

Making Diversity 'Count': *empowering students through* *co-creation of inclusive* **STEM curricula**

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Diversity in STEM: An Overview

- Why do we need it?
- How did I embed it in my modules?
- What did students say and what impact it did it have?
- Conclusion remarks and next steps

Need for Diversity in STEM

- STEM subjects usually taught through **memorisation** and repetitive application of **formulae**
- Often **limited emphasis on historical aspects and contributions** by diverse individuals
- If done, mostly confined to **white, male, European** mathematicians/scientists/engineers
- Consequently, **very few students relate** to these STEM figures (no role models)
- Adds to the stigma that studying **STEM is esoteric, inaccessible and difficult**

How did I embed it in my modules?

- Student-staff co-creation of teaching toolkit with **current undergraduate students**
- Teaching toolkit comprising short biographies and visual posters of **both historical and present-day 'STEM champions'** from diverse and under-represented backgrounds (e.g. African, Islamic, Asian, female, disabled, LGBTQ, those with non-traditional pathways)
- Implemented in **two large** (300-400 students each) **first and second-year** undergraduate **applied mathematics modules** for engineering students
- Embedded as **asynchronous non-assessed** resources alongside course content

✓ Making Diversity 'Count': Profiles of STEM Champions (RS)

Motivation

The profiles of past and present diverse individuals provided below form part of an ongoing scholarship research initiative to diversify STEM curricula being undertaken by Dr. Rehan Shah in SEMS with collaborators from the School of Mathematical Sciences at QMUL. These are designed to increase students' awareness of diverse representation and provide positive role models through exposure to mathematicians, scientists, and engineers from under-represented backgrounds (female, disabled, and queer) and non-traditional pathways in academia and industry.

If you are more interested in this area and would like to engage in it further, please get in touch with Dr. Shah.

STEM Champions

1. Mary Somerville (1780 - 1872)
2. Peter Landin (1930 - 2009)
3. Nira Chamberlain (1969 - present)
4. Gladys West (1930 - present)
5. Sofia Kovalevskaya (1850- 1891)
6. The ENIAC Six: Betty Holberton, Jean Jennings Bartik, Kay McNulty, Marlyn Wescoff and Ruth Lichterman and Frances Bilas Spencer

Task

Please engage and have a look through these materials and then provide your feedback by completing the survey below by the end of Week 10 (Friday 29 March 2024).



Biographies of STEM Champions



Completion ▾



Feedback Survey

Opened: Saturday, 17 August 2024, 9:00 AM Closes: Wednesday, 30 October 2024, 4:00 PM



Completion ▾

Mary Somerville (1780 - 1782)



Brought continental calculus to Britain, known as the 'Queen of Science'

"Whatever difficulty we might experience [...] in choosing a King of Science, there could be no question whatever as to the Queen of Science." – The Morning Post 1872



A Scottish writer and Polymath who is dubbed as the world's 'first ever scientist' as well as one of the first female members of the Royal Astronomical Society. Awarded a silver medal in 1811 for solving the Diophantine problem, which include 'Fermat's Last Theorem', thought to have been unsolvable for 400 years. In addition to this, she can be credited with being one of the first people to suggest Neptune's existence and mentoring Ada Lovelace.

Somerville grew up as 1 of 6, and unlike her brothers, did not receive formal schooling as a young child. Only being taught to read by her mother but not to write. Her first interaction with science came from her art teacher who introduced her to 'Euclid's Elements'. In 1817 she was introduced to the works of Laplace, Poisson and Poincaré whilst visiting Paris. Following this visit, Somerville used her connections in Paris to bring these concepts to Britain.

Scientist (noun):

First used in print in 1834 in William Whewell's anonymous review of Somerville's work, 'The Connexion of the Physical Sciences'

Somerville was the first person to be dubbed a 'scientist' in print, as her work was becoming so separate to the standard terminology at the time of 'philosopher'. She was a revolutionary in her field.



"Age has not abated my zeal for the emancipation of my sex from the unreasonable prejudice too prevalent in Great Britain against a literary and scientific education for women".

Somerville had to work hard to gain acceptance for her work, and at the start of her career, even publishing under the pseudonym, 'A Lady' to avoid scrutiny. She even described her husband as having 'a very low opinion of the capacity of [her] sex'

Always keen liberal, she was the first supporter of Mill's petition to Parliament to grant female suffrage as well as advocating for abolition of slavery.



