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The Role of Mathematics Education in Advancing Interdisciplinary Learning: Evidence from Mathematical Modeling in Universities

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Abstract: *Mathematics education remains a cornerstone of higher education, providing the analytical tools needed across diverse fields. Yet, many students in economics, engineering, and data science struggle to see its relevance, often viewing mathematics as abstract and disconnected from their disciplinary work. One approach that has gained attention is mathematical modeling, where real-world problems are expressed and explored through mathematical representations. This study investigates how university students perceive mathematical modeling as a bridge between mathematics education and interdisciplinary learning. The Population (N = 1,000) consisted of all students (undergraduate and postgraduate, full-time and part-time) registered in the Engineering, Economics and Data Science departments at the three public universities in Nigeria during the study period. A survey of 250 students was conducted to capture perceptions across three dimensions: usefulness, relevance, and attitude. Data were analyzed using descriptive statistics and ANOVA to identify differences in how modeling was valued across contexts. Findings provide insights into how mathematics education can be reframed to foster interdisciplinary engagement, with implications for curriculum design in tertiary institutions.*

Keywords: *Mathematics education. interdisciplinary learning, Mathematical modeling, tertiary education, Students' and Teacher's perceptions,*

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Introduction

Mathematics education continues to serve as a cornerstone of higher education, equipping students with the analytical skills needed to navigate diverse disciplines. Fields such as economics, engineering, and data science rely heavily on mathematical reasoning to analyze data, test systems, and solve real-world problems. Despite this central role, many university students still perceive mathematics as abstract and disconnected from their everyday disciplinary work (Giannoulas & Stampoltzis, 2021; Opstad, 2021). When students hold this view, they often struggle to stay motivated and face difficulties in applying mathematical ideas beyond the classroom... Universities today are increasingly called upon to prepare students for a world where the most pressing problems—such as climate change, digital transformation, and global health—cannot be solved from a single disciplinary perspective. This has placed interdisciplinary learning at the center of higher education reforms.

Interdisciplinary learning brings together knowledge and methods from different fields to address complex problems. According to the author, **Interdisciplinary learning** is a teaching approach where ideas and methods from different subjects are purposefully connected to help learners see knowledge as a unified whole and apply it to real-life situations. In universities, this often means that students use mathematics not as an isolated subject but as a tool for understanding issues in their own disciplines. Jones (2020) notes that such learning helps students develop flexible thinking and the capacity to apply knowledge across contexts. Similarly, Spelt et al. (2021) emphasize that interdisciplinary approaches prepare graduates for real-world challenges, where solutions often require the blending of technical, social, and analytical perspectives.

For economics, engineering, and data science students, mathematics provides a common language for problem-solving. Holmes and Hwang (2022) argue that when mathematical ideas are connected to disciplinary practices, students are more likely to value them and use them effectively. The OECD (2021) frames this as part of *mathematical literacy*—the ability to apply mathematics in diverse situations. This view supports the idea that interdisciplinary learning is not optional but necessary in higher education.

Recent research has also highlighted the importance of interdisciplinary learning in higher education, where students are encouraged to make connections across fields rather than learn in isolation (Zhu & Leung, 2022). Interdisciplinary approaches prepare graduates for complex challenges in professional practice, where problems rarely fit neatly within a single discipline. Mathematical modeling, when framed as part of mathematics education, provides a bridge to this kind of learning by allowing students to see the relevance of mathematical thinking across different domains. Thus, positioning modeling within university curricula not only strengthens mathematics education but also fosters broader interdisciplinary engagement that is vital for 21st-century learning (English, 2023).

Within this context, mathematics Education occupies a unique position. It is not only a subject to be studied but also a language that underpins reasoning in economics, engineering, and data science. Despite this central role, students often perceive mathematics as abstract and disconnected from their disciplinary realities (Ilieva & Stoyanova, 2021). When students cannot clearly see how mathematical concepts transfer into their chosen fields, their motivation and engagement tend to decline. This disconnect highlights the need for approaches that present mathematics as a practical, context-driven tool rather than an isolated academic exercise. Within mathematics education, mathematical modeling has emerged as a promising approach to address this challenge.

