

MAKING
DIVERSITY COUNT:
EMPOWERING
STUDENTS
THROUGH
INCLUSIVE STEM
CURRICULA

Student:

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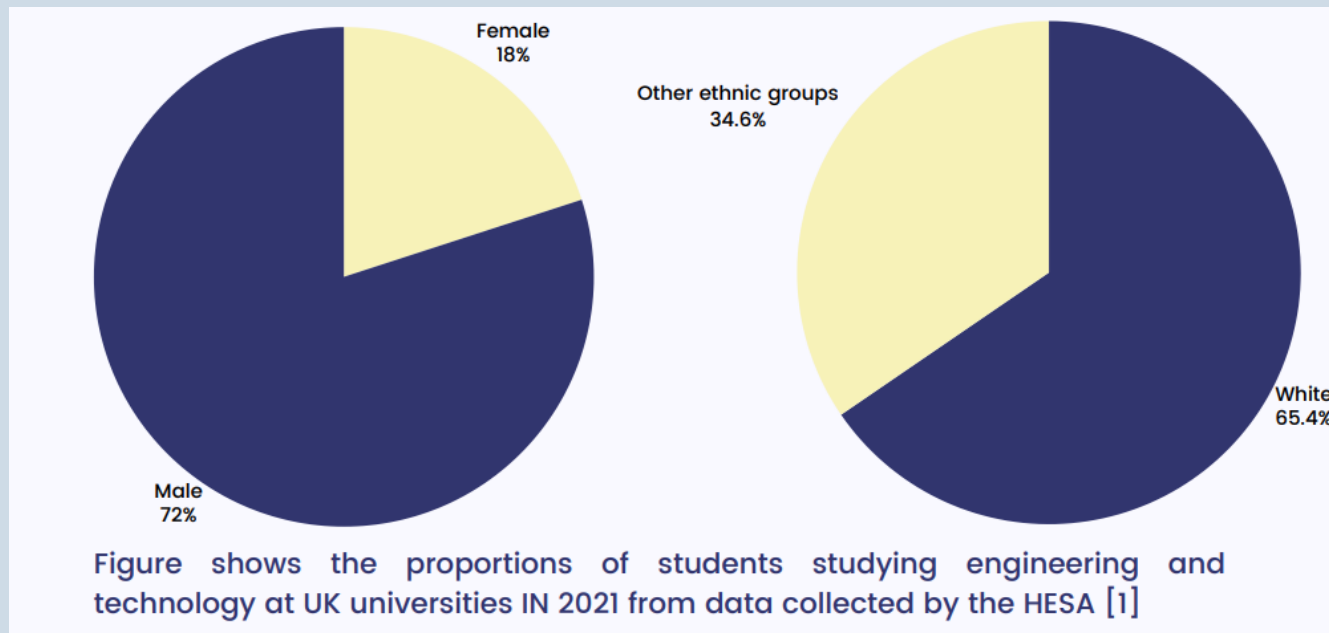
Supervisor :

Dr. Rehan Shah



WHY?

- Increase visibility of under-represented groups and shed light on previously under-recognised work
- Create a more realistic perception of who ‘can’ be an Engineer/Mathematician
- Create a curriculum that is representative of the student body it serves



INITIAL WORK

68 Dr Gladys West (1930 – present)

Mathematical modelling, Computer Programming, Applied Mathematics

Keywords: Female, Black, African American, Uncredited, Awards

Dr Gladys West produced work that enabled the development of the GPS, but due to her being a black female during a time where segregation was still prevalent, she is known as one of the 'hidden figures' of history.

Growing up working in the fields of Virginia, it was expected that West would follow in the footsteps of her parents and either work on the farms or on the tobacco processing plant. However due to her aptitude for maths and problem solving, West was able to graduate valedictorian and pursue mathematics at university level.

