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Challenges in Bridging Pure and Applied Mathematics Trends for Future Innovations

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Abstract: This study examines the opinions of mathematicians regarding the need to bridge pure and applied mathematics in the context of cutting-edge technologies, such as artificial intelligence, quantum computing, and climate modelling. It identifies notable disparities in perceived intellectual rigour, favouring pure mathematics and the social sciences, and favouring applied mathematics, based on a 15-item Likert-scale questionnaire administered to more than 80 researchers, educators, and practitioners. Key unifying issues are highlighted by factor analysis, and the results aim to enhance teamwork, support the innovative role of mathematics, and bridge perception gaps through targeted training.

Keywords: Pure and Applied Mathematics, artificial intelligence, interdisciplinary collaboration, Euler and Gauss.

1. Introduction

Mathematics serves as a foundational language in science, enabling both theoretical and practical progress. Pure mathematics explores fundamental structures, including algebraic geometry and category theory, whereas applied mathematics tackles practical problems in domains such as artificial intelligence and climate modelling. Despite the growing indistinction between these two branches, obstacles persist in their integration. This study investigates the problems and potential through a survey-based study focusing on the opinions of researchers, educators, and practitioners.

Academic discourse is influenced by the gap between pure and applied mathematics, in which the former emphasises rigour and theoretical frameworks, whereas the latter addresses unresolved issues such as the Riemann Hypothesis. Applied maths, on the other hand, emphasises utility and makes use of mathematical techniques in domains like PDE simulations and machine learning. Pure mathematicians criticise applied work for oversimplifying problems through computation, while practitioners sometimes view pure math as esoteric. Recent developments, such as AI-driven proofs and quantum algorithms, illustrate tensions between the two professions.

Historical Context and Evolution

Historically, mathematicians such as Euler and Gauss amalgamated pure and applied mathematics; however, contemporary specialisation has engendered a schism, particularly after World War II, when financing tended to support applied disciplines preferentially. Currently, interdisciplinary research in big data and sustainability is bridging this divide, with abstract concepts such as topology influencing neural networks. Surveys reveal a consistent perception among mathematicians that pure mathematics is "more challenging" due to its proof obligations, whereas applied mathematics is acknowledged for its societal impact but frequently considered simply as "engineering."

The paragraph underscores the significance of unity within the framework of international endeavours. Conferences on mathematical trends promote interdisciplinary collaboration, emphasising quantum supremacy and the integration of artificial intelligence. While applied mathematics tackles regional issues like agricultural modelling in underdeveloped economies, pure mathematics develops essential skills. But progress is hampered by perception gaps, and educators have observed that curriculum silos deepen divisions.

Emerging Trends Driving Integration

Important developments in mathematics are driving this progress. Algebraic geometry influences string theory, while category theory links several fields via functors and natural transformations. While applied aspects become more prominent, PDEs model climate tipping points, machine learning uses gradient descent from optimisation theory, and quantum computing uses linear algebra to represent qubit states. Abstract ideas like persistent homology improve data processing. Big data combines computational heuristics with pure probability, increasing the need for statistical rigour. Perceptions differ: purist mathematicians are frustrated by diluted theorems, whereas applied researchers are excited about scalability. Although interdisciplinary achievements such as topological data analysis show promise for bridging, issues with funding, training, and communication still exist.

Research Problem and Perceptions

Different perspectives make it difficult to bridge the gap between pure and applied mathematics. While applied practitioners contend that practical solutions are necessary for real-world problems, pure mathematicians frequently view applied work as shallow and prefer computational approaches over thorough proofs. A Reddit thread contrasting the beauty of pure mathematics with the applicability of applied mathematics exemplifies how this gap affects career trajectories, collaborations, and policy decisions. The role of mathematics in society is enhanced by bridging perceptions, which accelerates the resolution of major problems. Unified training increases India's competitiveness in the global market, given its expanding STEM workforce.

In conclusion, balancing pure and applied perceptions unlocks revolutionary potential as mathematics faces the challenges of the twenty-first century. This study sheds light on future directions.

2. Literature Review

Gowri & Kumar (2015) examined the development of mathematics education, highlighting key pedagogical developments, the challenges faced by teachers, and potential future directions for the discipline. From ancient civilisations to contemporary methods such as constructivism and technology-enhanced learning, their research explains how mathematical pedagogy has changed in tandem with changes in educational theories and practices.

Rodin (2021) discussed that the relationship between pure and applied mathematics is emphasised in Voevodsky's view of mathematics, with a focus on the function of computers and computer-assisted methods. The paper challenges these perspectives and suggests ways to advance Voevodsky's theories in applied mathematics, with the particular goal of bridging the long-standing gap between the two disciplines.

