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An Empirical Study on the Development and Application Model of Fragmented Learning Resources Based on the Attributes of Statistics Courses

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Abstract: With the deepening of the digital transformation of higher education, the teaching mode of traditional statistics courses faces the problems of complex and disordered knowledge system, abstract content and high difficulty for students to accept. Based on the relationship between the knowledge structure of the course and the cognitive characteristics of students, this paper creates a fragmented learning resource development and application model based on the attributes of statistics courses, and also conducts empirical research on this. By modularizing and hierarchical division of statistics course content, integrating students' learning behavior data and feedback, a resource development system in line with the "concept-model-application" logic is established. Resources are further arranged and teaching practice is carried out in the scenario of hybrid teaching. The analysis of quantitative data and comparison of teaching effects confirm that fragmented resources are effective in improving students' learning efficiency, strengthening the depth of knowledge mastery, and improving course satisfaction experience. The research results show that fragmented learning resources with systematic design and differentiated delivery can reduce students' cognitive load, and also create a replicable and popularizable practical example for statistics teaching reform. This study has key implications for the future data-driven educational resource design.

1. Introduction

Against the backdrop of the surging wave of digitalization and the rapid expansion of educational informatization, higher education is in a stage of profound change. The traditional teacher-centered teaching model can no longer meet the needs of college students in the new era for learning flexibility, autonomy and personalization. Especially in statistics, a basic course with a high degree of abstraction, rigorous logic and strong technicality, traditional teaching faces many difficult challenges, such as compact and extensive course content, large differences in students'

basic levels, and difficulties in understanding abstract concepts. These have led to students generally having insufficient motivation to learn and a lack of in-depth knowledge. Fragmented learning, which appears in the form of a new learning method, has aroused widespread concern. It breaks down systematic knowledge into micro-learning units that can be easily accessed, conforming to students' fragmented learning time and cognitive rhythm, thereby improving learning efficiency.

Fragmented learning resources are still extensive in the development of statistics courses in colleges and universities. There is a lack of in-depth analysis of the structure of course content and its fit with students' cognitive laws, which leads to unstable teaching effects. This article attempts to use statistics courses as an example to analyze how its knowledge system adapts to the logic of fragmented learning resource development. At the same time, it uses empirical data to verify the teaching effect of such resources, thereby providing theoretical support and practical reference for the construction of college course resources and innovation of teaching models.

2. Problem

2. Many limitations of traditional statistics course teaching model

Traditional statistics teaching generally adopts a linear teaching path that combines lectures with blackboard writing, emphasizing the training of formula derivation and calculation, and neglecting the cultivation of students' statistical thinking and data analysis capabilities. In terms of teaching arrangements, the content is compactly arranged and the time arrangement is fixed. Teachers often advance according to the established system of textbook chapters. Students have to master a large number of concepts and methods in a short period of time, which can easily make the learning load exceed the normal level. In terms of the statistics of the final grades of a statistics course in a certain science and engineering university, in the spring semester of 2023, the median score was only 71 points. Although the pass rate reached 89%, the excellent rate did not reach 15%, reflecting the overall poor learning effect. The questionnaire survey showed that 62% of students said that "it was difficult to keep up with the rhythm of the course", and more than 70% of students believed that "the formulas and methods were not easy to understand", exposing the obvious shortcomings of traditional teaching in supporting students to understand and apply statistical knowledge.

2.2. Fragmented learning needs caused by students' learning behaviors and cognitive rules

The learning methods of contemporary college students are showing a trend of being highly digitalized, networked and fragmented. The survey results show that among a sample of 300 undergraduates, 89% of the students use mobile phones to study for more than 30 minutes a day, and about 78% of the students prefer to conduct independent learning in non-classroom situations with the help of short videos, pictures or interactive software. Integrating Bloom's cognitive taxonomy theory with cognitive load theory, when learners understand and apply statistical knowledge, if they can implement segmented learning within the range allowed by cognitive rhythm, it will help to form a more reliable knowledge network and problem-solving ability. The "micro-learning" and "task-driven learning" models based on the core of the learning unit can reduce the learning frustration caused by high cognitive load in statistical learning. According to the cognitive laws and digital behavior characteristics of students, the development of adaptive fragmented learning resources is an urgent requirement for statistical teaching reform.