In 1956, after pursuing teaching in segregated schools, West was hired by the US navy as a computer programmer and a project manager. Then in the 60's after working on an award-winning piece of research, proving that Pluto's motion was relative to Neptune, West's talents were recognised and she began to analyse satellite altimeter data from NASA's Geodetic Earth Orbiting program, to create models of the Earth's shape, her team managed to reduce the processing time, again, proving her proficiency. This then led to her spending the 70's and 80's using programming calculate the shape of the Earth, a geoid. In order to this, West created an accurate geopotential model with complex algorithms accounting for all factors impacting the shape of the earth. This model was later used as the basis of the GPS.

In 2018, West's work finally received the deserved recognition as she was inducted to the United States Air Force Hall of Fame, one of the highest honours in space command. That same year, West won the award for "Female Alumna of the Year" at the Historically Black Colleges and Universities Awards in 2018. Then in 2021, she was awarded the prince Phillip medal by the Royal Academy of Engineering.

When asked about her experience as a black female as she rose through the ranks, West said that "I carried that load round, thinking that 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, especially women. [...] I strived hard to be tough and hang in there the best I could." And then speaking of the experiences of women today and the impact she hopes she has had, "We have made a lot of progress since when I came in, because now at least you can talk about things and be open a little more. [...] But they still gotta fight."

Read more on [Britannica](#)



African-American and Black British mathematicians

7 Nira Chamberlain (1969 - present)

Data science, Mathematical models, Simulation algorithms

Keywords: Black British, Latin American heritage, Non-linear path, Non-academic career, Dissemination of Mathematics

Prof Nira Chamberlain OBE is a British born with Jamaican heritage mathematician (1969-). Nira grew up in Birmingham and always enjoyed mathematics during his studies. Regardless of the lack of encouragement given by their teachers to pursue mathematics, Nira was supported by his family and studied a BSc in Mathematics at Coventry Polytechnic (1991), MSc in Industrial Mathematical Modelling at Loughborough University (1993). While working several positions on the industry he did his part time PhD at Portsmouth University, entitled "Extension of the gambler's ruin problem played over networks". Later received the Degree of Doctor of Science *honoris causa* by the University of Greenwich (2018), University of Bath (2022) and University of West England (2022). In 2022, he received an OBE in the New Years Honours List for Services to Mathematical Sciences.

His international career was in France, Netherlands, Israel but also throughout the UK. Where in the UK was in charge of the creation of a mathematical cost capability trade-off model for the HMS Queen Elizabeth. Among Nira honours and awards are: Big Math Off - World's Most Interesting Mathematician, Powerlist 2018 5th Most Influential Black Person in the UK, Top 100 Most Influential BAME Leaders in UK Tech Sector (2019), Honorary Member of the Mathematical Association (2020), Fellow of African Scientific Institute (2021) and The First Black (of African diaspora) President of The Mathematical Association (2023).

Right now is Principal Business Modelling Consultant at SNC-Lavalin Atkins and has been nominated for FIN-Forbes Best of Africa - Mathematician of the Year Award (2023).

Read more on [Bath](#), [Speakers for schools](#), [York](#), [Wikipedia](#), [LMS](#), [Twitter](#) and [Linked In](#).



59 Mary Fairfax Somerville (1780 - 1872)

Calculus

Keywords: Women, Scottish, Historical

Mary Fairfax Somerville was a mathematician (1780-1872). Mary was born in a big family with 6 siblings, although 3 died very young. While her brothers received a good education, as a woman she did not, so her mother taught her to read but not to write. Later, she spent 1 year at Musselburgh school for girls, but promptly left to return to her home to educate herself without the approbation of her family. It was through her teacher of paint that she was indirectly introduced to Euclid's *Elements* as basis for painting, astronomy and other sciences. She later became interested in algebra as she read about it in an article in a magazine.

At the age of 24, she married Samuel Greig (1804), a naval officer, who did not support her intellectual interests, but he later died after 3 years of marriage; Mary had 2 sons with him. At this point Mary discussed mathematical problems set in the *Mathematical Repository* by correspondence with William Wallace which lead her to win the silver medal for the solution of one of those problems in 1811.

Later in 1812, Mary got married with William Somerville, who encouraged her to continue studying. In 1814 her oldest daughter and so her only child with William died. Later the family moved to London, where Mary interacted with the leading scientific circles and later in 1817 was introduced to Laplace, Poisson, Pointset, and others during a visit in Paris. Mary continued working and published her first paper in 1826. She also translated the *Mécanique Céleste* of Laplace, which was well accepted in England. She was the first to bring the *continental* calculus to the United Kingdom via her connections to French mathematicians.