Scan for additional information!

Peter Landin (1930 – 2009)



CHANGED THE FACE OF COMPUTER PROGRAMMING

"Most papers in computer science describe how their author learned what someone else already knew."



Aside from his work as a computer programmer, Landin was also an active campaigner for LGBT rights and was a member of the Gay Liberation Front during the 1970's, following the separation from his wife in 1973. Landin's distancing from computer science was triggered by his belief that computer science has become a capitalist idea focussed on profit taking and was ashamed by its move away from innovation.

"There's a good part of computer science that's like Magic"

Peter Landin was a pioneering British computer scientist whose work in the 1960s laid critical foundations for the development of programming languages. Known for his contributions to the theory of programming languages, Landin introduced key concepts such as the SECD machine, the first abstract machine for lambda calculus, and coined the term 'syntactic sugar.' His innovative ideas greatly influenced the design and implementation of many modern programming languages, cementing his legacy as a visionary in the field of computer science.

Peter Landin aimed to create a programming language that was not limited to a single machine but could be used across various machines and manufacturers. To achieve this, he employed lambda calculus as the foundation for a new language. By utilizing lambda calculus, he integrated it into his own language, ISWIM, which featured higher-order functions, automatic storage management, and abstract syntax notation. ISWIM influenced the development of languages like LISP, ML, and Haskell. Landin's work also led to the introduction of 'Landin's Off-side Rule', an indentation rule commonly used in Python. This rule was detailed in his paper, 'The Next 700 Programming Languages', and is crucial for maintaining code structure and scope.

Landin's legacy is left by the archives in the Bodleian Library in Oxford containing an archive of all of Landin's work. There is also an annual seminar entitled the 'Annual Peter Landin Semantics Seminar' as well as the Peter Landin building at Queen Mary University of London which is home to the computer science department of the university.



Scan for additional information!

Dr Gladys West (1930 – Present)



COMPUTER PROGRAMMER CREDITED WITH THE INVENTION OF THE GPS

"I had to be the best that I could be, [...] Always doing things just right, to set an example for other people who were coming behind me."

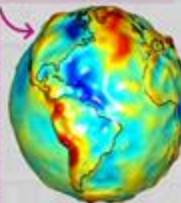


The work of Gladys West enabled the creation of the GPS. This was done through her analysis of satellite altimeter data from the NASA Geodetic Earth Orbiting Programme. This was the foundation of her work to programme an accurate geopotential model of the earth, a Geoid. This model then served as the basis of the GPS. Her complex algorithms were able to account for all factors impacting the shape of the Earth and its irregularities.

Born in 1930's Virginia, West felt certain she would follow in the footsteps of her parents, a work in the farms and tobacco plants, however her determination and aptitude for maths allowed for her to pursue a career in computer programming and modelling.

Graduating from Virginia State in 1955, following a stint as a teacher in segregated schools, West was hired by the U.S. Navy, where she was one of four black employees. Her work here involved: determining the movements of Pluto in relation to Neptune, project manager of SESAT (a satellite used to provide data on oceanographic conditions, and then eventually the development of the mapping of the Geoid.

West did not receive recognition for her work until the early 2000's and receiving her first award for her work in 2018. In more recent times being known as a 'Hidden Figure' in history. However, she did not aim for recognition only for academic excellence. Notably earning her PhD in public administration and policy affairs at the age of 70, 2 years after her retirement.



Awards:

2018 – Inducted into the United States Air Force Hall of Fame

2018 – Female Alumna of the Year at the Historically Black Colleges and Universities Awards

2018 – One the BBC's 100 Women

2021 – The first female to be awarded the Prince Philip Medal by the Royal Academy of Engineering (the highest individual honour)

"I have realised my dreams and reached a height beyond what I anticipated. I encourage young women to believe in yourself, find your passion, work hard and apply yourself [...] and most of all – follow your dreams"



Scan for additional information!

Student Feedback Survey Responses

(1) Were you aware of any diverse mathematicians before coming across these biographies?

*"Before reading these biographies, I was **not aware** of any diverse individuals within the STEM sector. The large **majority** of mathematicians/scientists/engineers that I knew **were of white-European origin**."*

*"I was **not aware** of the diversity in the STEM industry. As a person of ethnic minority studying engineering, I was **pleased to see representation in this industry**."*

*"I was surprised that I **never heard about Gladys West** (African American mathematician) **or the six ENIAC** (Electronic Numerical Integrator And Computer) **women programmers**".*

(2) What did you find most enjoyable or interesting about these resources?