2.3. Deficiencies and gaps in the application of fragmented learning resources in current statistics teaching

Although some universities have tried to develop "micro-courses", "knowledge point animations" and "teaching video clips" in recent years to assist in the teaching of statistics courses, most of the resources tend to introduce basic concepts and explain calculation formulas, with a lack of presentation styles and poor knowledge relevance, making it difficult to support students in systematically building a knowledge system. In 2022, a university in Jiangsu Province introduced more than 30 micro-video resources in the "Probability Theory and Mathematical Statistics" course, and the proportion of students using them was as high as 85%. However, in the subsequent learning effectiveness evaluation, there was no significant difference in the average course score compared with the control group that did not use videos. The interviews further revealed that students remember fragmented content quickly but forget it just as quickly, failing to build a bridge of internal connections within knowledge. The development of fragmented resources has not yet broken away from the positioning pattern of "shallow assistance", and lacks functional positioning and logical planning based on the overall curriculum system.

3. Problem Analysis

3. Modularization and hierarchical analysis of the knowledge structure of statistics courses

Statistics course knowledge highlights the highly modular attribute, generally including descriptive statistics, probability foundation, random variables and their distribution examples, parameter estimation, hypothesis testing, regression analysis and other units. Each module also includes multi-level objectives such as concept grasp, application of mathematical tools and practical analysis. The "parameter estimation" module includes the basic definition points of point estimation and interval estimation, as well as technically difficult content such as maximum likelihood estimation and confidence interval construction. With the help of course content map analysis , it is found that each module has a very obvious hierarchical dependency relationship. It is more appropriate to divide the knowledge into blocks with the three-layer structure of "foundation-extension-application". Combined with the outline of Tsinghua's statistics course, 15 core knowledge points are modularly reorganized. After exploration, it is found that each module can be disassembled into 3.7 core micro-tasks on average, and the average learning time is no more than 10 minutes, which builds a natural content support point for fragmented design.

3.2. Analysis of the survey data on the stages and differences in students' mastery of statistics learning content

In order to analyze the stage differences in students' mastery of different contents, this paper designed and implemented a stage assessment and questionnaire survey involving 235 statistics learners from two universities. The results of the assessment showed that in terms of the "Descriptive Statistics" module, the students' knowledge mastery rate reached 82%; in the "Hypothesis Testing" module, the proportion dropped sharply to 42%, proving that the complexity of the content has a significant impact on learning outcomes. More than 60% of students reported that they could only understand abstract content after studying it in stages multiple times. About 48% of students expected to use the "short video + instant feedback" method to master the key content. This reflects that students are more adaptable to a gradual and decentralized learning rhythm. Subsequent cluster analysis also found that in the "application questions" part, the performance gap

between students with uneven learning foundations was the most obvious. This suggests that resource design should be layered according to different learning levels, thereby improving the adaptability and effectiveness of resources.

3.3. Empirical study on the relationship between cognitive load and learning outcomes under fragmented learning resource design

In order to verify the actual effectiveness of fragmented resources in reducing students' cognitive load and improving learning outcomes, this paper selected the "parameter estimation" module as the experimental object, and constructed a four-section fragmented resource package consisting of animation explanation, micro-test, formula derivation and case analysis. The average duration of each resource was limited to 6-8 minutes, and a corresponding cognitive load scale (7-point system) and learning effectiveness test questions were designed. This study adopted a randomized controlled experimental method and selected two groups of students. The experimental group consisted of 60 people and the control group adopted a sample size of 60. The control group implemented a conventional teaching model, and the experimental group carried out auxiliary learning with fragmented resources. The results of the experiment confirmed that in terms of cognitive load score, the mean score of the experimental group was 3.2, which was significantly lower than 4.6 points of the control group, and the difference was extremely significant; the average score of the learning effectiveness test was 83.1 points, and the test score of the control group was 74.7 points, and the difference was statistically significant. When giving feedback after class, students in the experimental group generally said that "knowledge is easier to understand and absorb" and "the learning pace is more in line with personal habits." This empirically verifies the feasibility and effectiveness of structured fragmented resource design, showing that it can not only improve learning efficiency, but also enhance students' desire to actively learn.

