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The Exploration of the Interdisciplinary Education of Mathematics in Universities: A Case Study of Mathematics and Finance

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Abstract

Under the background of the deep integration of subjects in the contemporary education field, the teaching concept and practice mode of higher mathematics as a basic subject are undergoing profound changes. Based on the teaching scene of colleges and universities, this study systematically analyzes the interdisciplinary mathematics education from three aspects: strategic significance, realistic bottleneck and breakthrough path. Combined with the classic example of mathematics and finance, it is found that the cross-penetration of mathematics and other disciplines not only significantly improves the quality of students' innovative thinking, but also effectively activates the kinetic energy of the collaborative development of discipline groups. In view of the obstacles formed by the traditional teaching inertia, this paper puts forward a reform scheme with the core of "knowledge graph reconstruction - learning scene reconstruction - evaluation paradigm upgrade" : realize the cross-border integration of knowledge through the construction of modular course group, carry out immersive teaching practice with the help of virtual simulation platform, and establish a multi-dimensional ability-oriented dynamic evaluation system. These explorations provide an operational action framework for interdisciplinary integration in higher education, which has methodological significance for deepening teaching reform.

Keywords

Interdisciplinary Education, Curriculum Reform, Teaching Innovation, Advanced Mathematics, Finance

1. Introduction

Interdisciplinary education in university mathematics holds unique educational value and academic significance, demonstrating multi-dimensional and far-reaching impacts on talent cultivation and disciplinary development. This educational model not only breaks down the cognitive barriers of traditional disciplines but also builds a three-dimensional educational ecosystem through knowledge integration and innovative application. This training approach can cultivate versatile talents who can innovate in multiple academic fields and have diverse career opportunities.

In the dimension of innovative thinking training, mathematical finance education realizes the cognitive coupling between abstract model and concrete market. When stochastic analysis theory is applied to the pricing of financial derivatives, learners must deal with the rigor of mathematical axioms and the complexity of market anomalies simultaneously. Taking the dynamic hedging strategy design as an example, students need to map the ITO integral theory to the continuous-time financial framework, while parsing the market implied information of the volatility surface[1]. This doublethink training promotes students to establish the

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dialectical cognition of risk-neutral measure and real world probability, and cultivate the ability of compound thinking across mathematical logic and financial intuition.

In terms of the improvement of comprehensive quality, the cross education of mathematics and finance has built a multi-level ability training system. In the practice of fintech algorithm development, students need to integrate stochastic optimization theory, machine learning algorithm and regulatory technology requirements to complete the whole process of "model building-historical backtesting - compliance review" research and development. More importantly, in the interdisciplinary collaboration simulating high-frequency trading scenarios, students simultaneously hone core literacy such as quantitative modeling, regulatory communication and ethical evaluation through role division and knowledge integration.[2]

From the perspective of discipline development, the deep integration of mathematics and finance has given birth to a new academic growth pole. As a typical interdisciplinary discipline, financial mathematics perfectly interprets the interaction mechanism between basic theory and application practice: the breakthrough application of stochastic control theory in dynamic asset allocation not only expands the application boundary of mathematical tools, but also promotes the deepening of the theory of backward stochastic differential equations. This two-way enabling mechanism not only maintains the logical rigor of mathematics, but also gives it practical vitality to explain the complex financial system, forming a discipline ecology of continuous innovation.

The innovative significance of this educational model is more reflected in the transformation level of research paradigm. The cross study of mathematical finance builds a methodological bridge connecting abstract proofs and empirical tests. In systemic risk analysis, the creative application of graph theory and network flow model is reshaping the quantitative assessment paradigm of financial contagion effects. In the field of behavioral finance, the combination of nonlinear dynamic system and investor sentiment modeling has opened up a new path for the interpretation of market anomalies[3]. These practices not only verify the universal value of mathematical tools, but also promote the evolution of mathematical theory to a higher dimension through the feedback mechanism of financial markets.

At present, mathematical financial education is undergoing a paradigm transition from instrumental application to cognitive theory reconstruction. Through the establishment of a three-dimensional knowledge framework of "stochastic analysis-market microstructure - regulatory policy", this paper cultivates interdisciplinary talents who are proficient in quantitative modeling and financial essence[4]. This education mode not only redefines the coordinates of mathematics in the financial knowledge system, but also provides key intellectual support for coping with the complex challenges in the digital economy era through continuous theoretical innovation and practical feedback. The future development direction should focus on the cross integration of intelligent algorithms and compliance technology to build a more resilient interdisciplinary education ecosystem.

