Open Access Library Journal
2023, Volume 10, e11036
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Applying What Is Learned: The Application of Advanced Mathematics in Different Disciplines

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How to cite this paper: Wei, Z.S. (2023) Applying What Is Learned: The Application of Advanced Mathematics in Different Disciplines. *Open Access Library Journal*, **10**: e11036.
https://doi.org/10.4236/oalib.1111036

Received: November 24, 2023
Accepted: December 23, 2023
Published: December 26, 2023

Abstract

This paper explores various applications of advanced mathematics in fields such as economics, management, psychology, and other disciplines, as well as in everyday life and work through the literature review method. It reveals the close connection between advanced mathematics and other professions, deepening the understanding of the historical and practical background of advanced mathematics. The paper finds that only by choosing appropriate mathematical methods for different problems can problems be solved effectively. The application of mathematics permeates different fields, and this makes the teaching of advanced mathematics meaningful and valuable.

Subject Areas

Mathematics

Keywords

Advanced Mathematics, Mathematical Modelling, Applications

1. Introduction

When it comes to advanced mathematics, the first reaction of many students is often filled with various formulas on the blackboard and numerous computations in their minds. Definitions, theorems, and corollaries come one after another. Concepts such as limits, continuity, differentiability, and integrability encompass each other. The extensive content, high level of difficulty, and abstract nature are all characteristics of advanced mathematics. Moreover, the narrow application scope of examples or exercises in advanced mathematics textbooks, as well as the disconnection from professional knowledge, contributes to some students' insufficient understanding of the widespread applications of advanced mathematics. They may even consider learning mathematics useless, fear mathematics, or become tired of it.

In fact, advanced mathematics is an essential foundational course in universities and has a wide range of applications in various disciplines such as physics, chemistry, astronomy, biomedical science, aerospace engineering, engineering technology, and economics and management. For example, mathematical models are used in macroeconomics to study the dynamics of exchange rates and how they are affected by the fiscal and monetary policies of multiple countries. In addition, the application of mathematics in microeconomics is also very extensive, such as the maximization of consumer utility subject to the price of various goods and money income. It serves as not only an important tool for developing intellect and learning various specialized knowledge but also a crucial tool for scientific research. It can cultivate and enhance college students' logical thinking, problem-solving abilities, and scientific expression skills. These abilities are particularly important for students' learning in their major courses and for further expanding their knowledge and adjusting their knowledge structure in the future.

With the increasing cross-disciplinary knowledge integration and permeation, the application of mathematics in various fields has become crucial. This article aims to change the perspective that "mathematics is useless" by illustrating interdisciplinary modeling cases that involve advanced mathematics and other subjects.

2. The Role of Mathematical Modeling

Mathematical modeling is an effective way to train college students to apply advanced mathematics to solve practical problems. Mathematical modeling is based on a specific object in the real world, aiming at the internal rules of the specific object, making appropriate simplified assumptions, so as to facilitate the flexible use of mathematical tools at the same time, get the corresponding mathematical structure, in order to achieve the purpose of analyzing the problem to solve the problem (Tong, 2017) [1]. In the middle of the 20th century, with the increasingly extensive application of mathematical models and the successful solution of a large number of practical problems, its status in mathematics is constantly improving. The situation of proving theorems as the main goal of mathematical research in traditional mathematics has changed, and creating mathematical models has gradually become one of the important goals of mathematics(Hu, 2009) [2].

2.1. Mathematical Modeling Is Conducive to the Formation of Scientific Attitudes

A model with terse, graceful, rigorous and standard expression means the combination of scientific exploratory spirit, research means, mode of thinking and reasoning art. In the modeling process, researchers start from the actual part and use advanced mathematics such as calculus, algebra, and geometry to draw accurate and rigorous conclusions. Researchers can cultivate a scientific attitude of seeking truth and practicality through scientific thinking, serious exploration, and rigorous expression.

