Working together: mathematics education in a changing landscape

Royal Society Advisory Committee on Mathematics Education

2018 conference report

THE ROYAL SOCIETY

Introduction

The Royal Society Advisory Committee on Mathematics Education (ACME), held its 2018 conference *Working together: mathematics education in a changing landscape* at the Royal Society on Tuesday 17 July 2018. Over 150 delegates attended, including teachers and senior leaders, mathematicians, policymakers and education researchers, to discuss the key issues in mathematics education policy.

The conference explored how the mathematics community can effectively work together to:

- facilitate progression in mathematics from early years to primary;
- enhance professional learner journeys for mathematics teachers;
- strengthen post-16 mathematics pathways;
- develop data science within mathematics; and
- signal the value of mathematics across all phases of education.

The conference is a key part of the Royal Society ACME's work, providing an opportunity to engage with the education community and explore policy priorities in mathematics education to inform its future activities.

Image: delegates at the conference.

Foreword

The Royal Society ACME 2018 conference *Working together: mathematics education in a changing landscape* was about working together to ensure that the UK education system supports high-quality teaching and that young people understand the importance of mathematics and quantitative skills. Key aspects of the changing landscape of mathematics education were discussed in workshops and panel discussions. Delegates and speakers also explored how best to signal the value of mathematics across all phases of education.

The conference provided an opportunity for the Royal Society ACME to engage with the education community and explore policy priorities in mathematics education to inform future activities.

The Royal Society has a long history of supporting education and the Royal Society ACME's work is key to ensuring mathematics education policy and practice are informed by educational research, developed in collaboration with experts and robustly evaluated to ensure that all young people have the opportunity to study appropriate mathematics up to 18.

Professor Frank Kelly CBE FRS
Chair, Royal Society ACME

Dr Mary McAlinden
Chair, Conference Organising Committee

Workshop sessions

The conference began with four parallel workshop sessions exploring key themes in mathematics education from early years up to age 19. Led by Royal Society ACME committee members and Royal Society ACME Contact Group chairs, the workshops explored existing curriculum and pedagogy issues.

Organised by educational phase, each of the workshops included presentations and discussions on key policy issues impacting the sector:

- Mathematical needs of pupils in early years and primary education.
- Professional needs of secondary teachers of mathematics.
- Data science needs within the A level mathematics curriculum.
- Suitable post-16 mathematics pathways for all learners.

A plenary panel session followed the workshops, permitting time to explore cross-phase issues.

"In our workshop, we had an interesting discussion about professional development, in the context of Royal Society ACMEs recent report, *Professional learning journeys for teachers and mathematics*. And our discussion was focused on how we could achieve a coherent framework... that provides a right and responsibility for all secondary maths teachers and other teachers to engage in professional development throughout their careers."

Professor Jeremy Hodgen

Image: workshop participants.

Workshop 1: Progression in mathematics from early years to primary

Workshop leads: Lynne McClure, Dr Sue Gifford, Dr Alison Borthwick

Through the consideration of division and algebra, the workshop explored progressions in mathematics through early years to the end of primary education. The discussion examined teaching and assessment, with particular focus on implications of reforming curriculum content, teaching methods and teachers' professional development.

Delegates expressed a need for:

- a simplified and clearer progression in the National Curriculum to help teachers plan within an overall framework, rather than having to focus on yearly teaching objectives;
- a shared understanding of deep conceptual issues to be able to consider progression from early years to primary, and to develop an agreed approach to teaching;
- identification of key aspects of the curriculum for teachers to assess, with examples;
- closer linking between the National Curriculum and testing, to include reasoning and problem solving; and
- professional development and support to deepen teachers' conceptual understanding of progression in mathematical learning.

Workshop 2: Professional learner journeys for secondary teachers of mathematics

Workshop lead: Professor Jeremy Hodgen

This workshop examined a key recommendation of the 2016 ACME report, *Professional learning for all teachers of mathematics*, which was to achieve 'a coherent framework on mathematics-specific professional learning'.

The workshop discussion covered strategies for achieving a coherent framework, including:

- time needed;
- national, regional and local geographical scales;
- anticipated costs;
- mitigation of negative effects; and
- the role of the Royal Society ACME.

