Manual processing is time consuming	System processing is time consuming	Efficiency improvement
Data consolidation and cleansing	3.5 hours	2 minutes	105 times
Calculation of achievement degree of curriculum objective	2 hours	10 seconds	720 times
Generate a visual report	1 hour	5 seconds	720 times
Total	6.5 hours	2 minutes and 15 seconds	390 times

Conclusion: The system compresses the traditional analysis work which takes several hours to complete to 3 minutes, and significantly reduces the repetitive work of teachers.

5.3. Error Rate Comparison

Manual statistics is prone to errors due to misuse of formulas and omission of data. Ten groups of data were randomly selected to compare the error rates of the two methods:

Manual statistics: 3.2 errors (such as weight calculation error and data entry deviation) occur every 100 pieces of data on average.

System analysis: The error rate is 0 (the algorithm logic strictly matches the syllabus formula, and the data is automatically checked).

Error analysis: In the manual calculation, the scores of five students were omitted because the Excel formula was not pulled down, and the system could avoid such problems through automatic verification.

5.4. 5.4 Function display and user evaluation

(1) Data integration interface: support one-click import of Excel, automatically identify fields and verify formats (as shown in Figure 5).

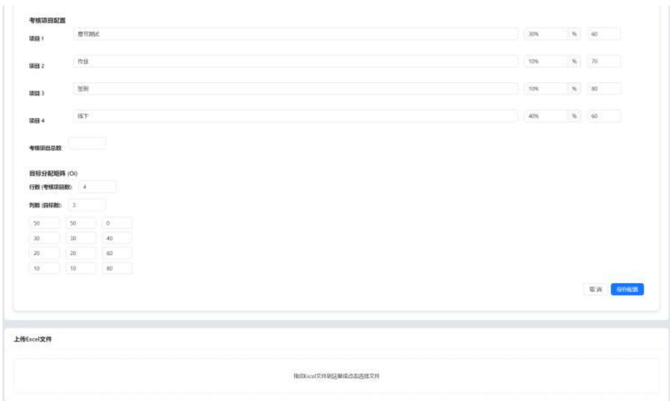

Figure 5. Multi-source data import and automatic cleaning interface

(2) Dynamic visualization Kanban: real-time generation of the histogram of the achievement degree of course objectives and the scatter diagram of the achievement degree of individual students (as shown in Figure 6).

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Figure 6. Visual Analysis Interface of Course Goal Achievement Degree

6. Conclusion

Guided by the concept of OBE, by integrating multi-source data and using dynamic weight allocation mechanism, the course goal achievement analysis system developed in this study effectively overcomes the drawbacks of traditional assessment, which emphasizes results over process, and realizes the comprehensive evaluation of students' multi-dimensional abilities, while enhancing the scalability of the system. The core value lies in the construction of standardized evaluation framework and real-time feedback mechanism, which not only supports teachers to quickly locate the weak links in teaching, but also provides data-driven decision-making basis for the continuous improvement of education quality. At the technical level, the combination of MATLAB and Web technology also verifies the adaptability in the educational scene, and its modular architecture design provides flexible configuration space for the personalized needs of different institutions. Future research can further explore technologies such as federated learning, solve privacy issues such as cross-institutional data sharing, and optimize the generation ability of personalized teaching suggestions through the development of adaptive algorithms, so as to promote the evolution of educational assessment from a single tool to an ecological service system.

Acknowledgments

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