Through the years Mary was elected to many societies, including the Royal Astronomical Society (1835), the Royal Irish Academy (1834), the American Geographical and Statistical Society (1857), and the Italian Geographical Society (1870). She was also given an honorary membership of the Société de Physique et d'Histoire Naturelle de Genève (1834), was awarded a civil pension (1834-1841) by the prime minister Sir Robert Peel and prime minister William Lamb, and received the Victoria Gold Medal of the Royal Geographical Society (1870).

Mary Somerville was a strong supporter of women's education and women's suffrage and due to this Somerville College in Oxford was named after her (1879).

Read more on [MacTutor](#).



✓ 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 see the [Task](#) below.

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 ▾

STUDENT FEEDBACK

*“Incorporating these narratives into academic discussions not only gives a variety of viewpoints and role models but also **helps promote an inclusive learning atmosphere**. By showcasing the achievements of individuals from underrepresented backgrounds students can be inspired from all walks of life to do the same and empower them to recognise their own potentials.”*

*“I like that it shed light on people who deserved as much recognition as their more famous counterparts. It is heartening to see that **their stories are actively being searched for despite falling towards obscurity for several decades**. Furthermore, it is always inspiring to see talented individuals find each other as in the ENIAC six.”*

*“I did not know about how diverse stem was before. As reading this represents diversity, as it **encourages young minds from diverse backgrounds to pursue careers in STEM**, creating a **positive cycle of inclusion**. By embracing the talents and perspectives of minorities in STEM, we can **build a more equitable and dynamic scientific community**.”*

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."



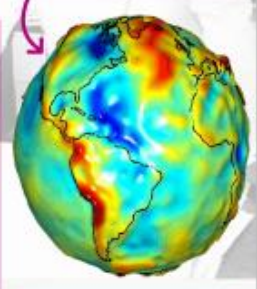
The work of Gladys West enabled the creation of the GPS. This was done through her analysis of satellite altimeter data from the NASA Geodetic Earth Orbiting Programme. This was the foundation of her work to programme an accurate geopotential model of the earth, a Geoid. This model then served as the 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.

"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"



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)



Scan for additional information!

OBE receiver for Services to Mathematics

"My name is Prof. Nira Chamberlain, and I am proud to be a mathematician."



Chamberlain's career spans over several industries, from aerospace, energy, defence and finance. His use of modelling has provided solutions to real world issues, one of the most notable being his cost capability trade-off for HMS Queen Elizabeth, modelling the lifetime running costs of aircraft carriers versus operating budgets. This was later included in the Encyclopaedia of Mathematics, making him one of the few British mathematicians included.

"Mathematics is indisputably the greatest subject in the world! Why? Because it is the language of the world. Mathematics crosses racial, geographical and cultural boundaries."

A regular speaker for the charity 'Speaker for Schools', which focusses on inspiring state-school students to maximise their potential, Chamberlain is a champion for diversity within the mathematical sciences.

His lecture entitled: 'The Black Heroes of Mathematics' is a part of his mission to highlight the lack of black role models in mathematics and as proof that anyone can make it in the field. As a child, Chamberlain was discouraged from pursuing mathematics and was a victim of bullying via his peers. He used this to spur him on, and when his son experienced the same treatment, Chamberlain pushed harder to fight the stereotypes being forced onto him.



Scan for additional information!

Chamberlain studied mathematics at Coventry Polytechnic, graduating in 1991, later then studying Loughborough University where he worked towards his Masters in Industrial Mathematical Modelling, and then rounding off his initial academic career with his PhD at Portsmouth University where he wrote the 'Extension of the Gamblers Ruin Problem Played Over Networks'

Achievements:

2018 - Powerlist's 5th Most Influential Black Person in the U.K

2018 - named the 'World's Most Interesting Mathematician'

2019 - Top 100 Most Influential BAME Leaders in U.K Tech Sector

2020 - Honorary member of the Mathematical Association

2022 - OBE for services to Mathematics

2023 - First Black President of The Mathematical Association

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 included '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 one of six children, 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'



Scan for a short video

SO FAR...

