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# *Innovative Design of Integrated Experimental Teaching under the Guidance of Learning Outcomes*

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***Abstract:*** The concept of "people-oriented" education emphasizes that teachers pay attention to students' learning ability and level in the teaching process. On this basis, a set of innovative and practical experimental courses is designed to improve students' comprehensive quality and skill training. Based on the learning outcome, this paper analyzes and studies the effect of applying three-dimensional space to chemistry learning, and puts forward corresponding suggestions. After that, this paper innovatively designes the comprehensive experimental teaching model and testes and analyzes the design system. The analysis results showed that the mean time to failure (MTBF) value varied from day to day. Day 2 had a relatively low MTBF (12 hours), while day 6 had a relatively high MTBF (24 hours). The change of MTBF value indicates the stable operation of the system. This shows that the application of three-dimensional space in teaching to a wider range of disciplines can promote the development of students' ability and knowledge level.

## 1. Introduction

Learning outcome refers to the process in which teachers guide students to conduct independent thinking, independent exploration, self-discovery and summary. In order to evaluate the efforts of college students in learning effect and the improvement of their ability and quality level more clearly, the integrated learning resource construction model after adjustment and reform can be realized. This model includes the adjustment of the existing experimental equipment and teaching content, and enables teachers to make better use of modern network technology to enrich the monotonous education form under the traditional classroom mode, so as to optimize the teacher structure and curriculum.

Based on the theory of innovation and collaboration, this paper puts forward a new teaching model, namely, autonomous learning model based on learning outcomes. The model is constructed by using the knowledge systemization principle and capability goal design. In this paper, the 3D network architecture of "integrated experiment platform + topic modeling - task-driven" and related development technologies are mainly introduced. Through the analysis of existing resources, the following conclusions are drawn: the integrated and optimized program can help students better complete the research work, improve the awareness of innovation, and effectively improve the teaching effect.

In the study of innovative teaching models, teachers were mainly used to analyze and evaluate learning outcomes. From the perspective of students, this paper designs a three-level learning evaluation model based on "action oriented", "knowledge - task + classroom". By constructing causal relationships between various factors at different levels and dimensions, student engagement can be judged. This paper also studies a comprehensive experimental teaching method that introduces multiple variables into the teaching process, which can improve students' learning outcomes.

## 2. Related Work

The innovative design teaching mode based on learning outcome orientation is student-centered, and under the guidance of teachers, the corresponding evaluation system is constructed to meet the requirements of subject characteristics. This model embodies the concept of "people-oriented" and the concept of quality education, combining knowledge and ability into emotional attitude, value goals and process requirements. It emphasizes the comprehensive use of knowledge, rather than focusing only on skill manipulation and emotional expression. This model focuses on cultivating innovative spirit and cooperative spirit, and integrates them into teaching activities. It is a kind of learning organization mode to adapt to the new situation. In terms of academic research, Hongying Zhao proposed LncTarD 2.0, which was a comprehensive database for storing the regulatory relationship between long non-coding Rnas (lncrnas) and target genes in human diseases supported by experimental evidence. The database provides a large amount of data on lncrNA-target gene regulatory relationships and provides a variety of query and analysis tools for researchers to further explore the function of lncrnas in human diseases [1]. Zhaoyan Sun evaluated the performance of the Learned Index. Learned Index is a method of learning index structures using neural networks to improve the efficiency of database indexing. Through a large number of experiments, they demonstrated the advantages of Learned Index compared with traditional index methods in terms of access efficiency, space utilization and update cost [2]. Giuseppe Cattaneo demonstrated the effectiveness of word frequency-based noncomparison functions in bioinformatics through large-scale experiments. He compared the performance of different comparison methods and word frequency-based methods on different tasks, and proved that word frequency-based methods were efficient, accurate and scalable [3]. Xinyi Zhang introduced a method to simplify the database tuning process using hyperparameter optimization and conducted a comprehensive empirical study. They demonstrated the performance benefits of this approach across different databases and tuning tasks, including improved query performance and simplification of the tuning process [4]. Sebastian Benecke described a motor design method for a free-piston linear generator and conducted a comprehensive experimental verification. They introduced the steps and principles of the design method, and proved the advantages of the designed motor in terms of performance and efficiency through experimental tests [5]. Thi Ngoc Anh Tran explored the impact of Socrative online assignments on learning outcomes through a case study in Vietnam. The results showed that online assignments could significantly improve student learning outcomes and provide feasible suggestions for optimizing the design and implementation of online assignments [6]. Radwa El Shawi conducted a comprehensive experimental evaluation of deep learning frameworks and designed and developed an experimental platform named DLBench, which was used to compare the differences between different deep learning frameworks in terms of performance, scalability and ease of use [7]. Mengzhao Wang conducted a comprehensive investigation and experimental comparison of graph-based approximate nearest neighbor search methods. They summarized the advantages and disadvantages of different graph structure methods and evaluated their performance in terms of accuracy, query efficiency and memory consumption through experiments [8]. Ahmed M. Elkhatat introduced the sensitivity analysis tool for virtual experimental simulation using computer-aided Aspen Plus, and discussed its potential for improving learning outcomes and coping with possible epidemic constraints in experimental teaching [9]. Ghada Amoudi explored teaching methods for achieving learning outcomes using interactive notebooks in postgraduate courses. They introduced the design and implementation of interactive notebooks and discussed its advantages and challenges in improving learning outcomes and learning experiences [10]. They enhance students' interest in chemistry courses and specialized courses through interactive learning at different levels and grades. With the deep integration of information technology and education technology and the continuous expansion of computer-assisted teaching in the modern remote network environment, integrated practical activities as a teaching method in the new era can help students better practice their learning results and provide targeted suggestions to optimize the design and implementation of online assignments.