2.2. Mathematical Modeling Is Conducive to the Accumulation of Scientific Knowledge and Methods

Mathematical modeling requires researchers to have a solid basic mathematical foundation, in addition to learning and mastering many branches of mathematical knowledge, such as optimization, differential equation, analytic hierarchy process, structural equation model, mathematical statistics, analysis software SPSS, MPLUS basic knowledge and practical operation and so on; Building mathematical models also requires researchers to understand economics, management, demography, engineering, sociology and other aspects of knowledge according to the problems to be solved. Mathematical modeling requires researchers to make full use of library and network resources (CNKI database, Wanfang database, etc.), query and retrieve information and data related to the topic, and order and integrate the collected information to form a new knowledge network. Mathematical modeling also requires researchers to master the paper writing, such as the basic framework of the paper, writing steps, normative language, and hypothesis and verification process and so on. The entire process requires the application of multidisciplinary and interdisciplinary knowledge, which helps to accumulate scientific knowledge and methods.

2.3. Mathematical Modeling Is Conducive to the Cultivation of Practical Ability

Mathematical model is based on mathematical symbols, formulas and quantitative relations, the description and reflection of the real prototype problem. In the field of engineering technology, economic management, social life and other practical problems, simply relying on the description of words to reason, cannot guarantee the scientific, normative and correct research. Therefore, taking advanced mathematics as the basic analytical tool becomes one of the most important tools in the research. It has become an important method and means to use mathematical model to express the logical relationship between variables and rules, and to use mathematical language to express the hypothesis and deduce and verify the relationship between environment, individual and organization behavior. Integrating the idea of mathematical modeling into related disciplines, learning knowledge in application, and promoting the coordinated development of knowledge level and practical ability will play a great role in promoting the training of talents.

3. Application of Advanced Mathematics in Different Fields

3.1. Application in Economics

By using the step-up regression method proposed by Baronand Kenny (1986) [3] and the mediation effect test model proposed by Wen Zhonglin and Ye Baojuan

(2014) [4], the following mediation effect test model can be constructed:

$$Y = \varphi_1 + \theta_1 X + \epsilon_1 \quad (1)$$

$$M = \varphi_2 + \theta_2 X + \varepsilon_2 \quad (2)$$

$$Y = \varphi_3 + \theta_3 X + \theta_4 M + \varepsilon_3 \quad (3)$$

In the above equation, X is the independent variable, M is the mediating variable, Y is the dependent variable, φ represents the intercept, ε represents the error term of the model, and θ represent the regression coefficient. Mfunctions as a mediator when it meets the following conditions: 1) If the regression coefficient θ_1 is significant, it can be shown that there is a linear relationship between the independent variable (X) and the dependent variable (Y); 2) If the regression coefficient θ_2 is significant, it can be shown that there is a linear relationship between the independent variable (X) and the mediating variable (M); 3) If θ_4 in Equation (3) is significant, and θ_3 is significantly smaller than θ_1, indicating that the mediating variable (M) helps to predict the dependent variable (Y). If θ_2 or θ_4 is not significant (or neither), then the effect between X and Y is not mediated by M.

If Y stands for employment, X stands for physical appearance, and M stands for employment quality, Using data from the Chinese Family Panel Studies (CFPS) data, *M.* WANG and LU (2018) find that people's physical appearance has a significant positive effect on the employment of both men ($\theta_1 = 0.0270, p < 0.01$) and women ($\theta_1 = 0.0160, p < 0.05$),which is still valid after the estimation of instrumental variables. After that, researchers add the variable of "employment quality" into the employment equation to investigate whether "employment quality" plays a mediating role. In the male sample, the results show that "employment quality", as the intermediate variable, is significant ($\theta_4 = 0.0070, p < 0.01$). In contrast, for women, "employment quality" is not significant ($\theta_4 = 0.0010, p > 0.1$). This means good—look man have better employment quality, thus increasing their employment opportunities, while this mechanism do not apply to women. It can be seen, laborer's appearance has become an important factor in China's employment market, and appearance—based discrimination should also be concerned (M. WANG & LU, 2018) [5].