*"I like that it **shed light on people who deserved as much recognition** as their more famous counterparts. It is **heartening to see their stories** being actively searched for despite falling towards obscurity for decades."*

*"I found it **interesting to learn about the challenges women faced** in the academic world and **how much harder they had to work than their male counterparts** in order to be recognised for their achievements."*

*"The **video QR codes, achievement sections, quotes, and cohesive theming** between the different people is what stood out to me the most."*

*"How these resources bring together **rich, multi-dimensional narratives of individuals** whose technical achievements are interwoven with their personal journeys and societal impact."*

Student Feedback Survey Responses

(3) Have these biographies made you want to learn about the contributions of diverse mathematicians?

*“Yes - these biographies **highlight the rich and varied contributions of individuals from diverse backgrounds** in STEM, underscoring the **importance of inclusivity** in science and mathematics. Each story brings a unique perspective, **showing how overcoming personal and societal challenges can lead to significant advancements** in their fields.”*

*“Yes, it **makes women motivated** as we rarely hear about their contributions in STEM, so reading these biographies **made me very proud.**”*

*“**I do not particularly want to learn more about people only based on their diversity**, I would rather learn about individuals that are committed to their field and passionate about their jobs and life regardless of their ethnic background.”*

(4) Would you like such material to be introduced in a classroom setting e.g. in lectures or tutorials?

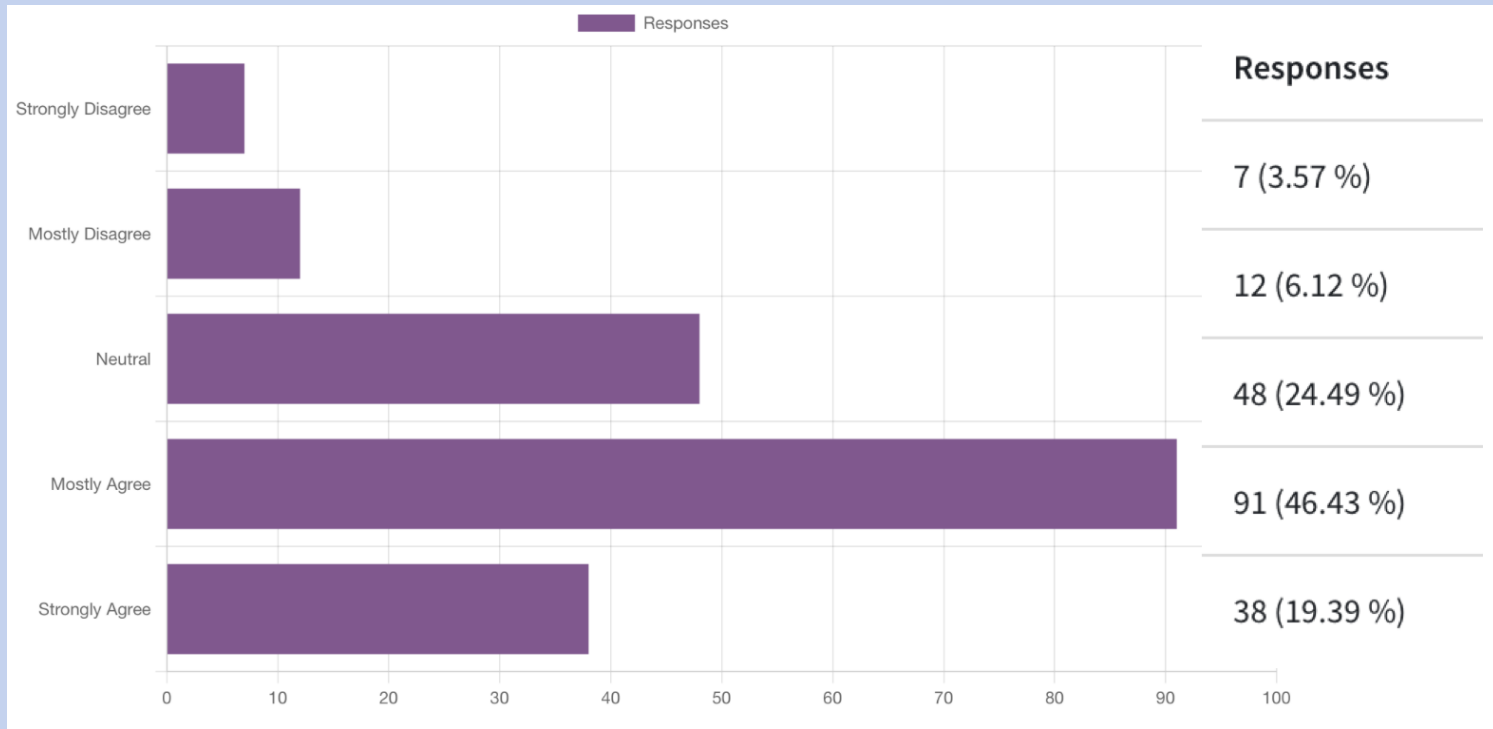
*“Yes, it would be nice to **mention the contributions from individuals not recognised in history**. For example, if we had a **classical mechanics lesson, Sofia Kovalevskaya’s work** on the spinning top could be mentioned.”*