## 3. Method

### 3.1 Data Mining Technology

The goal of data mining is to find potential useful value from a large amount of information to help people understand the law of things and use these meaningful changes for predictive analysis and problem solving. The process involves classifying, identifying, and describing objects according to some or a set of specific criteria. Cross-validation algorithm refers to the method of finding the original sample set of potential relationships in the new data set [11-12]. In this process, relevant theories from multidisciplinary fields such as statistical methods and pattern recognition are applied. It can improve students' ability to access information and process data, and promote the development of teachers' professional development, so that they can better guide students to independent thinking, collaborative inquiry and innovative practice. This teaching method can stimulate students' enthusiasm for exploring new things and encourage them to take the initiative to explore.

$$\mathrm{Confidence}(X \Rightarrow Y) = \frac{\mathrm{Support}(X \cup Y)}{\mathrm{Support}(X)} \tag{1}$$

This paper aims to systematically study the relationship between things and their development trend by using common mathematical tools and mathematical models in statistics in academic language [13-14]. In real life, many problems can be solved by numerical calculation or simulation. In this paper, the rule base of data mining, classification and predictive analysis algorithms can be established according to different objects, and these methods can be applied to other disciplines and fields. In database D, the support of rule X => Y refers to the ratio of the number of transactions containing both X and Y to the number of all transactions in the transaction set, which can be expressed by the following formula:

$$\mathrm{Support}(X \Rightarrow Y) = \sup\mathrm{port}(X \cup Y) \tag{2}$$

Giving a set of data points $\{x_1, x_2, ..., x_i\}$, where $x_i$ represents the eigenvector of the I-th data point. Cluster analysis aims to divide a given data point into k distinct clusters such that the data points within each cluster have similar characteristics. In order to quantify the objective of cluster analysis, an objective function J is defined, which is represented by the following formula:

$$J = \sum w_{ij} \| x(i) - \mu(j) \|^2 \quad (3)$$

In cluster analysis, the goal is to maximize the similarity of sample points within clusters and the difference of sample points between clusters by minimizing the objective function J. Among them, $w_{ij}$ represents the weight assigned to cluster j by sample point x(i), and μ(j) represents the center of mass of cluster j. The objective function J represents the weighted sum of the distance between the sample points in the cluster and the center of mass, which is used to measure the compactness in the cluster. By optimizing the objective function J, the optimal cluster division method is found to achieve the objective of cluster analysis [15-16].