2. Multi-dimensional Value and Far-reaching Significance of Interdisciplinary Education in Mathematics in Universities

Interdisciplinary mathematics education demonstrates distinctive pedagogical merits in cultivating students' comprehensive competencies. Its significance extends beyond individual cognitive development to exert transformative impacts on disciplinary evolution at the

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systemic level[5]. This educational paradigm serves as a powerful catalyst for developing innovative cognition and complex problem-solving capacities. Conventional mathematics instruction, constrained by its inherent logical formalism, tends to produce circumscribed cognitive patterns[6]. In contrast, the cross-disciplinary application of mathematical knowledge necessitates epistemological boundary-crossing and multidimensional perspective-taking. When employing topological invariants to characterize protein folding in biophysics or applying stochastic differential equations to model financial market behaviors, learners must transcend disciplinary silos to achieve conceptual synthesis[7]. Such epistemic practices not only deconstruct subject-based cognitive constraints but also cultivate the ability to generate novel solutions through disciplinary hybridization. The pedagogical outcomes manifest as enhanced adaptive expertise and sustained innovation potential, as evidenced by a 32% improvement in divergent thinking test scores among participants of MIT's interdisciplinary math programs[8] .

Interdisciplinary mathematics education shows unique value in talent training and discipline innovation, which reconstructs the paradigm connotation of mathematics education through multi-dimensional knowledge integration. This paper takes the combination of finance and mathematics, which is currently popular, as an example, and the advantages of this education mode are particularly prominent.

At the level of cultivating innovative thinking, the interaction between mathematics and finance has broken the traditional cognitive boundary. The core problems of risk modeling and asset pricing in the financial system are essentially the combination of mathematical abstraction and market rules. When constructing stochastic differential equations to describe financial fluctuations, students should not only maintain the rigor of mathematical models, but also take into account the particularity of market behavior. Through the learning process of combining measurement theory with financial derivative pricing theory, learners gradually establish a systematic thinking framework that spans mathematical logic and financial practice.

In terms of the construction of comprehensive ability, the cross education of mathematics and finance has forged a unique compound knowledge structure. While mastering mathematical tools such as probability statistics and optimization theory, students must have a deep understanding of the operation mechanism and regulatory logic of financial markets. This dual knowledge reserve enables them to flexibly use mathematical tools to analyze the essential laws of financial phenomena when dealing with complex scenarios such as high-frequency trading algorithm optimization and portfolio risk management. More importantly, in the interdisciplinary collaboration of simulated financial engineering projects, students can simultaneously improve their professional dialogue ability and team coordination ability through the division of roles and knowledge integration.

From the perspective of interdisciplinary observation, the deep integration of mathematics and finance gives birth to an important growth pole of theoretical innovation. As a typical interdisciplinary discipline, financial mathematics perfectly interprets the interaction mechanism between basic mathematical tools and real economic needs: the breakthrough application of stochastic analysis theory in the pricing of financial derivatives not only expands the application dimension of mathematical methods, but also promotes the deepening research of probability theory, partial differential equation and other basic theories in reverse. This two-way empowerment between disciplines not only maintains the theoretical depth of

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mathematics, but also gives it new kinetic energy to explain complex economic phenomena, forming a unique academic innovation ecology.

The innovative significance of this educational model is more reflected in the breakthrough of methodology. The interdisciplinary research of mathematical finance has broken the traditional disciplinary barriers and built a bridge between quantitative analysis and economic interpretation. In the field of financial risk management, the creative application of extreme value theory and Copula function is reshaping the quantitative assessment paradigm of modern financial risk[9]. In asset pricing research, the coupling analysis of nonlinear dynamical systems and market microstructure has opened up new paths for understanding the price formation mechanism[10]. These practices not only verify the universal value of mathematical tools, but also promote the evolution of mathematical theory to a higher dimension through realistic feedback.

In general, the interdisciplinary integration of mathematics and finance not only cultivates interdisciplinary talents who can connect mathematical logic and financial practice, but also builds a model of collaborative innovation between basic disciplines and application fields. Through the three-dimensional reconstruction of the knowledge system, this education mode continues to release the unique value of mathematics in explaining complex systems and promoting social progress, and provides an important talent delivery for coping with the comprehensive challenges of modern society.[11, 12]

3. The Current Situation and Challenges of Interdisciplinary Mathematics Education in Universities

As a typical paradigm of the integration of arts and sciences, the cross education of mathematics and finance not only shows unique application value in the practice of higher education, but also faces deep integration dilemma. At present, although the major of financial mathematics has been widely set up in universities around the world, there are still systematic obstacles in the curriculum system, teacher structure, evaluation mechanism and other dimensions.

At the level of curriculum system construction, the knowledge integration of mathematics and finance often falls into the trap of "mechanical splicing". Most colleges and universities have a simple superposition phenomenon of "mathematics module + finance module" in the curriculum, for example, stochastic process course and corporate finance course are offered side by side, but the substantive relationship between mathematical model and financial decision-making is not established. This discrete course structure makes it difficult for students to combine the theoretical derivation of stochastic differential equations with the analysis of market microstructure when dealing with the optimization problems of high-frequency trading algorithms, which exposes the structural defects of knowledge transfer ability.

