Mathematics, the Racial Integrator

As a child if someone had told me that later in life, I would be writing an editorial for the *Mathematics Today* magazine, to celebrate Black History Month, I would have laughed and looked for the hidden cameras. Black children, like me, were often misclassified as having special educational needs. Moreover, the chances of me going on to obtain a PhD in a mathematical subject was much less than 0.1%.[1] However, this is exactly what I went on to achieve.

Dr Howard Haughton

My love for mathematics was insatiable and I was not prepared to let other people's view of me become my reality. I recall reading books on calculus (even before being formally taught the subject) and setting myself problems to solve even though I did not know the solution. I was keen to find someone that looked like me who also loved mathematics, but I found none, not even in the books provided to me for my studies. Was it that Black and Brown people had made no significant contribution to the development or application of mathematics? Surely, this could not be the case.

As a teenager, I took inspiration from what I had read about the Indian mathematician Srinivasa Ramanujan FRS. Those that chose to shine a light on the work of Ramanujan, perhaps including Ramanujan himself, could have been dismayed by critiques of his early work. One such critique came from Micaiah John Muller Hill FRS (see [1]) who found technical flaws in Ramanujan's work, made suggestions for his further reading but also suggested that he lacked the educational background to be accepted by mathematicians. Notwithstanding this, Ramanujan went on to state numerous theorems (most of which have been independently proved by others) such as the Mellin transform [2] that has contributed to the evaluation of definite integrals. Ramanujan also went on to work with Godfrey Harold Hardy FRS, a person with whom he had very little in common except for the love of mathematics. Differences in colour, religion or ethnicity seem to have played no part in their relationship and although their 'mathematical dialect' was different it proved to be their integrator.

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After completing my PhD in mathematical computer science my first job was as a research scientist working on the application of category theory and logic to defining computer program semantics. Out of 60 research staff, only three were Black. This statistic made me reflect on whether I had made the right choice for the start of my career. None of the key figures in this field of applied mathematical research were Black. Once again, I had no role model in my own image. Notwithstanding, my love for mathematics proved to be the integrator and I successfully co-authored the publication of more than a dozen papers and three books. Looking back on my choice of studies at university, I believe I chose well since my skills are applicable to a host of areas including:

- Finance e.g., quantitative researcher, exotic derivatives trader/structurer
- Data scientist
- Accountancy
- Research scientist
- Software engineer
- Mathematical modeller
- Statistical/quantitative researcher in public/private sector

Despite the successes I achieved as a scientist there were numerous barriers to navigate as a Black person. Institutional racism made it difficult to scale the corporate leadership ladder and no matter how many papers I wrote, this issue appeared to be persistent. This situation was the catalyst for a period of self-reflection. It also led to my desire to better know the contributions of Black and Brown people to the development of mathematics. My hope would be that I could use this to spread the news to others with a view to using this as an integrator for racial equality.

Nearly all textbooks in calculus (or university courses) will refer to Gottfried Wilhelm Leibniz and Isaac Newton as being the people who, independently, developed the subject. However, it is known that many aspects of calculus were developed many years before the birth of these individuals. Notable contributions include the Arab mathematician Abu Ali al-Hasan ibn al-Haytham [3] and Archimedes of Syracuse [4]. Whilst it is true that these contributions were aimed at solving specific problems, might lack generality and did not formally recognise the fundamental theorem of calculus, they influenced the direction of travel for its development.

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The awareness that various aspects of what we now call calculus were not solely developed by Europeans gave me the desire to do further research. After all, a common application of integration is to calculate areas and volumes and it might be that such calculations even predate Abu Ali al-Hasan ibn al-Haytham and Archimedes. The answer was to be found in papyri: the Rhind Mathematical Papyrus (RMP) and the Moscow Mathematical Papyrus (MMP). Both RMP and MMP provide evidence that the ancient Egyptians were able to solve problems that we would now write in the form of linear algebraic equations as well as to calculate the area and volume of various shapes. This provided me with my aha moment.

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This, as well as other mathematical competencies, is very likely to have influenced many Greek scholars such as Thales, Pythagoras, Socrates, Plato, and others to study in Egypt and possibly other places like Babylon. Unfortunately, whereas the contributions of the ancient Greeks are well known, little credit seems to have been given to the Egyptians or Babylonians who may have provided much of the foundation for such contributions.

For example, the Berlin papyrus refers to a specific example whereby the area of a square of 100 square cubits is equal to the sum of the areas of two smaller squares with the side-length of one being $1/2 + 1/4$ that of the other. This can be formulated as

$$x^2 + y^2 = 100, \quad x = \frac{3y}{4}$$

with solution $x = 6$, $y = 8$. As with other historical ancient Egyptian calculations this example is not general, but this does not suggest they did not know that the relationship existed for all square values on the right-hand side of the sum of squares, for a right-angled triangle.

Both Aristotle and Herodotus [5] give credit to the Egyptians for the birth of geometry despite disagreeing on the reasons for its existence. Nonetheless, this acknowledgement provided the basis for mathematics to be used as an integrator between diverse cultures. Today, there are those who would seek to use mathematics as a differentiator suggesting only Europeans have advanced the state of mathematics and science. It is, however, evident that this is not true.

In this month's *Mathematics Today*, there are several contributions by a diverse group of mathematicians. Nira Chamberlain provides details on building a powerful mathematical identity in his Presidential Address. Nira explains that his quest to build this identity arose from a discussion at an IMA event in 2004 during which a delegate stated, 'They would not call themselves a mathematician at a cocktail party'. Nira's response was to ask, 'Who among you would defend mathematics live on a radio station if the DJ had earlier declared that mathematics is boring?'