- Increase in module student satisfaction results (from 67% to 82%)
- Student-staff joint presentation and panel at the QMUL Inclusive Scholarship workshop
- Presented at Posters in Parliament event at the House of Commons
- Poster received 'Best Innovation Poster Award' at the QMUL Festival of Education
- Creation of repository to share resources with staff to embed in their own modules
- Successfully awarded QMUL Student Enhanced Engagement and Development Award for contributions to curriculum and educational development

DIVERSIFYING AND DECOLONISING THE CURRICULUM

Aiming to motivate, showcase and give credit to marginalised groups in STEM subjects

MOTIVATION

The contributions of marginalised groups in engineering and mathematics have been largely ignored throughout history. This is highlighted by the lack of these individuals covered by the STEM curriculum. In a multicultural society and industry where the amount of individuals in minority groups contributing and seeking careers in STEM on the rise, students deserve to see the people making headway in their fields from non-traditional backgrounds, and these people deserve recognition. With Queen Mary being the most diverse of the Russell group universities, with 75% of the cohort being from BAME groups, it is critical that the curriculum that is taught is representative of the student body it is taught to.

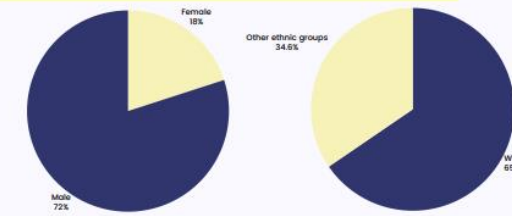


Figure shows the proportions of students studying engineering and technology at UK universities in 2021 from data collected by the HESA [1]

METHODOLOGY

To address this issue, a teaching toolkit has been prepared as part of a joint collaboration between the QMUL Schools of Engineering and Mathematics. This resource is a compilation of a large list of biographies of STEM champions, past and present, from marginalised groups. This list includes: individuals with disabilities, members of the queer community and ancient Islamic mathematicians to name a few. These individuals are then categorised into different areas of mathematics for ease of use in order to be effectively integrated into modules as an additional resource available to students. The aim of this being to reduce the stigma and widen the scope of who 'can' study STEM subjects.

DR. GLADYS WEST

"You're always competing and trying to survive because you're in a different group of people." [2]



West's work enabled the development of the GPS, but due to her being a black female during a time where segregation was prevalent, she is known as one of the 'hidden figures' of history.

In the 60's after working on an award-winning piece of research, proving that Pluto's motion was relative to Neptune, West began to analyse satellite altimeter data from NASA's Geodetic Earth Orbiting program, to create models of the Earth's shape. Her team managed to reduce the processing time, proving her proficiency. This then led to her spending the 70's and 80's using programming to calculate the shape of the earth, in order to this, West created an accurate geopotential model with complex algorithms accounting for all factors impacting the shape of the earth. This model was later used as the basis of the GPS.

RUDRANATH CAPILDEO

"Too many brilliant scholars are not given the opportunity to make a meaningful contribution to the development of our country." - following Capildeo's death [3]



Capildeo is best known for being the leader of the DLP in Trinidad and Tobago from 1960-1969 as well as the first leader of the opposition of an independent Trinidad and Tobago.

He was also extremely multi-talented and his contributions to mathematics cannot be ignored. Much of his work was inspired by Einstein's theory of relativity, which led to the birth of Capildeo's Theory of Rotation and Gravity, otherwise known as Capildeo's Theory. In addition to his research into 'The Flexure Problem in Elasticity'. All of these have useful applications in aerodynamics and were used in the early space expeditions in the 60s and 70s. In 1969 he was awarded the Trinity Cross for his contributions to science from the government of Trinidad and Tobago

CONCLUSION

By providing students with relatable role models from a range of backgrounds which are in line with the multicultural society the curriculum serves, the resource developed takes one step closer to de-stigmatising and widening the access to a successful future in STEM. It also acknowledges under-credited individuals who are excluded from the everyday conversation and discourse due to systemic prejudices spanning from the past to the present that are yet to be fully dismantled. This project gives a glimpse into the huge number of individuals being ignored by the curriculum and helps identify how this has impacted student perception of STEM subjects.