The professional fragmentation of the teaching staff is a key pain point in the field. Mathematics teachers generally lack the understanding of the pricing mechanism of financial derivatives, and often limit themselves to the solution of partial differential equations when teaching the Black-Scholes model, but ignore its dynamic application scenarios in risk management. Finance teachers, on the other hand, have cognitive blind spot for mathematical tools such as measure theory and functional analysis. This fault of knowledge structure directly leads to the separation of classroom teaching into "mathematical deduction - financial application".

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The lack of dimensions of the evaluation mechanism is particularly prominent. Traditional assessment methods are difficult to accurately evaluate students' interdisciplinary comprehensive ability: mathematics examination focuses on theorem proving and formula derivation, but cannot test the modeling ability of financial scenarios; Financial case studies emphasize economic interpretation and lack an assessment of the rigor of mathematical models. There was a typical phenomenon in the financial mathematics course of a university that students could skillfully deduce the Copula function but could not construct the credit risk correlation model, which reflected the structural misalignment between the evaluation system and the training objectives.

4. The Implementation Strategies of Interdisciplinary Mathematics Education in Universities

As an important education model in the era of quantitative economy, the cross-education of mathematics and finance needs to build a trinity reform system of "curriculum reconstruction, teaching innovation and evaluation transformation". The core contradiction in this field is that there is a methodological effective conclusion between the abstract formalization of mathematical tools and the concrete complexity of financial problems. Targeted solutions are proposed from three dimensions as follows.

4.1. Build a "Layer-penetrating" Curriculum System

At the level of modular curriculum design, it is necessary to break through the simple superposition mode of "mathematical theory + financial case" and establish the knowledge framework of two-way penetration. The first level sets up the "Foundation of Financial Mathematics Methodology" module, which deeply integrates abstract mathematical tools such as measure theory and stochastic analysis with financial problems such as derivatives pricing and risk management. For example, when teaching ITO integral, its dynamic hedging strategy design in option pricing is analyzed simultaneously to realize the simultaneous construction of mathematical derivation and financial logic. The second level creates the "Algorithmic Financial Practice" module, focusing on cutting-edge fields such as high-frequency trading and intelligent investment consulting, combining deep learning algorithms with market microstructure theory, and developing a progressive teaching unit of "mathematical modeling-data backtesting - strategy optimization". The third level builds an interdisciplinary module of "regulatory technology", integrating cryptography, game theory and financial regulatory policies, and guiding students to design a cross-border payment verification system based on zero-knowledge proof.

4.2. Innovate the Teaching Mode of "Virtual and Real Coexistence"

The "double scene" teaching reform is implemented, and the interactive mechanism between theoretical deduction and market simulation is established. In the theoretical teaching, the "concept mapping teaching method" is adopted: the concept of pause in martingale theory is mapped to the optimal investment decision problem, and the economic connotation of risk-neutral pricing is explained by the measure transformation theory. In the practical teaching end, a "digital twin financial laboratory" can be built to develop a virtual trading system including real historical events[13]. Students need to complete the following task combinations in the dynamic market: using Copula function to model tail risk correlation degree , designing asset allocation strategy based on stochastic optimization ,using reinforcement learning algorithm to realize adaptive adjustment of strategy. At the same time, quantitative trading algorithms written by students are required to pass regulatory assessments such as market impact test and liquidity stress test.

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4.3. Establish the "Three-dimensional Ability" Evaluation System

Design a three-dimensional evaluation framework including mathematical rigor, financial explanatory power and technological innovation[14]. In the basic layer, "Mathematical finance Case analysis" can be set, which requires students to reconstruct the Black-Scholes model in measure theory and demonstrate its explanatory limitations in the volatility smile phenomenon. To carry out the "algorithm strategy attack and defense drill", students need to design countermeasures based on game theory for the machine learning trading strategy of the counterparty, and the effectiveness of the actual combat is evaluated by quantitative fund practitioners. The innovation layer carries out "regulatory technology scheme design", requiring students to combine homomorphic encryption and smart contract technology to develop a real-time risk monitoring system in line with the requirements of Basel III, and accept the feasibility demonstration of the risk control department of commercial banks.[15]

In a word, through systematic educational reconstruction, the cross education of mathematics and finance can cultivate interdisciplinary talents who are proficient in both quantitative tools and the essence of finance, providing the core driving force for the innovation and development in the era of digital finance.

5. Conclusion

Interdisciplinary education in colleges and universities is an important way to cultivate innovative talents and promote the development of disciplines. Taking the combination of mathematics and finance as an example, this paper analyzes the pain points and puts forward some suggestions. In the future, colleges and universities should continue to explore new models and methods of interdisciplinary mathematics education, integrate specific mathematics with diversified disciplines, and develop mathematics education models suitable for colleges and universities. This will make a greater contribution to the training of interdisciplinary talents with interdisciplinary thinking and innovation ability, and to the promotion of the integration of disciplines and talent training.

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