In his piece, Nira speaks about the perception of mathematics, as portrayed by some in the media or public, as being disliked, unattractive and less relevant than other subjects. To counter this, Nira suggests that mathematicians should proudly position themselves as those that lead by action or example in this era of mathematics. As Nira observes maths is the glue which supports several other disciplines such as information technology, engineering, economics and other sciences. Through his personal mathematical journey, Nira provides a reminder that mathematics is for everyone, and that age should not limit one's ability to make contributions to this discipline.

Mark Richards describes his use of the Nyquist–Shannon sampling theorem to aid in the recovery of a signal (a continuous function of time) from a sequence of discrete sensors. Mark demonstrates the use of this theorem in assessing the feasibility of replacing a dense network of static air pollution sensors with a smaller number of devices fitted to buses.

In his piece, Mark remarks that his use of sampling theory was due to serendipity arising out of a discussion with fellow scientists Stephon Alexander and Bill Massey about the under-representation of Black scientists and researchers in the US and UK. Although perhaps not the focus of Mark's work, it is likely that the results could help to support urban planning, in particular transportation. Given what we now know about the relationship between air pollution and COVID-19 and their disproportionate impact on Black lives, remedial action could be taken to reduce pollution and improve the well-being of many people.

Lloyd Kilford discusses Magic Squares motivated by the work of the Black African Muhammad ibn Muhammad al-Fullani al-Kishnawi who was a mathematician, astronomer, mystic and astrologer. In a brief review of a page from al-Kishnawi's manuscript, Lloyd draws similarities between groups formed by the set of squares under rotation and reflection with those of dihedral groups and suggests the former could be used as a basis for discovering abstract groups like the dihedral group. Lloyd describes several methods, devised by al-Kishnawi, for

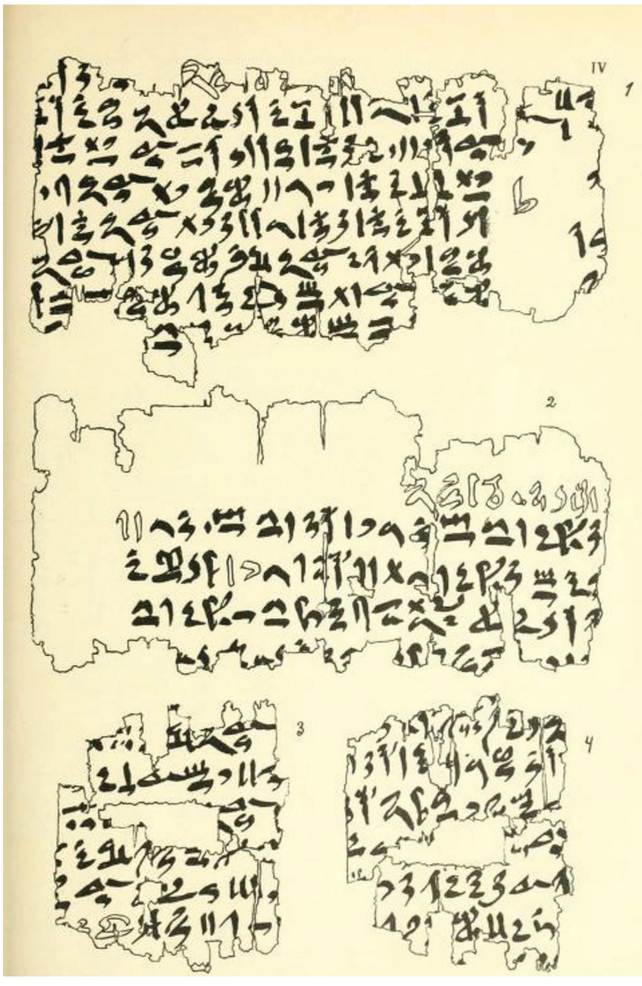

Image credit: Historic Images | Alamy Stock Photo

Berlin papyrus 6619

the construction of magic squares one of which exemplifies the type of perseverance al-Kishnawi talked about in his writings due to the exacting nature of its procedures.

Ejay Nsugbe discusses the design and application of an AI-driven pregnancy labour prediction decision support system. Ejay highlights the results of studies which reveal that obstetric outcomes vary by ethnicity and that preterm labour is higher for Black than for White mothers. Consequently, a key motivation for the development of this system is to be able to predict labour imminency more accurately by explicitly accounting for ethnicity. Such a system could be used to trigger the use of early treatment or other strategies to aid labour. Ejay describes the mathematical physics behind magnetomyography sensing and how such sensing data can be combined with the machine learning technique of a support vector machine to produce highly accurate labour predictions.

Finally, Snezana Lawrence discusses the work of the late American civil rights activist Robert Parris Moses. Snezana draws attention to the work Moses undertook as a mathematics educator and the important contribution of the Algebra Project which he started in 1982. The aim of the project is to develop high school mathematical literacy in students from under-represented groups, specifically Black/ethnic minorities and/or those belonging to low-income families, as preparation for higher-level studies. This project survives Moses and is implemented across several states in the USA.

These diverse contributions further support the view that mathematics can be used not just as an integrator for racial equality but for other protected characteristics.

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Notes

1 This figure assumes a Black person obtains AAA at A-level, goes on to obtain at least a 2:1 degree and has a 1.2% chance of being funded for a PhD (not necessarily in mathematics) which they successfully complete.

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4 Boyer, C.B. (1959) *The History of the Calculus and its Conceptual Development*, Dover Publications Inc., New York.

5 Macdonald, C. (1950) Herodotus and Aristotle on Egyptian geometry, *The Classical Review*, vol. 64, no. 1, p. 12.