Research on the Integration Model of University Mathematics Education Knowledge Resources under Fuzzy Analytic Hierarchy Process

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Abstract: This paper aims to explore the application of the Fuzzy Analytic Hierarchy Process (FAHP) in developing a knowledge resource integration model for college mathematics education, with the ultimate goal of enhancing both teaching quality and student learning outcomes. Initially, a comprehensive framework for the integration model is established, encompassing three primary layers: the goal layer, the criterion layer, and the scheme layer. The goal layer concentrates on achieving an effective consolidation of knowledge resources. Furthermore, the criterion layer is meticulously divided into three distinct facets: integrating teaching content, unifying teaching methodologies, and consolidating teaching resources. The scheme layer puts forward specific integration measures, such as optimizing the curriculum system, popularizing the mixed teaching mode and establishing a resource sharing platform. The fuzzy consistent matrix is used to analyze the weight of each layer of factors, and the relative importance of each factor is determined by expert scoring. Taking a comprehensive university as an example, the model is applied to the case analysis, which verifies the effectiveness and practicability of the model. The results show that the integration of teaching methods has the highest weight, so the mixed teaching mode is given priority; In the aspect of teaching content, it focuses on optimizing the curriculum system and increasing the knowledge points of modern mathematics; The integration of teaching resources promotes the immediate acquisition of resources through a shared platform. The FAHP model constructed in this paper not only provides a scientific basis for the optimal allocation of knowledge resources in college mathematics education, but also significantly improves the teaching efficiency and students' learning quality, and provides a model for resource integration in the field of education.

1. Introduction

In today's highly information-based society, mathematics is not only a basic subject, but also the key to innovation and development in many fields. As the cradle of talent training, the quality of mathematics education in universities is directly related to the quality and ability of the country's future scientific and technological talent team. However, with the continuous updating and expansion of knowledge, college mathematics education is facing some problems, such as scattered knowledge resources, repeated teaching contents, and inefficient utilization of resources. Therefore, how to effectively integrate the knowledge resources of college mathematics education and improve the teaching efficiency and students' learning effect has become an urgent problem in the current education field.

Fuzzy Analytic Hierarchy Process (FAHP), as a multi-attribute decision-making method that combines qualitative and quantitative analysis, has been widely applied in multiple fields to handle evaluation and decision-making problems of complex systems [1-2]. It constructs a hierarchical structure model to analyze the weights of various factors, providing decision-makers with scientific decision-making basis. In the integration of knowledge resources in university mathematics education, the FAHP method can comprehensively consider multiple influencing factors, providing strong support for the optimal allocation of educational resources.

The purpose of this study is to use FAHP method to construct a model of knowledge resources integration in university mathematics education, so as to optimize the allocation of university

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mathematics education resources and improve teaching efficiency and students' learning quality through scientific methodological guidance.

2. Construction of knowledge resources integration model of college mathematics education

2.1. Hierarchical structure of integration model

When determining the integration model of knowledge resources in college mathematics education, we need to build a clear hierarchical structure, which includes target layer, criterion layer and scheme layer. Each layer carries different functions and meanings, which together constitute the basic framework of the integration model. Through the construction of the above three levels, the integration model of knowledge resources in college mathematics education forms an organic whole, which improves the quality and efficiency of college mathematics education in all directions from teaching content, teaching methods and teaching resources [3-4].

The primary objective of the goal layer is to actualize the seamless integration of knowledge resources within college mathematics education. This ambition reflects the commitment to enhancing the productivity and caliber of mathematics instruction, as well as the resolve to streamline the distribution of educational assets. Successful integration can eradicate the detachment and disarray of knowledge resources, resulting in a structured, consistent, and proficient teaching framework.