Four possible strategies emerged:

1. Ring-fencing time (perhaps two–three days) for subject-specific professional development, focusing on the five days of In-Service Training (INSET) that schools run each year.
2. Encouraging Ofsted to include subject-specific professional development within the inspection framework.
3. A contractual or registration requirement for teachers to complete a minimum amount of subject-specific professional development on an annual or other regular basis.
4. Devising a 'national curriculum' for teacher education in mathematics.

When considering change, delegates expressed a need for caution. Unintended consequences of these strategies, particularly in the context of teacher shortages, were a key consideration. A much-needed cultural shift among mathematics teachers, recognising the pressure to perform and lack of time to engage in training, would also need to be coupled with better quality assurance about the value and benefits of continued professional development opportunities.

Workshop 3: Post-16 mathematics pathways for all: challenges and opportunities

Workshop lead: Professor Andrew Noyes
Introduction: Professor Paul Glaister

In this workshop, experts from across the mathematics education community came together to consider post-16 pathways in mathematics. A broad-ranging SWOT (strengths, weaknesses, opportunities, threats) analysis generated comments about the opportunities and challenges faced by schools, sixth-form centres/colleges and Further Education colleges.

Strengths

- Functional skills reform.
- High value placed on GCSE mathematics resits.
- Availability of Core Mathematics qualification.

Weaknesses

- Insufficient qualified teachers.
- Pay discrepancies between school and FE teachers.
- New GCSE is more difficult, adding to the pressure on students and teachers.
- High level of English literacy required for Functional Skills qualification.

Opportunities

- Functional Skills provides an alternative to develop vital mathematical skills.
- Primary Maths mastery should lead to greater confidence in mathematics.
- Mathematical skills can be developed within the context of other subjects.

Threats

- Insufficient teachers.
- Insufficient qualified teachers.
- Poor pipeline of teachers.
- Progress measures potentially having negative impact upon students' access to pathways.

Significant opportunities for mathematics pathways have also arisen in the last year. These include funding for additional students to study level 3 mathematics, the development of T levels with embedded mathematics, and a continued increase in schools offering Core Mathematics. However, these opportunities have been balanced by challenges ranging from a lack of overarching design for different pathways, to the insufficient supply and retention of teachers.

The discussion finished with consideration of an overarching redesign of post-16 mathematics education to:

1. create a set of qualifications and curriculum pathways with continuity of development, ensuring that – at its core – what it is to learn mathematics remains stable, and that progression is possible; and
2. ensure there is a clear understanding of what students will gain, how to teach, and what professional development should look like.

Workshop 4: Rising to the data science challenges within new A level mathematics

Workshop leads: Professor Emma McCoy, Dr Vanessa Pittard

Although this workshop focused on incorporating data science into A level mathematics teaching, the discussion also considered data science across the curriculum.

Data science is shifting the landscape of education and its potential impact reaches beyond mathematics and the sciences into arts and the humanities. Schools and colleges face considerable challenges around the use and analysis of data – issues that are increasing in importance to society. Schools must think differently about teaching statistics, and this topic should be addressed in a coherent way across the curriculum.

Possible future avenues include:

- encouraging schools to include data challenges within organised student challenges;
- professional development opportunities and data science resources for teachers, helping them learn how data can be explored with their students; and
- providing students with 'data days' during which they can explore and understand how to interrogate and analyse data.

Working together: Mathematics education in a changing landscape

This plenary session provided an opportunity for the workshop leads to share key messages with delegates and to consider the areas in which everyone can work together to build greater cohesion across mathematics education.

Panel

Dr Mary McAlinden (Chair), Royal Society ACME member, Head of the Department of Mathematical Sciences, University of Greenwich

Lynne McClure, Royal Society ACME member, Director, Cambridge Mathematics

Professor Jeremy Hodgen, Royal Society ACME member, Professor of Mathematics Education, University College London

Professor Andrew Noyes, Head of School of Education, University of Nottingham

Dr Vanessa Pittard, Deputy Chief Executive, Mathematics in Education and Industry (MEI)

Summary

- In the discussion it was suggested that more cohesive mathematics education policy messages could be achieved through:
- communication of key stories in mathematics across all phases of education, to provide a common and meaningful context for teaching, aid transition between phases and develop a common language that is accessible to all mathematics teachers;
- a coherence about what 'mathematics education' is across mathematics curricula and qualifications at all levels, and in respect of the teaching of mathematics in other subjects;
- a slowing in the pace of change in order to allow the time required for this coherence to be developed; and
- ensuring through professional development that mathematics teachers are critically engaging with teaching and research, thereby creating a teaching profession that is more informed about evidence-based research.