Table 1: Learning Effectiveness and Cognitive Load Comparison Between Groups

Group Type	Average Cognitive Load (7-pt scale)	Learning Effectiveness Score (out of 100)	Score Improvement (%)
Control Group	4.6	74.7	—
Experimental Group	3.2	83.1	11.20%

Table 1 highlights a significant improvement in student outcomes using fragmented learning resources. The experimental group reported a 30% reduction in cognitive load and an 11.2% improvement in learning performance. This confirms the pedagogical advantage of well-structured micro-resources in enhancing understanding and knowledge retention in abstract topics like parameter estimation.

4. Problem-solving strategies and model construction

4.1. Principles and technical approaches for developing fragmented learning resources that fit the characteristics of statistics courses

In view of the fact that the knowledge points of statistics courses are logically compact, the degree of abstraction is significant, and the hierarchical relationships are complex, the development of fragmented learning resources should be systematically designed in accordance with the core principles of "structuring, adaptability, and interactivity". Structuring requires that each learning

fragment be embedded in the course knowledge system, and that the three functional positionings of concept explanation, method acquisition, and application practice be realized to achieve the organization of knowledge from point to surface and step by step. Adaptability is determined according to the individual differences and cognitive development stages of learners, providing differentiated resource paths to support the content layout that combines "high-frequency access + in-depth supplementation". Interactive design must strengthen the relevant mechanisms for resource feedback, relying on instant tests, intelligent questions and answers, branch paths, etc. to promote learning participation and feedback efficiency.

In terms of the technical implementation path, a three-in-one development model based on "micro-courses, knowledge maps, and interactive assessments" can be adopted, using Python and R languages as the supporting environment, combining H5 interactive technology, data visualization tools, and the Learning Analytics platform, splitting the course content into "knowledge cards" (such as: definition categories, derivation categories, case categories, etc.), and using a personalized recommendation mechanism to drive learning from passive acceptance to active construction. Taking the "Probability Theory and Mathematical Statistics" course at a university in Nanjing as an example, the development team split the 45-hour course into 112 learning nodes, distributed in 16 thematic units, and also built corresponding learning maps and interactive learning paths, which effectively promoted the structuring of fragmented resources.

4.2. Create a fragmented learning resource system of "concept-model-application"

In order to more effectively promote the achievement of statistical learning goals, this paper proposes a fragmented resource development framework under the three-dimensional model of "concept-model-application". This model is developed according to the logic of the natural evolution of statistical knowledge and divides learning resources into three categories:

• Concept resources: mainly focus on statistical terms, basic definitions and principles, etc., using graphic descriptions, animation presentations and analogies to help students form preliminary cognition.

• Modeling resources: focus on the deduction of formulas, operational logic and modeling process, and use step-by-step demonstration videos, interactive formula boards and parameter control experiments to help students master the technical points of statistical reasoning.

Application-oriented resources: focus on knowledge transfer and solving practical problems, construct small cases, open topics and virtual experimental tasks based on real data sets, and guide students to conduct comprehensive analysis based on what they have learned.

For the theme of "Normal Distribution", the resource design includes in order: understanding and grasping the definition of normal distribution and its graph. Relying on logical connections and navigation methods, students can choose the order of learning by themselves and complete personalized learning path planning. In the experimental teaching of pilot universities, this model has shown good adaptability and effectiveness. Among the 120 students who adopted this resource system, 91 chose to carry out learning according to the path of "model type-concept type-application type", showing that students' ability to actively plan knowledge acquisition methods according to needs has improved.