To fulfill the aim defined by the goal layer, three pivotal criteria are established: the unification of teaching content, pedagogical approaches, and instructional resources. The consolidation of teaching content centers on the effective amalgamation of mathematical concepts across diverse courses and textbooks, eliminating redundancies and gaps, and ensuring that students are educated within a logically connected and comprehensive knowledge architecture. The integration of teaching methods aims at exploring the way of combining traditional teaching methods with modern teaching methods, creating an efficient and vivid teaching mode, such as integrating modern scientific and technological means such as multimedia teaching and online teaching platform, and enhancing students' learning interest and effect. The integration of teaching resources focuses on making full use of and integrating all kinds of teaching resources inside and outside the school, including teaching materials, tutoring materials, online courses, experimental equipment, etc., in order to provide students with richer and more comprehensive learning materials and practical opportunities.

Under the guidance of the criterion layer, in order to directly affect the actual teaching of college mathematics education, specific integration measures are formulated. This entails the restructuring and refinement of the mathematical curriculum framework, eliminating overlapping material, reinforcing any deficient knowledge areas, guaranteeing the coherence and comprehensiveness of the syllabus content, and revising the instructional matter in step with the ongoing advancements in the field to maintain the relevancy and prescience of the coursework. Furthermore, it advocates for the adoption of a blended instructional approach, melding the merits of both online and offline pedagogy, amplifying student engagement, and harnessing contemporary educational technologies like virtual reality (VR) and augmented reality (AR) to revolutionize teaching strategies and enrich the learning journey for students. Additionally, there is a push to create a collaborative platform for mathematical instructional resources, amassing superior educational materials from both within and beyond the academic institution, enabling seamless access to pertinent information for educators and learners alike, fostering partnerships with industrial corporations and research bodies, ushering in more pragmatic educational tools and initiatives, and bolstering students' practical skills and creative reasoning.

2.2. Analysis on the importance of various factors in the integration of knowledge resources in college mathematics education

In this study, FAHP method is used as the main research method to determine the importance of various factors in the integration of knowledge resources in college mathematics education. FAHP method combines qualitative analysis and quantitative analysis, which can effectively deal with the evaluation and decision-making problems in complex systems.

After constructing the target layer, criterion layer and scheme layer, FAHP method is used to determine the importance of each layer factor in the integration model. The fuzzy consistent matrix in FAHP method is used to analyze the weight of each layer of factors [5]. Fuzzy consistent matrix is constructed by comparing the relative importance of each factor in pairs. Experts and related practitioners in the field of mathematics education are invited to compare each factor in pairs according to their experience and judgment, and give a score of relative importance.

According to the research problems and objectives, a multi-level structural model is constructed. The model usually includes the goal layer (the overall goal of the study), the criterion layer (the main factor affecting the overall goal) and the scheme layer (the specific implementation). In this study, the target layer is the effective integration of knowledge resources in college mathematics education, the criterion layer includes the integration of teaching content, teaching methods and teaching resources, and the scheme layer is the specific integration measures.

The priority relation matrix is used to indicate the relative importance of each factor. Through expert scoring or questionnaire survey, the results of pairwise comparison between various factors are obtained. Let $F = (f_{ij})_{n\times n}$ be the priority matrix, where f_{ij} represents the importance of factor i compared with factor j. Generally, the value of f_{ij} ranges from 0 to 1, where 0 means that factor j is absolutely more important than factor i, 0.5 means that both are equally important, and 1 means that factor i is absolutely more important than factor j.

In order to quantify the relative importance of each factor, it is necessary to transform the priority relation matrix into a fuzzy consistent matrix. The fuzzy consistent matrix $R = (r_{ij})_{n\times n}$ can be calculated by the following formula:

$$r_{ij} = \frac{r_i - r_j}{2n} + 0.5 \quad (1)$$

Where $r_i = \sum_{k=1}^{n} f_{ik}$ is the sum of rows in the priority relation matrix of factor i. The fuzzy consistent matrix satisfies the consistency condition, that is, if factor i is more important than factor j and factor j is more important than factor k, then factor i is also more important than factor k.

