

# 'Beyond the Formula': Embedding ethics and sustainability in mathematics through co-creation

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## 1. INTRODUCTION

For the last two decades, there has been a growing demand to incorporate **ethics and sustainability** within HE teaching. However, universities face **challenges in integrating these concepts into disciplines such as mathematics**, which often focus more on **abstract calculations and formulas** rather than practical applications.

This project highlights the **development of sustainability and ethics** toolkit by 2 undergraduate students, aimed at **integrating sustainability and ethics into mathematics** teaching. The **toolkit** includes **visually appealing posters** that explain the **relevance of sustainability and ethics mathematics**, along with **mathematical problems** aligned with the **SDGs and ethical considerations** as well as **formative practice quizzes**.

**Problem 3 – Simpson's Paradox**  
Mathematical topic: Probability  
Contribution to SDGs: Gender Equality (SDG 5), Reduced Inequalities (SDG 10)

**Context of the problem:** In a particular admissions cycle, a mathematics department observes a higher success rate for male applicants than for female applicants. To investigate whether this is the same across the two sub-departments of Pure and Applied Mathematics, the following year the department asks each applicant to give their preference for pure or applied mathematics (they are not allowed to be ambivalent) and records the resulting statistics as shown:

		Total:			
		Applications	Successful		
Female		300	30		
Male		1000	210		

		Prefer applied:		Prefer pure:	
		Applications	Successful	Applications	Successful
Female		270	18	30	12
Male		350	15	650	195

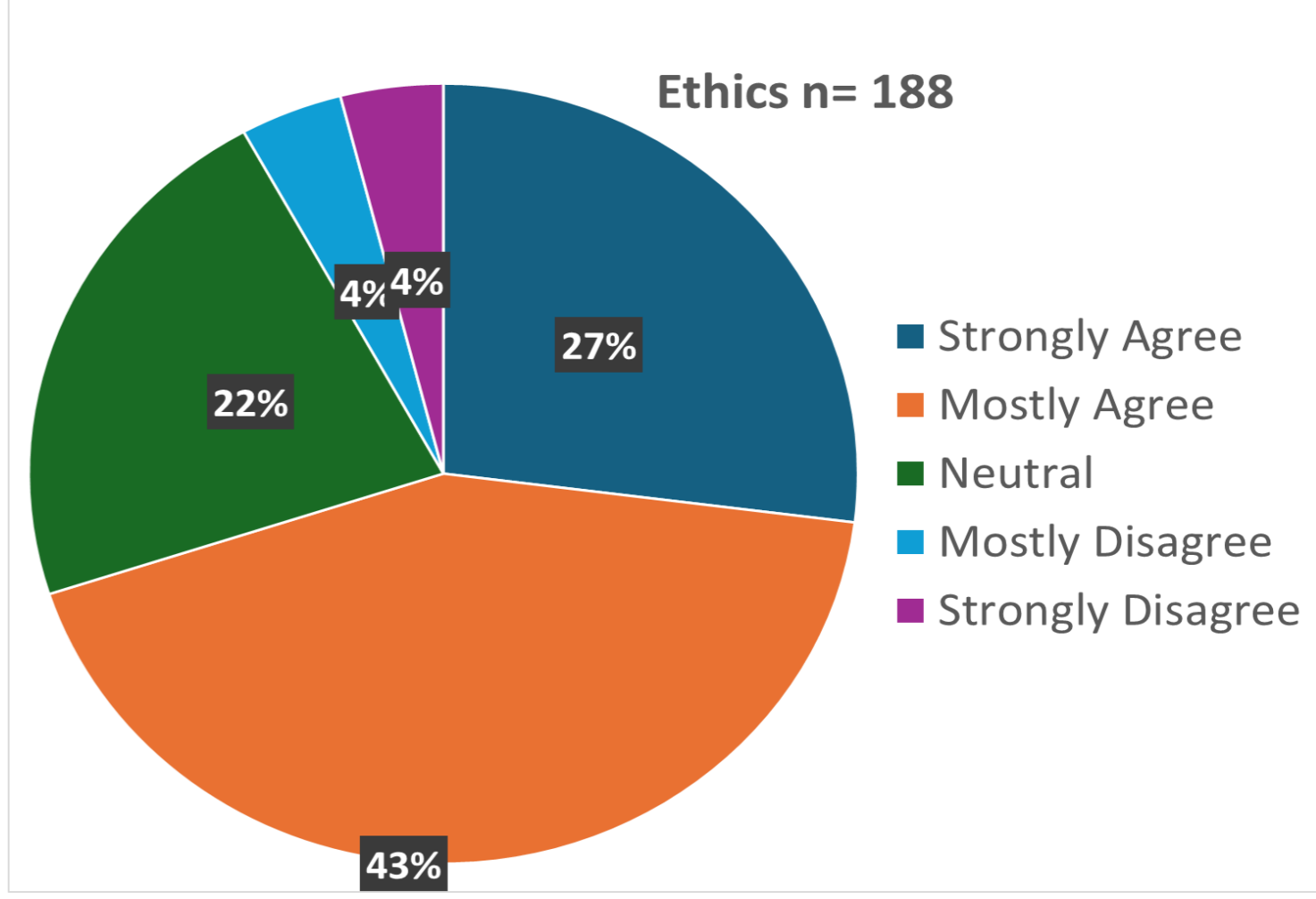
- Compare the success rates for male and female applicants that prefer applied mathematics, prefer pure mathematics and their success rates overall.
- What do you notice? Why is this possible? This is known as [Simpson's paradox](#).