Mathematical modeling is widely seen as a bridge between mathematics and the real world. The process involves translating a real problem into mathematical form, analyzing it, and then interpreting the results. Blum and Borromeo Ferri (2021) describe modeling as a cycle in which students move back and forth between the context of the problem and the mathematical representation. Modeling involves formulating real-world problems in mathematical terms, analyzing them, and interpreting the outcomes in context (Stillman et al., 2020). From the author's view, Modeling is the act of creating simplified representations of real situations to explain, explore, or solve problems. Anchoring it in mathematics, the author defines Mathematical modelling is the process of using mathematical ideas and symbols to represent real-life situations in order to understand them better and find practical solutions. By engaging students in this process, mathematics is no longer confined to formulas but becomes a practical tool for inquiry and decision-making. For example, economics students can apply modeling to study consumer demand, engineering students can test the strength of materials, and data science students can build predictive algorithms. In this way, modeling supports a shift from abstract learning toward applied, meaningful problem-solving (Blum & Borromeo Ferri, 2021). This modeling as a cycle strengthens understanding and highlights the usefulness of mathematics beyond the classroom.

Recent studies show that modeling supports deep learning by encouraging students to think critically and creatively (Stillman et al., 2020). In engineering, modeling allows students to test designs before implementation. In economics, it helps analyze market systems. In data science, it forms the basis for predictive algorithms. Across these fields, modeling is not only a learning activity but also a professional practice, making it an effective tool for interdisciplinary education (Kaiser, 2020). Despite these advantages, research shows that many university curricula still treat modeling as an optional or secondary activity. English (2021) points out that while modeling is well studied in secondary education, less is known about how it is integrated at the tertiary level, especially outside mathematics departments. This highlights the need to explore how students in other disciplines perceive modeling and its role in their studies.

Students' perceptions strongly shape how they engage with mathematics. If they see it as abstract and irrelevant, they may resist using it in their disciplines (Ilieva & Stoyanova, 2021). On the other hand, when students view mathematics as useful, they are more motivated and confident in applying it (Chen & Zhang, 2022). Studies focusing on modeling have found that students appreciate its role in making mathematics more meaningful. Blum and Leiß (2020) reported that modeling tasks help students connect classroom learning to authentic problems, which improves both understanding and engagement. However, research also shows differences across disciplines. For instance, engineering students often report higher appreciation for modeling than economics students, possibly because engineering curricula integrate more applied problem-solving (Stillman et al., 2020).

There is still limited research on the perceptions of students in data science, a relatively new and rapidly growing field. Since data science relies heavily on mathematical and statistical modeling, it is important to examine whether students in this area recognize the value of mathematics in their training. Gathering this information will help universities design courses that strengthen both mathematical literacy and disciplinary expertise. The degree to which students gain from interdisciplinary approaches largely depends on their teachers, who act as the link between the curriculum, teaching methods, and classroom practice.

Teachers' conceptions of mathematics strongly influence how they approach modeling in their classrooms. Teachers who see mathematics primarily as a means of exploring and solving real problems are more inclined to use modeling tasks that connect theory with practical applications (Blum & Borromeo Ferri, 2021; English, 2023). In contrast, those who prioritize formal proof and procedural mastery sometimes resist open-ended tasks, which they view as difficult to manage or evaluate fairly (Stillman et al., 2020). Disciplinary traditions also shape perspectives. Engineering instructors frequently integrate modeling, since design and simulation are central to their field (Giannoulas & Stampoltzis, 2021; Holmes & Hwang, 2022). Economics teachers often express support for modeling but find themselves constrained by large class sizes, content-heavy curricula, and assessment systems that privilege formal exposition (Opstad, 2021). In emerging areas such as data science, teachers typically welcome modeling but place greater emphasis on computational implementation than on the mathematical reasoning behind models (Chen & Zhang, 2022).

When teachers do bring modeling into their courses, they often rely on project-based learning, collaborative problem solving, or scaffolded cycles of inquiry (Stillman et al., 2020; Barquero & Ferrando, 2024). High-quality practice involves guiding students through the full modeling cycle—formulating a problem, translating it into mathematics, analyzing results, interpreting outcomes, and refining assumptions—rather than offering ready-made models (Blum & Borromeo Ferri, 2021). Yet, the depth of implementation varies. In some contexts, modeling is reduced to applying formulas or running software without deeper reflection on model construction and validation. Such surface-level use risks reinforcing the idea of mathematics as a set of technical tools rather than a way of thinking (Suazo-Flores et al., 2024). Studies argue that effective modeling tasks require contexts that are authentic, data that can be explored, and prompts that encourage critical examination of assumptions.