3.2. Application in Enterprise Management

In the field of enterprise management, a model can be built as follows:

$$\text{ROA} = \alpha_0 + \alpha_1\text{Lnpay} + \alpha_2\text{Lnpay} \times \text{PIT} + \alpha_3\text{PIT} + \alpha_4\text{Controls} + \varepsilon$$

Among them, ROA measures the output of the enterprise, Lnpay measures the average salary level of the enterprise employees, PIT measures corporate payroll tax planning, and Controls are a set of control variables. The expectation coefficient α_1 is significantly positive, indicating that salary has an incentive effect on enterprise output; the expected coefficient α_2 is significantly positive, indicating that enterprise payroll income tax planning has a promoting effect on the stimulating effect of salary on enterprise output. This model can be used to investigate the influence of firms' payroll tax planning on the incentive effect of compensation. Using A-share listed companies in Shanghai and Shenzhen stock exchanges from 2007 to 2013 as the original samples, X. Wang, Shi, and He (2016) [6] find that α_2 is significantly positive after importing relevant data, which indicates that payroll income tax planning has a promoting effect on employee compensation incentive. In other words, the tax planning behavior of enterprise payroll income tax can help employees pay less payroll income tax and increase the amount of after-tax salary of employees, which is conducive to stimulating the enthusiasm of employees. At the same time, it also shows that the payroll income tax planning behavior has an indirect effect on the company to promote the compensation performance effect. When this effect is greater than the tax planning cost, the enterprise will have the motivation to carry out the tax planning of the payroll income tax. The study has implications for payroll income tax and tax planning practice (X. Wang *et al.*, 2016) [6].

3.3. Application in Psychology

To provide evidence for a U-shaped relationship, researchers commonly regress the dependent variable Y on the independent variable X and its square:

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2$$

Including the first-order X in the regression equation is essential (Aiken and West, 1991), as leaving it out is tantamount to assuming that the turning point is at $X = 0$ — a very strong assumption to make, a priori. A significant and negative indicates an inverted U-shaped relationship and a significant and positive β_2 a U-shaped relationship (Haans, Pieters, & He, 2016) [7].

In the field of psychology, a model can be built as follows:

$$\text{CSR}_{i,t+1} = \beta_0 + \beta_1 Narcissism_{i,t} + \beta_2 Narcissism_{i,t}^2 + \beta_n X_{i,t} + \tau_t + \mu_i + \epsilon_{i,t}$$

where i denotes firms and t stands for year. CSR is a firm's overall net social performance. *Narcissism* signifies a CEO's narcissistic score, which is company and time variant but CEO invariant. X contains all other control variables, including the moderator variable, CEO power. τ controls for time fixed effects, which vary with time but are common to all firms. μ captures all firm-fixed unobserved heterogeneous factors that do not change over time. β and ϵ represent the coefficient and error terms, respectively. If a negative and statistically significant β_2 is predicted, indicating there is an inverted U-shaped relationship between CEO narcissism and CSR such that narcissism is positively related to CSR up to a point, after which the relationship becomes negative.

Based on an analysis of Fortune 500 firms from 2006 to 2013, Al-Shammari, Rasheed, and Banerjee (2022) [8] find evidence supporting an inverted U-shaped relationship between CEO narcissism and corporate social responsibility (CSR) ($\beta_2 = -1.628, p < 0.01$). This means, increases in CEO narcissism results in increased CSR up to a certain point beyond which further increases in CEO narcissismled to declines in CSR. The findings suggest that the assumption of a linear relationship between CEO narcissism and CSR may only hold within a limited range of narcissism levels. At extremely high levels of CEO narcissism, it becomes necessary to reconsider the nature of the relationship. While CEOs with lower narcissistic tendencies may focus on both market and non-market strategies, highly narcissistic CEOs may shift their focus towards attention-grabbing and riskier actions that would attract more media attention, rather than engaging in CSR activities, which are unlikely to receive the same level of visibility (Al-Shammari *et al.*, 2022) [8].

3.4. Application in Medical Research

Modern medicine is moving from qualitative research to quantitative research, towards a direction that is quantitative, precise, computable, predictable, and controllable. Achieving these goals requires the utilization of mathematical theories to explore the quantitative regularities. For example, the text describes a mathematical model for the spread of a certain infectious disease in a specific region. The population is divided into three categories: susceptible individuals, denoted by $S(t)$, who are not yet infected but are at risk of being infected at time t; infected individuals, denoted by $I(t)$, who are already infected and capable of spreading the disease at time t; and removed individuals, denoted by $R(t)$, who have either recovered from the disease or have died due to it at time t.