**Mathematical approach:** This problem focuses on applying **probability** and **data analysis** to demonstrate **Simpson's paradox**, a statistical phenomena in which a trend appears in several groups of data but disappears or reverses when the groups are combined. The question involves calculating and comparing the success rates for male and female applicants within each of the subgroups, which are Pure Mathematics and Applied mathematics, as well as for the whole group. By examining how group sizes and success rates contribute to combined data, the analysis provide a deeper understanding of the mechanics of the paradox.

**Key sustainability insight:** This question combines mathematics with real-world issues related to gender equality (SDG 5) in education and professional environments.

- Gender disparities in STEM:** This question draws attention to gender disparities in mathematics and other STEM fields worldwide.
- Broader inequalities:** It highlights how misinterpreting data can reinforce existing inequalities and shows the importance of transparency and accountability in data analysis, aligning with SDG 10.

This issue demonstrates the crucial role of mathematics in uncovering hidden disparities and supporting informed decision-making to promote fairness and equity.



## 5. STUDENT FEEDBACK

- "I found it interesting how **mathematics can be used in real-world decision-making and the ethical dilemmas that arise from these applications.**
- "The resources look great!! But I would suggest to **include these problems in the PBL sections** because these problems help student understand the importance of ethical considerations in relation to mathematical topics."

## 2. PROJECT AIMS

- To aid students to **understand the role of sustainability and ethics in mathematics**
- To **foster students' critical thinking skills in terms of sustainability and ethics.**
- To **enhance students' problem-solving skills** through the provided **mathematical problems aligned with sustainability and ethical consideration.**

## 3. IMPLEMENTATION

- Co-creation** (staff-student partnership) of teaching toolkit resources.
- Components of toolkit:**
  - Visually Appealing Posters
  - Practice Questions with Solutions
  - Formative Quizzes

Implemented in **first-year and second-year undergraduate applied mathematics** module (800 students) over 2-3 years.

- Embedded as **asynchronous, formative resources** for students to use alongside course content.

**Calculations:**  
The success rates for male and female applicants based on preference (Applied or Pure Mathematics) and overall are calculates as follows:

	Prefer applied	Prefer pure	Total
Female	$\frac{18}{270} = \frac{14}{210}$	$\frac{12}{30} = \frac{4}{10}$	$\frac{30}{300} = \frac{10}{100}$
Male	$\frac{15}{350} = \frac{9}{210}$	$\frac{195}{650} = \frac{3}{10}$	$\frac{210}{1000} = \frac{21}{100}$

**Observations:**  
**Simpson's paradox** is observed here: Females have higher success rates within each sub departments, yet their overall acceptance rate is lower than males; **0.21 (male) vs 0.1 (female).**

**Explanation:**

- The largest male cohort (those who prefer pure mathematics – 650 applicants) has a high success rate of 0.3, raising the overall male success rate.
- However, the largest female cohort ( those who prefer applied mathematics – 270 applicants) has a much lower success rate of 0.067, which drags down the overall female success rate.

This phenomena demonstrates the importance of examining sub-groups dynamics when analysing data to avoid misinterpretations.