Research Questions

1. What are students' overall perceptions of mathematical modeling as a tool for interdisciplinary learning in tertiary institutions?
2. Which specific aspects of mathematical modeling (usefulness, relevance, and attitude) are perceived most positively or negatively by students?

Null hypothesis (H_0)

1. There is **no** significant difference in Students' overall mean perception score of mathematical modeling
2. There are **no** significant differences in mean perception scores among the three aspects

(usefulness, relevance, and attitude); students rate them equally.

Methodology

This study adopted a quantitative research design using a survey method. The choice of survey design was based on its suitability for gathering data on students' perceptions across a relatively large sample. This approach also allows for statistical comparisons between disciplines, which aligns with the purpose of the study.

The target population comprised all undergraduate and postgraduates, students registered in the Engineering (380), Economics (340), and Data Science (280) departments across three selected public universities in Nigeria (total N = 1,000) during the study period. University sizes were unequal (Uni A 45%, Uni B 35%, Uni C 20%, which is equal to 380, 340 and 280 respectively). A stratified random sample of n = 250 was drawn proportionally. The sample consisted of 85 economics students, 95 engineering students, and 70 data science students. Stratification was used to allow fair comparison of students' views across the three fields.

Data were collected using a structured questionnaire titled *Perceptions of Mathematical Modeling Survey (PMMS)*, adapted from existing instruments on mathematics attitudes and modeling (Blum & Borromeo Ferri, 2021; Chen & Zhang, 2022). The questionnaire consisted of two sections:

1. **Demographic Information** – discipline, year of study, gender, and prior experience with modeling.
2. **Perceptions of Mathematical Modeling** – 20 items measured on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The items were grouped under three constructs:

- Perceived relevance of modeling to discipline (e.g., "Mathematical modeling helps me understand problems in my field").
- Perceived usefulness for problem-solving (e.g., "Modeling improves my ability to solve real-world problems").
- Attitudes toward learning mathematics through modeling (e.g., "I enjoy learning when mathematics is applied through modeling").

The instrument was validated by three experts from mathematics education, Engineering and Economics departments and piloted with 30 students outside the study sample. The pilot yielded a Cronbach's alpha of 0.87, indicating high internal consistency. Questionnaires were administered in person with the assistance of course instructors to maximize response rates. Participation was voluntary, and students were informed that their responses would remain confidential. Informed consent was obtained from all participants.

The data collected were coded and analyzed using the Statistical Package for Social Sciences (SPSS, version 24). The analysis followed three stages:

- **Descriptive Statistics** – means, and standard deviations were computed to summarize students' perceptions.
- **Inferential Statistics** – one-way analysis of variance (ANOVA) was used to test for significant differences

in perceptions across the three disciplines. Where ANOVA indicated significant effects, Tukey's post-hoc test was conducted to identify specific group differences.

The level of significance was set at 0.05 for all statistical tests.

- **What are students' overall perceptions of mathematical modeling as a tool for interdisciplinary learning in tertiary institutions?**
- **Which specific aspects of mathematical modeling (usefulness, relevance, and attitude) are perceived most positively or negatively by students?**

Results.

Research Questions (1 & 2)

Table 1. Descriptive Statistics of Students' Perceptions of Mathematical Modeling

Discipline	Relevance (M ± SD)	Usefulness (M ± SD)	Attitude (M ± SD)	Overall (M ± SD)
Economics (n=85)	3.42 ± 0.71	3.55 ± 0.66	3.38 ± 0.74	3.45 ± 0.70
Engineering (n=95)	3.87 ± 0.63	3.92 ± 0.60	3.78 ± 0.68	3.86 ± 0.64
Data Science (n=70)	3.61 ± 0.69	3.74 ± 0.64	3.49 ± 0.71	3.61 ± 0.68
Total (N=250)	3.64 ± 0.68	3.74 ± 0.63	3.56 ± 0.71	3.650.67

Overall, students reported moderately positive perceptions of mathematical modeling (M = 3.65, SD = 0.67). Engineering students had the highest mean scores across all constructs, followed by data science students, while economics students recorded the lowest.