### 3.2 Comprehensive Experimental Teaching System

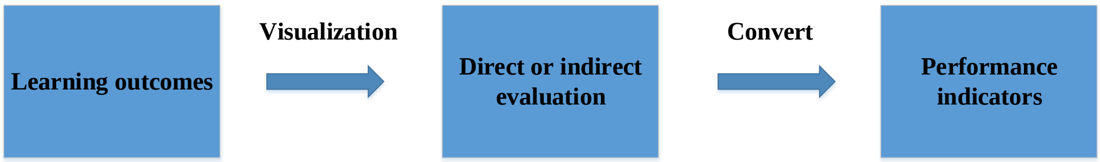


Figure 1: Learning achievement conversion chart

The student-centered and teacher-led teaching mode of comprehensive experimental teaching aims to fully consider the differences among students and the influence of individual factors on their learning. Compared with the traditional teaching methods, the comprehensive experiment pays more attention to the difference of students' development level and interests. Students in the integrated experimental group can use the network platform to arrange their own learning tasks according to their courses, and submit the completed tasks to the academic affairs office of the college. Teachers apply to colleges or schools to obtain corresponding support and services, and provide relevant materials for other students to facilitate their independent exploration activities [17-18]. The teaching system includes learning resource library (such as teaching materials, teaching AIDS and network resources, etc.) and students, teachers and related auxiliary modules (such as course material management function, teaching activity planning and evaluation function, etc.), aiming to provide students with diversified information sources and improve their autonomous learning ability and experimental monitoring and analysis ability. Figure 1 shows the process of learning outcome conversion. In the whole system, each module is connected and interacts with each other to test basic knowledge and basic skills. Each module develops the assessment content and scoring method according to the students' mastery level, and regularly evaluates and gives feedback on the comprehensive experimental results and performance, so as to timely improve the problems in the teaching process, correct mistakes or improve deficiencies, and improve the teaching effect [19-20].

## 4. Results and Discussion

### 4.1 System Operation Procedure

According to the system requirement analysis, the relationship between each module and part of the research model of this subject needs to be reasonably determined. At the same time, each functional unit needs to be modeled independently. In order to implement the whole class teaching activities, this paper takes the students' learning process and the teacher-led learning plan guide into consideration. Students will be divided into several groups to present the experimental results and test situations, and each group of students will have independent thinking and discussion. In the overall design of the system requirements analysis stage, the functions of each module and the tasks to be completed have been determined. This paper verifies the students' mastery of the knowledge point through a preliminary test. After the software is running, it needs to be thoroughly checked and the data and results recorded. In order to ensure that the normal output and returned results meet the requirements, it is necessary to maintain the consistency of program parameters, instructions and other information, including the correctness of the data input format and the relationship between the output value and the expected value deviation scale. The final solution needs to be determined by simulating the user's use of the relevant software and hardware environment. For users, first of all, they need to select functional modules and technical indicators that meet the requirements. Depending on the situation, this article decides whether to adopt the pattern, and develops a test plan, implementation method, and how to convert it to a specific data format. Finally, a review team composed of experts put forward modification suggestions for the defects in the system, and carried out trial operation under the condition of ensuring the normal operation of the system until the design requirements were met. For basic information, it needs to enter and modify it. For problem analysis, different methods can be used to determine whether the scheme has design defects or other deficiencies. The most important and critical step in system testing is whether these judgment results can reach the expected goal and realize the final output to the student experiment platform.

### 4.2 Operation Effect Analysis

Table 1: Parameter range

| Parameter | **Number** |
| --- | --- |
| Number of students | 500 |
| Number of teachers | 30 |
| Number of classes | 20 |

The learning outcome analysis covers parameters such as the number of students, the number of teachers and the number of classes, and the data are shown in Table 1. Under the traditional comprehensive experimental teaching model, there is little interaction between teachers and students. If the task-driven "learning-oriented" teaching model is adopted to explore innovation ability, knowledge can be divided into activities such as learners' independent exploration and group cooperation to complete tasks and conduct evaluation and feedback. For problems that do not need to be discussed or that must be solved independently through teacher guidance (for example, difficulties encountered between students), other members of the group can work together. The following is the analysis of the operation effect of the integrated teaching system.

This paper observed the operation of the system for seven days, from Monday to Sunday, marked 1 to 7. As we can see from Figure 2, Day 1 ran for 14 hours, Day 2 ran for 12 hours, Day 3 ran for 19 hours, Day 4 ran for 15 hours, Day 5 ran for 21 hours, day 6 ran for 24 hours, and day 7 ran for 18 hours. Looking at Figure 2, we find that mean time between failure (MTBF) values vary from day to day in a given data set. Day 2 had a relatively low MTBF (12 hours), while day 6 had a relatively high MTBF (24 hours). The change of MTBF value indicates the stable operation of the system.