Assuming that the total population in the studied region is constant, the rate of change of susceptible individuals over time is proportional to the product of the current number of susceptible individuals and the current number of infected individuals. Additionally, the rate of transition from infected individuals to removed individuals is proportional to the number of infected individuals. In this case, the mathematical model for the infectious disease can be expressed as:

$$S'(t) = -\beta SI \tag{4}$$

$$I'(t) = \beta SI - \frac{1}{\tau} I \tag{5}$$

$$R'(t) = \frac{1}{\tau} I \tag{6}$$

From the model, it can be deduced that when $\beta\tau S_0 > 1$ (where $S_0 = S(0)$ represents the initial number of susceptible individuals), the disease will spread. When $\beta\tau S_0 < 1$, the disease will not spread, and the number of infected individuals, $I(t)$, will monotonically decrease and eventually approach zero (Kermack & Mckendrick, 1927) [9].

Mathematical models, such as the one described, have been successfully used in predicting the course of infectious diseases, including the outbreak of SARS. By fitting the model to available data and estimating parameters such as the transmission rate, researchers can make predictions about the number of infections, the timing of the peak of the outbreak, and the approximate duration of the epidemic. These predictions can help public health officials and policymakers make informed decisions about implementing control measures and allocating resources to mitigate the impact of the disease. This is indeed a successful application of mathematical methods in medical research.

4. Conclusions

Advanced mathematics has numerous applications in various fields. Advanced mathematics plays a crucial role in engineering. It is used to establish and solve mathematical models for various engineering problems, such as structural mechanics, electrical engineering, and control systems. Concepts from calculus, linear algebra, and differential equations are widely applied in engineering design and analysis. Advanced mathematics plays a fundamental role in computer science. Concepts from discrete mathematics and algorithm design form the foundation of computer science. Advanced mathematics is extensively used in flight mechanics. Mathematical techniques such as calculus, linear algebra, and differential equations are employed to establish flight dynamics models and analyze the motion and stability of aircraft and spacecraft. These models can be used to predict the performance of vehicles, design control systems, and optimize flight trajectories.

It is evident that mathematics is closely related to everyday work and life, and it is highly practical and challenging. Mathematical models reveal the source of mathematics (where it comes from) and demonstrate the application scenarios of mathematics (where it is heading), enabling a close connection between mathematical theory and practice. Einstein once said that love is the best teacher. It is hoped that every college student, on the basis of fully understanding the universality and importance of the application of higher mathematics, can love advanced mathematics, can learn advanced mathematics well, can summarize practical problems into mathematical problems, and then solve problems, so that mathematics can truly become a weapon in our study.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Tong, M.L. (2017) The Integration of Mathematical Modeling and Mathematical Experiment in the Teaching Reform of Higher Mathematics. *Intelligent City*, **3**, 177.

[2] Hu, C. (2009) The New American Mathematics Educational Thoughts in Benchmarks for Science Literacy. *Journal of Educational Science of Hunan Normal University*, **8**, 74-77.

[3] Baron, R.M. and Kenny, D. (1986) The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal of Personality and Social Psychology*, **51**, 1173-1182. https://doi.org/10.1037/0022-3514.51.6.1173

[4] Wen, Z.L. and Ye, B.J. (2014) Analyses of Mediating Effects: The Development of Methods and Models. *Advances in Psychological Science*, **22**, 731-745. https://doi.org/10.3724/SP.J.1042.2014.00731

[5] Wang, M. and Lu, E. (2018) Does Physical Appearance Affect Employment?—A Study Based on China Family Panel Studies. *China Economic Studies*, No. 5, 111-124.

[6] Wang, X., Shi, Z. and He, J. (2016) Enterprise Salary Income Tax Planning and Employee Salary Incentive Effect. *Management World*, No. 7, 137-153.

[7] Haans, R.F.J., Pieters, C. and He, Z.L. (2016) Thinking about U: Theorizing and Testing U- and Inverted U-Shaped Relationships in Strategy Research. *Strategic Management Journal*, **37**, 1177-1195. https://doi.org/10.1002/smj.2399

[8] Al-Shammari, M., Rasheed, A.A. and Banerjee, S.N. (2022) Are All Narcissistic CEOs Socially Responsible? An Empirical Investigation of an Inverted U-Shaped Relationship between CEO Narcissism and Corporate Social Responsibility. *Group & Organization Management*, **47**, 612-646. https://doi.org/10.1177/10596011211040665

[9] Kermack, W.O. and Mckendrick, A.G. (1927) A Contribution to the Mathematical Theory of Epidemics. *Proceedings of the Royal Society of London Series A*, **115**, 700-721.