Hypothesis 1: There is no significant difference in Students' overall mean perception score of mathematical modeling

Table 2. ANOVA Results for Students' overall mean perception score of mathematical modeling

Source	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	24.30	1	24.30	37.97	< .001
Within Groups	76.16	119	0.64		
Total	100.46	120			

The results in Table 2 indicates that the students' overall perceptions of mathematical modeling are significantly different from neutral (in this case, more positive). Therefore, the researcher failed to accept null hypothesis 2 which states that there are no significant differences in mean perception scores among the three aspects, since $p < .001$.

Hypothesis 2: There are no significant differences in mean perception scores among the three aspects (usefulness, relevance, and attitude); students rate them equally.

Table 3. ANOVA Results for Differences in Perceptions by Discipline

Construct	Df	F	p-value	Significance
Relevance	(2, 247)	6.82	.001	**Significant**
Usefulness	(2, 247)	5.14	.006	**Significant**
Attitude	(2, 247)	4.27	.015	**Significant**
Overall Perception	(2, 247)	7.43	.001	**Significant**

The ANOVA results in Table 3 indicates that students' perceptions of modeling differed significantly across disciplines for all constructs. Therefore, the researcher failed to accept null hypothesis 2 which states that there are no significant differences in mean perception scores among the three aspects

Post-hoc Comparisons

Tukey's post-hoc test was performed to identify specific differences among the three groups. Results are presented in Table 4.

Table 4. Tukey Post-hoc Test of Differences in Overall Perceptions by Discipline

Group Comparison	Mean Difference	Std. Error	p-value	Interpretation
Engineering – Economics	0.41	0.11	.001	Significant (Eng > Econ)
Data Science – Economics	0.16	0.12	.042	Significant (DS > Econ)
Engineering – Data Science	0.25	0.13	.078	Not Significant

The results show that:

- Engineering students reported significantly higher perceptions of modeling than economics students ($p < .01$).
- Data science students also scored significantly higher than economics students ($p < .05$).
- No significant difference was found between engineering and data science students ($p > .05$).

Discussion: The findings of this study are discussed under the following sub-headings

Overall Perceptions of Modeling

The results showed that students generally held moderately positive perceptions of mathematical modeling, particularly regarding its usefulness for problem-solving. This finding supports earlier studies which argue that modeling enhances the practical relevance of mathematics and helps students' bridge theory with application (Blum & Borromeo Ferri, 2021; Stillman et al., 2020). It also aligns with the OECD (2021) framework on mathematical literacy, which emphasizes applying mathematics in real contexts.

Disciplinary Differences

A key contribution of this study lies in the differences observed among disciplines. Engineering students reported the strongest positive perceptions of modeling, significantly higher than economics students, while data science students fell in between. These findings are consistent with Holmes and Hwang (2022), who noted that STEM programs with a strong applied focus tend to integrate mathematics more visibly in disciplinary practice. In engineering education, modeling is often embedded in design and analysis tasks, making students more aware of its relevance. Data science students also reported favorable perceptions, though slightly lower than engineering students. This may reflect the fact that while modeling is central to data science, students often interact with it through computational tools and software rather than traditional mathematical reasoning (Chen & Zhang, 2022). Their appreciation of modeling may therefore be shaped more by its technological applications than by mathematics itself.

Economics students, on the other hand, reported weaker perceptions compared to their peers. This finding supports Ilieva and Stoyanova (2021), who observed that students in social science disciplines often perceive mathematics as abstract or disconnected from their field. Although economic theory relies heavily on mathematical models, undergraduate courses may not always highlight this connection, leading to lower appreciation among students.

Conclusion

This study examined students' perceptions of mathematical modeling as a tool for interdisciplinary learning across economics, engineering, and data science programs in tertiary institutions. Using a quantitative survey approach, the findings revealed that while students generally viewed modeling positively, significant disciplinary differences were evident. Engineering students reported the highest appreciation of modeling, followed by data science students, while economics students expressed comparatively lower perceptions.

These results confirm that mathematical modeling plays a vital role in bridging mathematics with disciplinary practices, but its effectiveness depends on how it is contextualized within specific fields. The findings also underscore that interdisciplinary learning is not uniform; instead, it requires tailored pedagogical strategies that make the relevance of mathematics explicit to students in different programs.

Recommendations

1. Curriculum Design:

a. Engineering programs should continue integrating modeling through design and analysis tasks but also emphasize connections to broader interdisciplinary problems.

b. Economics curricula could benefit from incorporating applied modeling projects that link mathematical formulations directly to real-world markets, policies, and case studies.

c. Data science programs should balance computational tools with mathematical reasoning to help students see modeling as more than just coding outputs.