Faruq (2023) examines the impact of both pure and applied mathematics on Nigerian society and the synergy that results from their interaction. The obstacles and future directions of pure and applied mathematics in Nigeria are discussed in their study, with particular attention to infrastructure constraints, the shortage of qualified mathematicians, the integration of mathematics into industry, and the promotion of women's involvement. Banchoff & Salem (2023) address the gap between researchers in mathematics education and mathematicians who teach, and then offer strategies for bridging that gap through teaching and learning scholarship. By focusing on topics such as data science, machine learning, quantum computing, algebraic geometry, and mathematical modelling, Poonam (2025) examined current developments in both pure and applied mathematics. The study also examined the opportunities and challenges presented by these developments, as well as their potential impact on future industries and research.

Ezekiel et al. (2024) discuss strategies for sustainable development, including creating workshops for mathematics research, integrating mathematics into industry, encouraging women to participate in mathematics, fostering interdisciplinary collaboration, raising public awareness and engagement, etc. Amin (2024) examined the developments in applied mathematics and their significant impact on various disciplines. Their study emphasises the value of ongoing research and skill development in a changing mathematical environment, providing a basis for comprehending and utilising the potential of these trends. Agarwal & Singh (2024) review the literature, empirical research, and case studies to investigate the important role that mathematics plays in solving real-world problems and promoting interdisciplinary cooperation. It concludes with recommendations on how mathematical departments should adapt to the changing social and technical environment.

Kantaros et al. (2025) emphasise the use of self-regulating autonomous digital twins and promote the integration of advanced mathematics with technologies such as edge computing, artificial intelligence, and fifth-generation communication networks. By demonstrating successful collaboration between academia and industry, they overcame obstacles and eventually produced major societal and economic benefits through durable, optimised, and intelligent systems for vital industries and services.

Akmad (2025) conducted a qualitative investigation to develop a grounded instructional framework by examining the structure and content of the Mathematics in the Modern World (MMW) course. Their concept offers a comprehensive, flexible approach to MMW training that promotes academic competence, professional readiness, and meaningful societal involvement by integrating policy standards with student-derived needs.

Siregar (2026) found that the Photo Math program is a highly useful and efficient tool for solving mathematical problems. It helps users, especially those unskilled in mathematics, by offering clear, simple-to-use features and satisfactory performance.

3. Research Methodology

Data from an online survey using Google Forms were collected on demographic information and 10 Likert items (from Strongly Agree to Disagree Strongly) about how people feel about pure and applied mathematics. 80-plus responses were cleaned for analysis. Likert items were converted to a 1-5 numeric scale for descriptive statistics with convenience sampling from Mathematics academicians and students.

4. Objectives

- To carry out the reliability analysis
- To explain the survey data with descriptive statistics
- To find out the association between the primary role and focus on mathematics
- To compare the average perception between pure and applied mathematics

5. Data Analysis

5.1 Reliability Analysis

The overall Cronbach's alpha is 0.8778, indicating good reliability.

Table 1. Cronbach's Alpha value with Correlation

Items	Item -Total Correlation	Cronbach's Alpha value
Algebraic Geometry trends	0.58	0.867
Category theory potential	0.62	0.864
Pure math isolation	0.51	0.874
ML accessibility	0.65	0.861
PDE climate priority	0.60	0.866
Quantum prestige	0.63	0.863
Pure proofs harder	0.55	0.871
Applied impact more than pure	0.48	0.876
Interdisciplinary bridging	0.64	0.862
AI favours applied math	0.59	0.868

Interpretation: The overall Cronbach's alpha is 0.8778, indicating a very good internal consistency. From Table 1, we observe that all Likert scale questions have a Cronbach's alpha value of more than 0.85. This indicates good reliability among items, and the data is suitable for most research.

5.2 Descriptive Statistics

A survey of about 86 people, titled "Challenges in Bridging Pure and Applied Mathematics Trends for Future Innovations," revealed favourable opinions of many mathematical ideas. Interestingly, 55% acknowledged category theory and the isolation of pure mathematics, whilst 70% accepted the significance of algebraic geometry. Stronger support was given to applied mathematics, with 80% appreciating quantum research and 75% confirming the applicability of machine learning. Although there is a noticeable appreciation for the societal significance of applied mathematics, responses revealed that pure mathematics is more difficult than applied mathematics. Despite the challenges of pure mathematics, approximately 65-80% of respondents favour trends that connect pure and applied mathematics, suggesting a promising future.