*“I suggest incorporating elements such as **discussion prompts or quizzes** to increase user interaction significantly. Additionally promoting a section dedicated to **STEM projects** could drive community engagement and participation.”*

*“A **quick mention and short introduction** would be enough and students can **use their own time** to check out the resources available.”*

Student Feedback Survey (n = 196)

(5) These resources made me want to learn more about diversity in STEM. Choose the most appropriate response.



Analysis of Student Feedback

- Most students **had not previously heard** of diverse STEM individuals (if at all, only in a secondary school setting, **not at university** – usually also **through films and books**)
- **Minority and female students resonated more** strongly and motivated by materials
- Suggestions to increase engagement through **discussion forums, quizzes and projects**
- Most students **highlighted strong need** for such resources, respite from technical content
- Would like **embedded in class in a relevant and limited manner**

QMUL-OU Student Focus Group Findings (n = 10)

(1) In what ways would you like to see diversity emphasised?

- introduce in **lectures** in a **relevance-focused** manner (e.g. formative Kahoot quizzes)
- **more conversation** needed to supplement developed resources (e.g. posters, videos, speakers)
- link in with **professional STEM skills courses** at university (e.g. reading week, advisor sessions)

(2) Are there ways in which emphasis on diversity is unhelpful?

- present **individuals as humans**, in a **celebratory, yet realistic** manner
- mention **challenges** faced to give students a **sense of identity**, avoid controversial parts as taglines,
- **Little and often** could be the better approach (**gradual changes vs. aggressive pushes**)

(3) How can these resources help you be a better mathematician/engineer?

- **inclusivity** very important for group dynamics and teamwork
- very important to **educate students to be more empathetic** and accepting of diversity
- help in **reducing sexism** in workplace, spreading **cultural awareness** and **religious tolerance**

(4) Should these resources form part of any assessment?

- **no, as becomes a 'one-time thing'** rather than an ongoing discussion (**formative > summative**)

Impact Highlights of Project

- **Increase in module student satisfaction results** over 2 years (from 67% to 82%)
- Student-staff joint presentation and panel at **QMUL *Inclusive Scholarship* workshop**
- Presentation with students at ***Posters in Parliament* event** at the House of Commons
- Poster **received ‘Best Innovation Poster Award’** at the *QMUL Festival of Education*
- Part of [UK History for Diversity in Mathematics Network’s](#) **online repository** to share resources with other staff (internal and external)
- Student **co-creators** awarded **QMUL *Student Enhanced Engagement and Development Award*** for contributions to curriculum and educational development
- Work nominated for **QMUL Education Excellence Award** and to be part of larger Science and Engineering Faculty’s university-wide **QS Reimagine Education Awards** submission

Conclusion and Next Steps

- **Complete analysis** of focus groups discussions (audio transcription, thematic analysis)
- Submission of a mathematics education **journal research paper** (with Open University)
- **Iterate toolkits** based on feedback, explore possibility of **video interviews**
- **In-person discussion sessions** with all students in *‘Reading/Skills Week’*
- Expansion of resources to **global context** (TNE education campus in China)

QMUL Toolkit (Dr. Rehan Shah): *‘Making diversity count’: inclusivity in STEM curricula*

Thank you for your time!

Please feel to get in touch with me at rehan.shah@qmul.ac.uk



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