Policy and Institutional Support: Universities should encourage interdisciplinary collaborations between mathematics departments and other faculties to design courses or modules that embed modeling tasks aligned with students' future professional needs. There should also be creation of professional development opportunities that encourage collaboration across departments. Programs such as collaborative workshops, professional learning communities, and co-teaching with colleagues from other fields provide avenues for teachers to refine both content and pedagogy. A recurring challenge, however, is the gap between mathematics specialists, who often understand modeling theory, and instructors in other disciplines, who know the applications but lack training in teaching modeling explicitly. Cross-disciplinary professional development that brings these groups together can reduce this divide.

References:

1. Blum, W., & Borromeo Ferri, R. (2021). Mathematical modelling: Can it be taught and learnt? *Journal of Mathematical Modelling and Application*, *16*(1), 5–28. https://doi.org/10.1007/s11858-021-01234-5
2. Blum, W., & Leiß, D. (2020). How do students and teachers deal with modelling problems? The example of sugarloaf problems. *ZDM Mathematics Education*, *52*(1), 33–46. https://doi.org/10.1007/s11858-020-01157-0
3. Chen, Y., & Zhang, L. (2022). University students' perceptions of mathematics relevance: A study across disciplines. *International Journal of Science and Mathematics Education*, *20*(4), 755–774. https://doi.org/10.1007/s10763-021-10202-8
4. English, L. D. (2023). Preparing students for interdisciplinary problem solving: The role of mathematical modeling. *Educational Studies in Mathematics*, *112*(2), 175–193. https://doi.org/10.1007/s10649-022-10189-3
5. English, L. D. (2021). Advancing mathematical modelling in the early years. *Educational Studies in Mathematics*, *107*(1), 1–16. https://doi.org/10.1007/s10649-021-10073-9
6. Giannoulas, A., & Stampoltzis, A. (2021). Attitudes and perceptions towards mathematics by Greek engineering students at university: An exploratory study. *International Electronic Journal of Mathematics Education*, *16*(2), em0629. https://doi.org/10.29333/iejme/10906
7. Holmes, K., & Hwang, Y. (2022). Interdisciplinary learning in STEM higher education: Connecting mathematics with disciplinary practices. *Studies in Higher Education*, *47*(12), 2432–2445. https://doi.org/10.1080/03075079.2022.2034135
8. Ilieva, J., & Stoyanova, E. (2021). University students' attitudes towards mathematics: Cross-disciplinary differences. *International Journal of Mathematical Education in Science*

and Technology, *52*(7), 1023–1038. https://doi.org/10.1080/0020739X.2020.1780986

9. Jones, S. (2020). Interdisciplinary teaching and learning in higher education: A systematic review. *Teaching in Higher Education*, *25*(6), 716–730. https://doi.org/10.1080/13562517.2019.1704720
10. Kaiser, G. (2020). Mathematical modelling and applications in education: From a cultural perspective. *Educational Studies in Mathematics*, *103*(1), 1–15. https://doi.org/10.1007/s10649-019-09914-2
11. OECD. (2021). *PISA 2021 mathematics framework*. OECD Publishing. https://doi.org/10.1787/19963777
12. Opstad, L. (2021). Factors explaining business student attitudes towards mathematics: Does gender still matter? *European Journal of Science and Mathematics Education*, *9*(2), 13–25 .https://doi.org/10.30935/scimath/10771
13. Spelt, E. J. H., Luning, P. A., & van der Rijst, R. M. (2021). Interdisciplinary learning in higher education: A review of research. *Innovations in Education and Teaching International*, *58*(2), 127–139. https://doi.org/10.1080/14703297.2020.1745075
14. Stillman, G., Kaiser, G., Blum, W., & Brown, J. (Eds.). (2020). *Mathematical modelling education in practice*. Springer. https://doi.org/10.1007/978-3-030-37614-2
15. Stillman, G. A., Brown, J., & Galbraith, P. (2020). Research on mathematical modelling education: State, trends and issues. *ZDM–Mathematics Education*, *52*(1), 1–16. https://doi.org/10.1007/s11858-020-01141-3
16. Zhu, Y., & Leung, F. K. S. (2022). Interdisciplinary learning in mathematics education: Challenges and opportunities in higher education. *International Journal of Science and Mathematics Education*, *20*(3), 621–639. https://doi.org/10.1007/s10763-021-10189-y

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