Image: Panel members (left to right), Dr Vanessa Pittard, Professor Andrew Noyes, Professor Jeremy Hodgen, Ms Lynne McClure.

KEYNOTE ADDRESS

Rt Hon. Elizabeth Truss MP, Chief Secretary to the Treasury

During her time in government, the Rt Hon. Elizabeth Truss MP has been a strong supporter of mathematics education.

Providing a broader political context to the role of mathematics education in society, Ms Truss explained that in her role as Chief Secretary to the Treasury, she was responsible for helping to make the country more productive so as to ensure the economy grows. In theory, the Minister said, she had responsibility for an annual budget of £800 billion of public money (equating to £29,000 per household), and for ensuring good value for money for each penny spent. She described how people who lack confidence with numbers, and don't feel capable of using mathematical thinking, are not only held back in their individual lives, but this also has an impact on the economy.

During her speech, she encouraged the mathematics education community to maintain its efforts to change cultural attitudes towards mathematics in Britain. Her hope was that cultural change towards mathematics would result in many more young people perceiving it as an exciting subject, which they then want to study beyond age 16.

Ms Truss identified some of the symptoms that suggest cultural change should be a priority for the mathematics community. Gender imbalance in post-16 qualifications, she suggested, was one such symptom. The Minister highlighted the economic importance of increasing the numbers of girls taking mathematics post-16, given that the earnings premium for a girl studying mathematics was greater than that for a boy, and there were a wealth of career opportunities in sectors such as technology and finance, where women are underrepresented.

The regional disparity in the numbers of 16–18-year-old students studying mathematics was another issue highlighted. She stated that her ambition "is to see the levels of students studying mathematics in the North of England overtake that of the South of England". It was suggested that one way of tackling these differences was to encourage more universities to consider opening schools of mathematics. She noted that the Department for Education had recently announced a mathematics school would be opened in Liverpool and reminded delegates that the Treasury would be providing additional funding for this.

Enabling access to appropriate post-16 mathematics pathways was something the Minister has long prioritised, and she spoke of her pride in introducing the Core Mathematics qualification. Alongside this, she described her hopes for both the new T level qualifications and for the Advanced Maths Premium, which rewards schools with £600 funding for each additional 16–18-year-old pupil that studies post-16 mathematics.

Finally, the Minister invited the community to share with her any fresh ideas that might help create "a mathematically literate and mathematically excited country".

> "Giving children a good education in mathematics is part of helping them become their future selves. Mathematics education has a big role in our national life and actually is very important to us as an economy."
>
> Rt Hon. Elizabeth Truss MP

Signalling the value of mathematics: Making informed choices at all stages

In the context of growth in the demand for improved quantitative skills across society, signalling the value of mathematics takes on a new urgency. In introductory remarks, Chair Dame Jil Matheson DCB highlighted the need for urgent change, and echoing Ms Truss's earlier conference keynote, voiced her concern about the gender gap and the need to engage more girls in mathematical subjects.

Panel

Dame Jil Matheson DCB (Chair), Royal Society ACME member

Professor Louise Archer, Professor of Sociology of Education, University College London

Josh Hillman, Director of Education, Nuffield Foundation

Professor Mark Smith, Vice-Chancellor, Lancaster University

Amanda Spielman, Chief Inspector, Ofsted

Although a priority of the Royal Society ACME's work has been signalling the value of Level 3 mathematics study, which followed Sir Adrian Smith's review of post-16 mathematics, the session took a broader perspective, considering the impact of signalling across all phases of education.

Image: The panel members, from left to right: Amanda Spielman, Professor Mark Smith, Professor Louise Archer and Josh Hillman.

Summaries of contributions from panellists

Mr Josh Hillman, Director of Education, Nuffield Foundation

As the first speaker, Mr Hillman framed the discussion, emphasising the importance of a broad view of those signalling (universities, employers and teachers), those being signalled to (including young children and their parents) and the various ways in which quantitative skills are acquired beyond mathematics. He identified challenges, such as the gender gap and low attainment in the subject, while also pointing to recent research looking at how shortages of maths teachers affects their allocation in schools[1].