4.3. Application model of fragmented resources and teaching evaluation mechanism related to integrated hybrid teaching

In order to achieve efficient use of fragmented learning resources, it is necessary to organically integrate them into the hybrid teaching context of statistics. Based on the teaching design model

(such as the ADDIE model), a three-stage application path of "before class - during class - after class" can be established:

- Before class: Pre-study-oriented fragmented resource delivery, such as animation guidance of key concepts, small tests and warm-up cases, drive students into the stage of cognitive preparation;
- In-class: Task-driven resources are embedded in the teaching process. Teachers use questions as a guide to carry out teaching work, insert interactive videos and real-time feedback resources to enable students to practice while learning;
- After class: Strengthen the consolidation and expansion of resource support, rely on the intelligent learning platform to push different resources, achieve knowledge review, misunderstanding correction and personalized review.

As far as teaching evaluation is concerned, a diversified evaluation system based on process evaluation and learning data-driven should be created, and indicators such as resource click-through rate, learning time, completion rate and grade increment should be integrated to build a comprehensive teaching feedback loop. The learning analysis system and the Moodle platform should be combined to know the students' behavior trajectories at each learning node in real time, and give personalized learning suggestions based on the learning effectiveness prediction results. Taking the pilot data of the "Parameter Estimation" chapter of a certain university as an example, after the introduction of this resource and evaluation mechanism, the mastery rate of low-segment students increased from 42% to 64%, showing that the evaluation mechanism has played a significant role in promoting learning support and teaching improvement.

Table 2: Post-Implementation Outcomes of Fragmented Resource Application (Pilot Chapter)

Indicator	Before Implementation	After Implementation	Improvement (%)
Low-tier Student Mastery Rate (%)	42	64	52.40%
Completion Rate of Assigned Tasks	78	93	19.20%
Average Weekly Learning Time (min)	46	58	26.10%
Resource Click-through Rate (%)	61	87	42.60%

Table 2 demonstrates that after integrating fragmented resources into hybrid teaching, all key learning engagement indicators rose significantly. Low-performing students' mastery increased by over 50%, and resource usage rates surged. These metrics validate the model’s capacity to personalize learning, increase participation, and improve knowledge acquisition in diverse student groups.

5. Conclusion and Implications

This study takes statistics courses as the research object, focuses on its content characteristics and teaching needs, and conducts systematic empirical exploration around the development and application of fragmented learning resources. It deeply analyzes the problems existing in traditional teaching models, the laws of student cognition, and the current lack of resource application. It

knows that statistics teaching urgently needs flexible and adaptable digital resources. Based on empirical evidence, it proposes a resource development strategy based on the principles of "structuring, adaptability, and interactivity". It also builds a three-dimensional resource system with the dimensions of "concept-model-application". At the same time, it explores the application methods and multi-evaluation mechanisms that are deeply integrated with hybrid teaching. The results of the study confirm that if the structure of fragmented learning resources is reasonable, the content is accurate and appropriate, and the usage scenarios are diverse, it can significantly reduce the cognitive load of students, promote learning efficiency and teaching effectiveness, which is not only of key practical significance to the reform of statistics teaching, but also provides a paradigm reference and technical reference for the development of teaching resources for other mathematics and engineering courses. This study objectively has certain limitations. Resource development mainly focuses on general statistics courses at the undergraduate level, and does not cover professional courses and interdisciplinary courses. The teaching practice samples are mainly taken from universities in the eastern region, which has certain regional spatial limitations. Future research can further combine natural language processing technology with AI-driven learning analysis systems to achieve intelligent resource recommendation and dynamic matching; at the same time, expand relevant research objects to test the transferability and universal applicability of this research results in multidisciplinary and multi-platform contexts. The development and application of fragmented learning resources based on the attributes of statistics courses is not only the core breakthrough of the transformation of teaching models, but also the core point of promoting the deepening of the digitalization of higher education, which deserves further in-depth exploration and practical promotion.

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