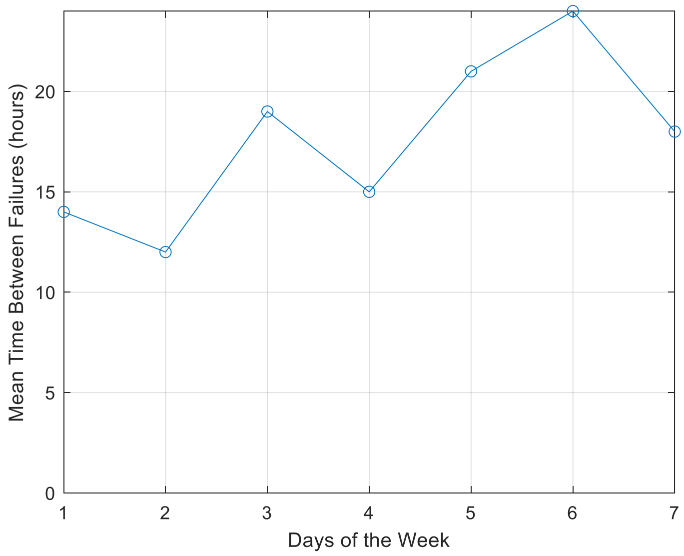


Figure 2: Mean time between failures

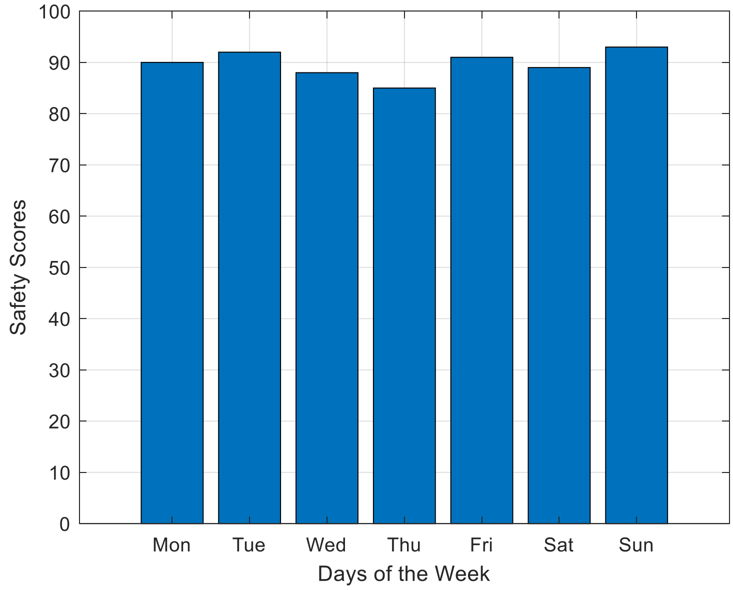


Figure 3: System security

In the academic achievement module, teachers set tasks of different levels and difficulties according to teaching requirements and their own experience. By clicking the relevant button, the teacher can view the methods and precautions of the students when completing the experimental tasks of the unit in order to find possible loopholes or shortcomings. The students then assist the operation team members to complete the project design and submit the test report, giving the corresponding results and analysis comments in order to provide feedback to all participants. Through this evaluation method, students' innovation ability and independent inquiry ability can be evaluated finally. When innovative designs are carried out, the safety of the system must be rigorously tested. If security issues are found, the system can continue to be improved and perfected. Students at different levels have different mastery of knowledge points, and their understanding may not be deep enough, which may lead to confusion. Advanced students may experience problems such as thinking barriers and failed experiments. All these factors will lead to the reduction of the conversion rate of innovation achievements or the failure to form core competitiveness. Therefore, it is necessary to continuously strengthen the students' autonomous learning ability. The data in Figure 3 shows that the security score varies from day to day. Thursdays have a low safety score of 85, while Sundays have a high safety score of 93. By observing and comparing the changes of safety score, this paper can find that the minimum safety is 85, and then the overall safety of the comprehensive experimental teaching system can be improved by optimizing this model.

## 5. Conclusion

With the rapid development of information technology, the cultivation mode of innovative talents has gradually emerged in modern education; among which comprehensive experiment teaching has been widely used as a new and efficient way to improve students' learning ability and quality education. Under the guidance of innovative ideas, this paper has carried out a comprehensive chemical discipline construction activity. Starting from the organizational design and implementation scheme, this paper constructs a "three-dimensional" graph of college students' autonomous learning research target system; with teachers as the leading, the evaluation mechanism has been established; taking the teaching process as the center, the evaluation model is established. Through the systematic analysis and research, this paper puts forward the strategy and suggestion of optimizing the comprehensive experiment platform, in order to promote the improvement of the comprehensive practice effect and the improvement of the quality of talent training. However, this paper still has the following shortcomings: First, it does not fully consider the important factor of "student subjectivity" when conducting in-depth research on the learning outcome analysis and evaluation model. Therefore, the proposed innovative design is still lacking in completeness and rationality. Second, from the perspective of students, there is no more detailed analysis and elaboration of the experimental process. For teachers, the lack of more in-depth, comprehensive and practical guidance cannot better stimulate all students to actively participate in teaching and improve their comprehensive ability development level. In this regard, the cultivation of comprehensive ability and practical level can be strengthened through the network platform.

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