He explained that teaching capacity was an underlying concern. The percentage of teachers with a specialist degree is lower for mathematics than for English, and evidence suggests that schools serving the most socioeconomically disadvantaged students tend to have the least qualified teachers[1]. Many schools allocate their most qualified teachers to A level classes and Mr Hillman's view was that this may affect pupils' progression in the subject at younger ages, given the enormous influence teachers have on young people's attitudes to, and choices of, subjects.

Previous research commissioned by the Nuffield Foundation found that in England, Wales and Northern Ireland, participation in post-16 mathematics was lower than in many other countries[1]. Low participation is at odds with the increasing demand for advanced mathematics and data skills across the UK labour market. Other researchers have found that 28% of students taking at least one A level, take A level mathematics, which makes it the most popular subject. However, 39% of males taking A levels take mathematics compared with 20% of females, indicating a significant gender gap[2]. He expressed his concern that this needed to be addressed if uptake of A level mathematics is to increase.

In his presentation Mr Hillman stressed that if the objective of signalling was to increase participation of all students in mathematics, and help inform choices, then there was a need to look well beyond A level mathematics. He mentioned the low take-up of Core Mathematics so far, and the significant regional disparity in its provision. Ongoing Nuffield-funded research, he said, was looking at the progress of this new qualification[2].

The presentation finished with a number of recommendations. He suggested more work was needed on supporting ways of encouraging the development and accreditation of maths skills in other subjects. He also encouraged increased take-up of A level statistics. He suggested that universities need to continue to find imaginative ways of supporting students who have not taken a post-16 mathematics qualification. He cited Nuffield's Q-Step programme supporting quantitative social science training in universities across the UK, and said that Nuffield would like this approach to extend beyond the social sciences into natural sciences, arts and humanities[3].

He expressed the view that more effort needed to be made at an earlier stage as teachers exert enormous influence on young people's attitudes to subjects, and their choices of subjects. He also said that alternative means for achieving GCSE mathematics should be considered for those that do not achieve a good grade the first time, as statistics show that retaking the exam is not effective. In his view, the aspiration for all post-16 students to study some form of mathematics was in danger of being unachievable within the current qualification system.

Professor Louise Archer, Professor of Sociology of Education, University College London

Professor Archer's presentation challenged three assumptions underlying signalling as a way forward, drawing on her ten-year study funded by the Economic and Social Research Council (ESRC), examining the subject choices of over 40,000 pupils aged 10–18[4].

1. Allen, R. and Sims, S. 2018. *How do shortages of maths teachers affect the within-school allocation of maths teachers to pupils?* The Nuffield Foundation. See: nuffieldfoundation.org/sites/default/files/files/Within-school%20allocations%20of%20maths%20teachers%20to%20pupils_v_FINAL.pdf (accessed 27 November 2018).
2. The Nuffield Foundation. The early take-up of core mathematics. See: nuffieldfoundation.org/early-take-core-mathematics (accessed 27 November 2018).
3. The Nuffield Foundation. Q-Step. See: nuffieldfoundation.org/q-step (accessed 27 November 2018).

Image: Professor Louise Archer (left) and Josh Hillman (right).

The assumptions were that young people:

- do or do not choose mathematics based on perceptions about how relevant it is;
- make rational subject choices; and
- must be the problem, not mathematics itself, if signalling is the answer.

The study found that 74% of year 13 students agreed that mathematics could help them obtain many different types of jobs, but that such a belief did not translate into higher post-16 mathematics participation rates. Self-confidence was identified as a factor, although feeling good about mathematics did not relate to attainment, with high attaining girls less likely to identify as being 'good enough' at mathematics. The system set-up and entry criteria, she explained, sent strong messages about who could be good at mathematics and the importance and utility of subjects.

The second assumption described was that young people make rational subject choices, when in fact, choices are mediated by identities and other factors. She said official sources of information and 'grapevine knowledge' were trusted and used differently depending on social class signalling, impacting how young people made decisions and whether they saw mathematics as a good choice for them.

The final assumption was that the issue rests with young people and not maths or signalling. Drawing on her research on science, she explained that the more likely it is that society thinks you have to be clever to study a subject, the more likely that schools will insist that young people have higher grades at age 16 in order to continue to study the subjects post-16. This leads to more socially differentiated patterns of participation and young people excluding themselves from studying these subjects.