**Key questions to think about:**

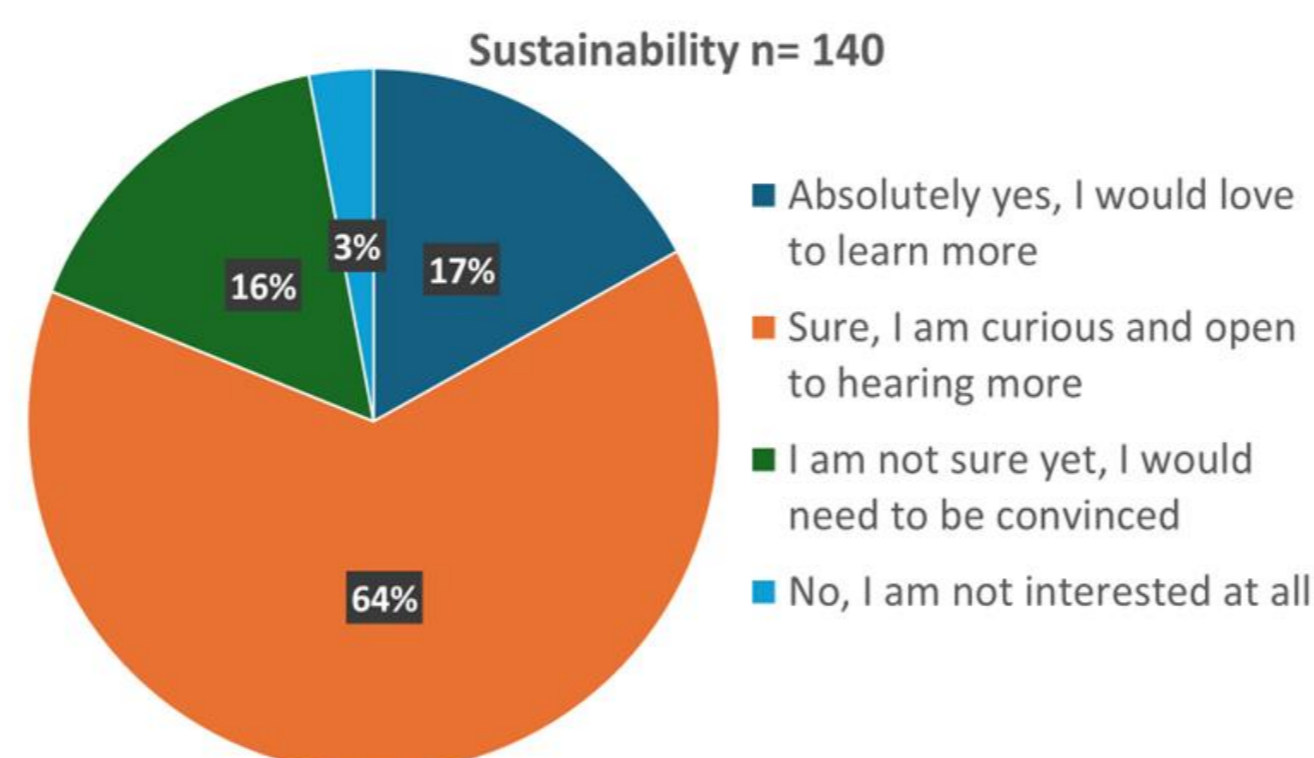
- Analysing fairness in data aggregation:
  - How do different cohort sizes influence the outcomes?
  - What is the impact of **Simpson's paradox** on policy making in education?
- Understanding sustainable systems
  - How can mathematics be used to promote equity and fairness in admission policies?
  - What steps can institutions take to ensure diversity and inclusivity in male dominant fields?
- Sustainability in decision making
  - How does this analysis connect with broader sustainability goals, such as reducing gender equality (SDG 5) and ensuring quality education (SDG 4).

**Why these questions matter:**

- Mathematical analysis supports sustainable problem solving by revealing hidden trends like Simpson's Paradox.
- In this way, it is possible to avoid misleading conclusions and promote the development of more inclusive, fair outcomes.
- These insights enable educators, policymakers, and researches to incorporate equity and sustainability into their decisions, supporting diversity and sustainable development.

## 4. Module Survey

**Did these resources make you want to learn more about sustainability/ethics in mathematics and its real-world impact?**

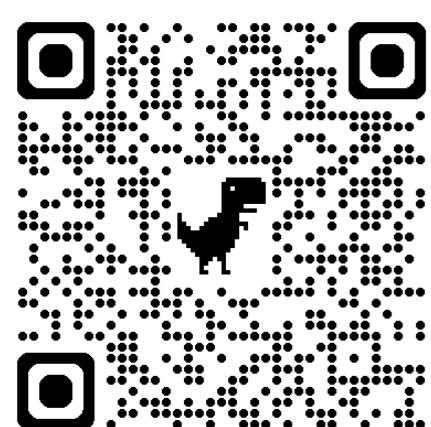


## 6. KEY FINDINGS

- Most students **were not aware of sustainability or ethics in mathematics** but found them interesting and relevant once introduced.
- Students **enjoyed** integration of sustainability and ethics in mathematics, through real-world scenarios
- Student **appreciated the clear layout, simple explanations, and step by step solutions**, which made the material easier to understand.
- Several students suggested adding more **videos, visuals and discussion-based activities** to improve engagement and learning.

## 7. CONCLUSION AND FUTURE WORK

- This project **successfully integrates sustainability and ethics into mathematical problem-solving.**
- It **supports academics in integrating sustainability and ethics into STEM courses.**
- Next step is to prepare and **submit a case-study paper to a mathematics education journal (MSOR Connections)** to share the aims, approach and outcomes of this project.



Scan QR codes for QMUL Sustainability in Mathematics Resources