NEXT STEPS

The teaching resource is currently being piloted in first and second year engineering mathematics modules in order to collect feedback from students to help inform how well this tool can be utilised in teaching. This feedback will also provide invaluable data as to how the biases in epistemology have effected the attitude of students to STEM subjects, for example epistemic feminism.

REFERENCES

1. Rigg, K. (2023) 'Diversity Concerns' from New Report on Engineering in Higher Education, WISE.
2. Buttery, A. (2018a) 100 women: Gladys West - the 'hidden figure' of GPS, BBC News.
3. Rudranath Capildeo Exhibition Central Bank of Trinidad and Tobago.

FUTURE WORK: FOCUS GROUPS

- Next steps for project: **joint student focus group interviews** featuring 5 QMUL and 5 OU current undergraduate students who study mathematics modules
- Students will be introduced to both sets of resources, after they will fill in written feedback forms
- Structured discussion (audio recorded) with specific examples guided by some question prompts
- These will be loosely based off on questions used in the pilot study:
 - *Were you aware of any diverse mathematicians, scientists, or engineers before coming across these biographies?*
 - *Have these biographies made you want to learn more about the contributions of diverse individuals in STEM disciplines?*

Diversifying the STEM Curriculum

Dr. Rehan Shah, Prof. Claudia Garetto, Ms. Ava Dahlia Belafonte and Ms. Maria Fernanda Pintado Serrano

INTRODUCTION

The history of science is a complex piece of theatre with many characters, each interacting with their contemporaries and their predecessors. The disciplines of mathematics and engineering, as they are traditionally taught, involve recounting major events of this play, restricting the cast to a narrow list of figures.

This project's objective is to introduce figures, past and present, who, despite their contributions to the field, are often left out of everyday discourse due to systemic and historic prejudices, discrimination and oppression. Our ongoing goal is to show more representative picture of the diversity in the field to the community.

By increasing the visibility of under-represented groups, we hope to inspire a better sense of belonging to students who do not feel a sense of kinship with the traditional story that ignores the efforts of all who had helped create the environment required for the advancement.

IT'S TIME FOR MORE STORIES

Very few people can relate to the 'geniuses' usually depicted, which contributes to the stigma that these disciplines are too difficult for them.

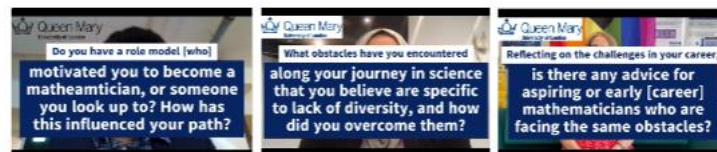
We can fight this stigma with increased awareness of diverse representation; not just with people from diverse backgrounds, but also by showcasing personalities applying their skills in diverse ways. This presents students with inspiring examples of someone who they can one day become.

QMUL has an incredibly diverse cohort of staff and students, so we believed this to be a fantastic opportunity to further educate and engage students.

BIOGRAPHIES

This project began in Summer 2022 with the creation of a booklet of short biographies of mathematicians, which has been adopted in taught modules of the School of Mathematical Sciences (SMS) at QMUL. The project has been extended to the School of Engineering and Materials Sciences (SEMS) to include additional profiles of relevant figures in science and engineering.

The resource incorporates keywords to categorize profiles, facilitating lecturers in identifying those relevant to specific modules and aiding students in searching for profiles aligned with their interests. This feature makes our toolkit a simple yet powerful resource to showcase diversity and contextualise the learning experience beyond the classroom.