Finally, Professor Archer suggested that the current education system (A level versus baccalaureate) affected participation. Recognising that a system change was unlikely in the immediate future, therefore, she suggested the focus should be on factors that could have an impact. Her research has shown that the way a subject is taught can radically change the way young people identify with it. Teachers were a key point of leverage, with the schools she has worked with showing big changes in the way that they teach, which affected the dispositions and ideas of young people, and their aspirations to continue further study.

4. Archer, L, DeWitt, J, Osborne, JF, Dillon, JS, Wong, B & Willis, B 2013, ASPIRES Report: Young people's science and career aspiration, age 10 –14. King's College London.

Professor Mark Smith, Vice-Chancellor, Lancaster University

Talking from a higher education perspective, Professor Smith focused on the mathematical content of A level and undergraduate subjects, from physical and life sciences to economics and business studies. He explained that in a 2013 review of 13 A levels, apart from physics, the mathematical skills and the level of those mathematical skills was not explicitly outlined. He consulted on and then recommended, elements within the curriculum design that defined the mathematics content within the A level qualifications. He considered this to provide important signalling about the mathematical content of the subjects, which was also important for progression and success at university where those mathematical skills were necessary in the same A level subjects.

Professor Smith then went on to explain the difficulty of changing the signalling messages coming from higher education about the mathematical content of subjects. He noted that while many universities were being clearer about the mathematics content of their courses, in some there has been an adaption of syllabi such that less mathematically challenging versions were being offered. He explained that this opened up a question around progression of people who have done low mathematical content versus high mathematical content degrees. He also raised a further question about what universities should do for those students where mathematics in and of itself was not necessarily needed to be successful in their chosen subject. He emphasised that if universities were to prepare graduates for the job market, and for broader life skills, there was a question around whether they should be putting on more general courses in fundamental mathematical skills to ensure that graduates were as well-prepared as possible.

His presentation finished with a broad view of higher education's response to mathematical signalling, explaining the disincentives for universities to act alone in raising the mathematical requirements of their degrees. In particular, he identified the fear that such action could have a negative impact on admissions, with the potential for applicants to perceive one university's course to be more difficult than that of another.

Image: Amanda Spielman (left) and Professor Mark Smith (right).

Amanda Spielman, Chief Inspector, Ofsted

Ms Spielman expressed her views about the importance of mathematics and then spoke about educational essentialism which she identified as the underlying concept in the British system. She spoke about the encouraging trend of maths for everybody post-16 but also expressed concern that the labour market needed to send out clear signals to children coming through the system.

She expressed her concern that there was confusion between grades and learning. She said that the focus should not be on getting as many marks or as high grades as possible, but that rather the focus should be more on learning as much as possible, getting the depth, mastery and control of a subject to make the best possible platform for carrying on future study in that subject, or the subjects that build on it. She explained the relevance to both primary and secondary education; expressed the hope of moving towards a more coherent curriculum; and encouraged thinking about the totality of the programme offered by schools, rather than grades and outcomes. Ms Spielman finished by saying that she would carry on trying to make sure that Ofsted uses the leverage that it has, not on children, but on teachers, schools, Multi-Academy Trusts (MATs), and various other parts of the education system, to think intelligently about the value of subjects and study for what they are, not just for the grades that they contributed to a CV.

Image: Participant during the question and answer session.

Question and Answer session

The first question asked the presenters whether the current pathways from early years to age 18 were appropriate for all young people. This question drew mixed responses from the panellists, although the general view was that the current pathways support some young people very well.

Panellists commented that:

- young people must be certain about what they want to study, as pathways will be closed off by certain, earlier choices;
- there was a supposition that the education system is geared towards one outcome – university – and it was questioned whether the system is appropriate for moving directly into the labour market; and
- the pathways are fairly complete but there isn't always enough effort put into making sure that good use is made of all of them.

The audience were encouraged to make sure that all of the current pathways get used by as many people as possible.

The next question asked what might be done to get schools to better appreciate the value of mathematics, beyond the value of high grades. The question referenced the pressure on teachers to get high exam performance, making it very difficult for them to teach the subject well for its own sake. The responses suggested that the mathematics community consider:

- teacher supply and how that is used in schools (deployment of maths specialists);
- routes into the teaching profession and whether a mathematics degree is necessary;
- giving teachers a framework for understanding maths while also making the subject more engaging and personally meaningful to the students; and
- moving the focus from grades to 'how you teach', ensuring teachers have confidence in what they are teaching.