Hierarchical total ranking is to calculate the relative importance ranking of the lowest factors to the highest level (target level). This is done by synthesizing weights layer by layer. Suppose that the upper layer (layer A) contains m factors $A_1, A_2, \cdots, A_m$, whose weights are $A_1, A_2, \cdots, A_m$, and the lower layer (layer B) contains n factors $B_1, B_2, \cdots, B_n$, whose weights about A_j are $b_{1j}, b_{2j}, \cdots, b_{nj}$ (where $j = 1,2,\cdots,m$). Then the total weight of each factor of layer B to the target layer is:

$$Total\ weight(B_i) = \sum_{j=1}^{m} a_j \times b_{ij} \quad (2)$$

In the model, the integration strategy of teaching content, teaching methods and teaching resources is adjusted according to the weight of each factor [6]. For example, more resources and energy will be invested in the integration of teaching content with higher weight to ensure the systematicness and consistency of the content; For the factors with lower weight, the investment will be appropriately reduced on the premise of ensuring the basic needs. Through this modeling process, we can ensure that the knowledge resource integration model of university mathematics education is scientific and practical, and can effectively improve teaching efficiency and students' learning effect.

The data of this study mainly come from experts in the field of mathematics education, university teachers, students and textbooks. The research team should collect data through questionnaire surveys, interviews, and literature analysis to build a priority matrix, and then carry out the FAHP (Fuzzy Analytic Hierarchy Process). At the same time, the researchers should refer to relevant research and policy documents both at home and abroad to ensure the comprehensiveness and accuracy of the study.

3. Model application and case analysis

In this study, a university is selected as the specific research object, and the integration model constructed before is used for example analysis. The university is a comprehensive university, and its mathematics department has a relatively perfect curriculum system and rich teaching resources, but it also faces the problems of scattered knowledge resources and repeated teaching content. Therefore, this university is selected as the research object, aiming at optimizing the allocation of its mathematical education knowledge resources and improving teaching efficiency and students' learning quality by applying the integrated model. The research team should collect the data of related knowledge resources of mathematics education in this university, including the curriculum, the use of teaching materials, teaching methods, and the utilization of teaching resources. These data come from the school's academic affairs office, teachers' questionnaires, students' feedback and classroom observation records. After collecting the original data, the data is cleaned and preprocessed.

In order to realize the effective integration of knowledge resources in college mathematics education, a hierarchical structure model including target layer, criterion layer and scheme layer is constructed. At the target level, the purpose of integration is clarified. At the standard level, three key integration areas are identified: teaching content, teaching methods and teaching resources. Finally, specific integration measures are formulated at the scheme level, including reorganizing and adjusting the curriculum system to ensure consistency and integrity, promoting the mixed teaching mode combining online and offline advantages, and establishing a teaching resource sharing platform to promote the immediate acquisition and effective utilization of resources.

Five experts in the field of mathematics education were invited to compare the factors at the criterion level and the scheme level, and give their relative importance scores. Table 1 below is a priority matrix (part) constructed according to experts' scores:

Table 1 Criterion layer priority relation matrix

factor	Teaching content integration	Integration of teaching methods	Integration of teaching resources
Teaching content integration	0.5	0.7	0.6
Integration of teaching methods	0.3	0.5	0.4
Integration of teaching resources	0.4	0.6	0.5

Note: The values in the matrix are relative importance scores, ranging from 0 to 1, and the diagonal element is 0.5 (indicating that it is as important as itself).