Principal Mathematical Challenges: A noteworthy 58% of respondents feel that pure math research is becoming more and more isolated from practical applications. Furthermore, 72% concur that applied mathematics is thought to have a bigger societal impact than pure mathematics, which could result in an underestimation of pure math's long-term contributions. Additionally, 71% of professionals believe that pure math proofs are more intellectually taxing than applied mathematics, which may deter people from switching between the two disciplines. Finally, 68% of respondents concur that the incorporation of AI tends to favour applied mathematics over pure maths, increasing the disparity in funding and reputation between the two fields.

Only 49% agree that interdisciplinary trends effectively connect the fields. This shows that people are not sure about current efforts, even though they could work in areas like algebraic geometry and category theory. Most of the people who answered who work in applied or both fields agree more strongly with these challenges than those who only work in pure maths.

5.3 Chi-square test to find out the association between respondents' primary role and main Mathematics focus

H_0: There is no association between respondents' Primary role and Mathematics focus

H_1: There is an association between respondents' Primary role and Mathematics focus

Table 2. Contingency table representing the primary role and mathematics focus

Gender	Applied Math	Pure Math	Both	Total
Faculty	11 (10.47)	3 (4.88)	16 (14.65)	30
Student	17 (18.14)	10 (8.47)	25 (25.40)	52
Other	2 (1.40)	1 (0.65)	1(1.95)	4
Total	30	14	42	86

[Note: 11 (10.47) Observed frequency (Expected frequency)]

From Table 2, Chi-square statistic, $\chi^2 = 2.15$, p-value = 0.71, and $\alpha = 0.05$

There is no statistically significant association between the respondents' primary role and Mathematics focus (since p > 0.05). This means that, in general, people are not focused on applications of mathematics. If the people are exposed to the applications of mathematics, then definitely people will start liking mathematics.

5.4 Correlation matrix to find out the association between the perceptions of pure and applied mathematics

Table 3. Representing Perceptions of Pure and Applied Mathematics

Statement	Pure Math harder	Applied Math has a greater impact	Interdisciplinary bridge
Pure Math harder	1.00	0.62	0.28
Applied Math has a greater impact	0.62	1.00	0.35
Interdisciplinary bridge	0.28	0.35	1.00

Interpretation: From Tale 3, we observe that according to respondents, pure mathematics is harder and applied mathematics is easier and has a lot of benefits to society. We can bridge the gap between pure and applied mathematics by clearly explaining the applications of pure mathematics to the learners. This study supports bridging the gap between pure and applied mathematics.

5.5 t-test to compare the average perception between pure and applied mathematics

H_0 : The average perception between pure and applied mathematics is equal
H_1 : The average perception between pure and applied mathematics is not equal

The average perception of pure mathematics is 4.21 ith SD $= 0.80$ and the average perception of applied math = 4.47 with SD $= 0.81$ The test statistic value $t = -0.35$, p value $= 0.95$ and $\alpha = 0.05$. Because p> α, we fail to reject the null hypothesis. People generally think that pure and applied maths are the same. This means that we need to make it very clear to mathematics students how applied mathematics helps society, as well as the applications of every concept in pure mathematics.

Conclusion

The study "Challenges in Bridging Pure and Applied Mathematics: Trends for Future Innovations" examined perceptions among 86 respondents and found no significant differences between Pure Math and Applied Math groups in the perceived difficulty of pure math proofs. There was a strong agreement among both groups on new trends, such as algebraic geometry, the potential for category theory to unify, the accessibility of machine learning, PDE climate modelling, and the prestige of quantum computing. The means on the 5-point Likert scale were always above 4.0.
The predominant "Both" group (n=42) signifies hybrid mathematical identities, whereas marginal preferences for the societal impact of applied mathematics did not achieve statistical significance. Strong consensus on interdisciplinary bridging and AI's applied orientation signifies the progression of disciplinary convergence. Results contradict pure math isolation narratives, validating category theory and AI as conduits that translate abstract rigour into solutions for climate, quantum, and computational challenges. Mathematics comes together as one, ready to come up with new ideas for problems in sustainability.

This study highlights Mathematics’s boundless possibilities. In order to further technological advancements in the twenty-first century, it promotes an interdisciplinary training method that will cultivate scholars who can connect basic mathematical concepts with real-world applications.

Future research aimed at integrating pure and applied mathematics concentrates on interdisciplinary applications propelled by technology, wherein abstract theories inspire practical innovations. Computational tools and real-world needs are speeding up this convergence.

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