Closing remarks

The Chair asked the panellists to contribute one final thought about what their message would be about signalling the importance of mathematics.

Mr Hillman said that more should be done to promote Core Mathematics and that the Royal Society should have a large role to play in this.

Professor Archer pragmatically encouraged people to approach signalling as a complex issue, instead of assuming that simple messaging will ensure increased take-up of A level mathematics.

Professor Smith believed that the strongest signal universities send is that they don't want rounded people at age 18. This is the part of the signalling which Professor Smith would like to change.

Ms Spielman ended by saying that she would continue to consider, and would welcome advice on, how Ofsted could send the most constructive signals around mathematics, and indeed other subjects. She finished the session by saying that schools, teachers, parents and children are at the receiving end of these signals and everyone needs to make sure that signalling to each of these groups generates the confidence that young people need to pursue mathematics.

KEYNOTE ADDRESS

Mr Paul Kett

As Director General for Education Standards at the Department for Education, Paul Kett is principal adviser to the Department's Board. Among his key responsibilities are teaching and the teaching workforce, the curriculum, assessment and qualifications.

In his opening words Mr Kett welcomed the opportunity to speak at the conference, telling the audience that he never turned down an opportunity to speak when 'mathematics' was in the title. This enthusiasm for mathematics was explored further, as he discussed the importance of making more people passionate about the subject. This passion, he said, was essential to attracting more people to pursue mathematics to higher levels.

He then set out the argument for mathematics education, talking about the necessity of good mathematical and quantitative knowledge and skills for everyday life, the relationship between numeracy skills and employment, and the increasing demand for mathematical and quantitative skills aligning with the increasing sophistication of technology.

He argued that all pupils needed to develop a secure foundation in mathematics in the early years, and that this was critical to later academic success. He continued by thanking teachers, who have implemented the strengthened curriculum and improved practice in how mathematics is taught. The Secretary of State for Education, he said, has set his most urgent task as addressing the problems that were driving teachers and leaders from the profession, and that were putting others off from joining. He talked about workload, as well as ensuring stability for the National Curriculum, and the accountability system. Mr Kett went on to discuss support and professional development for teachers, as well as the need to improve the professional status of teachers. He said that teachers' influence on mathematics education and participation meant that it was essential to get the recruitment, retention and development of teachers right.

The keynote concluded with Mr Kett articulating the aspiration for the Department for Education and the mathematics education community to continue to work together to improve mathematics education. He used his responses to the questions following his presentation to set out the work of the Department for Education on teacher retention, recruitment and professional development. He recognised that very little was known about the effectiveness of the available teacher professional development but said that he would like to see more high-quality professional development provision accompanied by support for schools to access it.

CLOSING SPEECH

Professor Frank Kelly CBE FRS

Professor Kelly is the Chair of the Royal Society Advisory Committee on Mathematics Education.

Professor Kelly closed the conference with observations on the day's discussions. He said that it was not enough that the Government comprehends the importance of mathematics to the economy, country, and society; effective policy measures needed to be developed in collaboration with the maths education community. Taking the conference's theme of 'working together', he stressed that everyone in the mathematics education community had a part to play in developing policy measures that would ensure mathematics education has the desired impact on individuals, society and the country.

The Royal Society ACME, he insisted, were ready to play a significant role in mediating the wide-ranging discussions that needed to take place. In this regard the newly established Curriculum Contact Groups would play a key part in assembling the range of qualitative and quantitative evidence required to bring about policy reform.

The Royal Society is a self-governing Fellowship of many of the world's most distinguished scientists drawn from all areas of science, engineering, and medicine. The Society's fundamental purpose, as it has been since its foundation in 1660, is to recognise, promote, and support excellence in science and to encourage the development and use of science for the benefit of humanity.

The Society's strategic priorities emphasise its commitment to the highest quality science, to curiosity-driven research, and to the development and use of science for the benefit of society. These priorities are:

- Promoting excellence in science
- Supporting international collaboration
- Demonstrating the importance of science to everyone

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Cover image:
Benjamin Franklin's Magical Circle of Circles from a letter by Benjamin Franklin to John Canton, 29 May 1765.

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