The priority relation matrix is transformed into a fuzzy consistent matrix by formula (1). Taking the criterion layer as an example, the calculation process is as follows:

Sum of each row of the priority relation matrix of the criterion layer:

The first line: 0.5+0.7+0.6=1.8

The second line: 0.3+0.5+0.4=1.2

The third line: 0.4+0.6+0.5=1.5

Constructing fuzzy consistent matrix;

$$\begin{pmatrix} 0.5 & \frac{0.7}{1.8} & \frac{0.6}{1.8} \\ \frac{0.3}{1.2} & 0.5 & \frac{0.4}{1.2} \\ \frac{0.4}{1.5} & \frac{0.6}{1.5} & 0.5 \end{pmatrix} = \begin{pmatrix} 0.5 & 0.389 & 0.333 \\ 0.25 & 0.5 & 0.333 \\ 0.267 & 0.4 & 0.5 \end{pmatrix}$$

The fuzzy consistent matrix is normalized to get the weight of each factor. Take the criteria layer as an example:

Normalized weight:

Teaching content integration: $\frac{0.5+0.389+0.267}{3}=0.385$

Integration of teaching methods: $\frac{0.333+0.5+0.4}{3}=0.411$

Integration of teaching resources: $\frac{0.333+0.333+0.5}{3}=0.391$

There are three factors at the scheme level: A (optimization of curriculum system), B (promotion of mixed teaching mode) and C (construction of teaching resource sharing platform), which correspond to the three factors at the criterion level respectively. The weights of these three factors under their respective criteria layers are equal (that is, the weight of each factor is 1/3).

Let the weights of teaching content integration, teaching methods integration and teaching resources integration be $w_1=0.385$, $w_2=0.411$, $w_3=0.391$ respectively. As for the scheme level factor A (curriculum system optimization), it completely belongs to the category of teaching content integration, so its weight to the target level is:

$$w_A = w_1 \times \frac{1}{3} = 0.385 \times \frac{1}{3} = 0.128$$

Similarly, for the scheme level factors B (promotion of mixed teaching mode) and C (construction of teaching resource sharing platform):

$$w_B = w_2 \times \frac{1}{3} = 0.411 \times \frac{1}{3} = 0.137$$

$$w_C = w_3 \times \frac{1}{3} = 0.391 \times \frac{1}{3} = 0.130$$

According to the weight of each factor, the department of university mathematics can adjust its integration strategy. For example, because the integration of teaching methods has the highest weight (0.411), schools can give priority to investing resources, popularize the mixed teaching mode, and use modern educational technology to improve the teaching effect.

Regarding the instructional content, there is a need to concentrate on refining and modernizing the mathematics course structure. This can be achieved by eliminating redundant and obsolete material, and by incorporating key points that are relevant to contemporary mathematical advancements, thereby ensuring the curriculum's relevancy and applicability. To enhance educational outcomes, it is advisable to advocate for a blended learning approach, which merges the merits of both online and in-person instruction. Moreover, the integration of real-world examples and problem-solving exercises will foster students' practical skills and creative thinking. In the realm of educational resource consolidation, the creation of a collaborative platform for mathematical materials is paramount. This platform should amalgamate superior resources from within and beyond the academic institution and bolster ties with industrial partners and research bodies. Such collaborations would facilitate the introduction of more hands-on teaching tools and initiatives, subsequently enriching the student learning journey.

The practicability and effectiveness of the integrated model in college mathematics education are verified by case analysis. This model not only improves the teaching quality and efficiency, but also provides students with a richer and more systematic learning experience.

4. Conclusion

In this study, a knowledge resource integration model of college mathematics education is constructed by FAHP method, aiming at improving teaching efficiency and students' learning effect. The proposed framework encompasses a target layer, a criterion layer, and a strategy layer, each of which suggests detailed actions for the amalgamation of educational content, pedagogical approaches, and resource consolidation. Findings indicate that through the enhancement of the curricular structure, the promotion of a combined instructional method, and the development of a platform for the sharing of educational resources, there is a substantial integration potential for higher education mathematics materials. Furthermore, such initiatives can lead to improvements in the quality of instruction and in the overall student learning encounter. The example analysis verifies the practicability and effectiveness of the model, and provides scientific basis and method guidance for the reform of college mathematics education.

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