71 The ENIAC Six: Betty Holberton, Jean Jennings Bar-klay, Kay McNulty, Marlyn Wescoff and Ruth Lichterman and Frances Biles Spencer

Computing and Programming

Keywords: Female, Diversified, Coding, Science, Human computer

These six women were pioneers in programming and were treated with remarkably progressive opportunities in the 1940s. In 1946, the U.S. Army recruited Holberton, Jennings, McNulty, Bar-klay, Wescoff and Lichterman to program the ENIAC, the world's first general purpose computer. The women were the only women to work on the machine during World War II. The role of these mathematicians included solving complex equations associated with ballistics, and they were given access to areas to complete this mission both at the time. The women were also granted clearance to work on the machine, a privilege not granted to most other women and engineers. Despite this, they were also not allowed to drink and could not wear makeup, and they were not allowed to wear jewelry. The computer was used until 1955 when it was decommissioned, but it still has been used to the present day. The ENIAC Six's contributions and their experiences are now being taught to all ages.

Read more in [The ENIAC Six: A Story of Women's Contributions to the Birth of the Computer](#), by Betty Holberton, Jean Jennings Bar-klay, Kay McNulty, Marlyn Wescoff and Ruth Lichterman, and Frances Biles Spencer.

77 Ron Buckmeier (1968 - present)

Fluid Dynamics, Numerical Analysis, Mathematical Education

Keywords: Space, Innovation, Outreach

Ron Buckmeier (1968) is a Canadian-American applied mathematician and mathematician educator. He has been a mathematician for his entire life, starting with an undergraduate research project on homogeneous functions, during which he realized that he would go on to learn mathematics. His PhD work looked at computational fluid dynamics, and much of his research work has been in fluid dynamics. He has also worked on developing new methods to provide numerical analysis for real-world financial models.

In recent years, Buckmeier has stepped into the role of Associate Dean for Academic Affairs at Yorkville College (YCU) and is Program Director with the National Science Foundation (NSF) in the USA. In his role with YCU, he oversees all academic initiatives and is responsible for improving the curriculum, and in his role with the NSF he has the responsibility of allocating funding to initiatives which will promote undergraduate mathematics education throughout the US. He also speaks at conferences for students who graduate with a mathematics degree and go on to research-related jobs.

Buckmeier is also a special advocate for opening up opportunities in STEM for marginalized groups. He is a co-founder of the QMUL+ mathematics organization. This role has given him many opportunities for improving mathematical education, its delivery, diversity and inclusion, and publishes many articles in these areas.

Read more in [The ENIAC Six: A Story of Women's Contributions to the Birth of the Computer](#), by Betty Holberton, Jean Jennings Bar-klay, Kay McNulty, Marlyn Wescoff and Ruth Lichterman, and Frances Biles Spencer.

VIDEO INTERVIEWS & POSTERS

We filmed short video interviews of mathematicians from diverse backgrounds and fields. The interviews prompted the participants to talk about what they enjoy about mathematics, who or what motivates them and brought to light lesser-known challenges they faced.

We also expanded several profiles covered in the biography booklet into a set of posters which are now on display in the SMS building at QMUL.

This very visible celebration of diverse figures beyond our modules promotes an inclusive culture at QMUL, for both students and academic staff.

IMPACT & FUTURE WORK

We have received positive feedback from both students who enjoy the incorporation of these figures in their curriculum, and from academics who support this practice. We have also presented this project at various universities and secondary schools in the UK.

Additionally, the profiles of mathematicians are being disseminated through the Schools' social media accounts on a weekly basis, while also including featured figures and video excerpts from time to time.

This project is constantly evolving, with resources continuously being added and updated over time. A possible future direction is to conduct research into the learning outcomes of students following the pilot implementation of the resources within several first and second year undergraduate modules across both Schools.

CONCLUSION

By providing students with relatable role models from a range of backgrounds, which are in line with the multicultural society that the curriculum serves, our resources take one step closer to destigmatising and broadening access to a successful future in STEM. This project gives a glimpse into the vast number of individuals overlooked by the curriculum and aims to identify the resultant impact on students' perception of STEM subjects.

ACKNOWLEDGEMENTS

This project was made possible by SMS and SEMS at QMUL, and by the work of a cast of PhD students, postdoctoral staff, teaching fellows and academic lecturers. We are also grateful to the Department of Chemistry at QMUL, whose similar project inspired our own.



THANK YOU FOR
LISTENING