

Professional learning for all teachers of mathematics

Principles for teachers, senior leaders and those
who commission and provide professional learning



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Foreword from the Chair, Robert Barbour



There is a very welcome aspiration for a world-leading education system in England, within which all young people develop high levels of mathematical competence and confidence¹. To achieve this highly-effective teachers of mathematics are paramount.

Those teaching mathematics should have the opportunity throughout their career to build on their knowledge about mathematics and knowledge about how to teach mathematics. The diversity of professional learning provision and competing demands on teachers and senior leaders mean that it can be difficult to know how to prioritise mathematics-specific professional learning. There is also no mathematics-specific professional learning guidance to guide these choices. To help fill this gap, the Advisory Committee on Mathematics Education (ACME) convened an expert panel to develop principles on professional learning for teachers of mathematics, bringing together expertise from the classroom, from research and professional learning (see page 13). As well as drawing on the knowledge of expert panel members, the panel held a number of events with teachers, senior leaders and experts and had over 200 responses to a teacher survey.

The principles are designed for teachers of mathematics at primary and secondary level and in Further Education (FE), as well as for senior leaders and for those who commission and provide professional learning in schools and colleges. We considered the knowledge needed by teachers of mathematics to become competent and confident teachers appropriate to the level they teach and who are able to motivate and inspire the next generation to achieve outstanding outcomes². We also provide advice on how mathematics-specific knowledge can be fostered both through personalised professional learning and collaborative learning groups.

A successful professional learning environment for all teachers of mathematics requires commitments from teachers, senior leaders, schools and colleges and from government.

- Teachers of mathematics reflect on the depth of their knowledge about mathematics and knowledge about how to teach mathematics.
- Schools and colleges enable teachers to build on their critical evaluation skills³.
- Teachers of mathematics have a personalised plan to deepen their knowledge about mathematics and knowledge about teaching mathematics.
- Teachers of mathematics have the opportunity within their school or college setting to sustain their mathematics-specific professional learning through the ongoing support of a collaborative learning group.
- School leaders work to transform current meetings of teachers of mathematics into collaborative learning groups.
- There is a commitment to a nationally-recognised mathematics-specific professional learning framework that emphasises the importance of sustained and quality-assured professional learning.

England's performance in mathematics is often benchmarked against other countries⁴. While a lot of focus has been on classroom practice in other jurisdictions, we also need to look at how other jurisdictions educate and nurture teachers of mathematics. England is well behind many other jurisdictions in terms of professional learning provision. Whereas in these countries there is a coherent embedded system, England is characterised by a more fragmented approach. There is also a diversity of routes into teaching and initial teacher education experiences vary greatly⁵. In addition, the issue of teacher supply is more urgent than ever (see box 1).

Andreas Schleicher, Director for Education and Skills at the OECD, noted that the mathematics curriculum in England is a 'mile wide and an inch deep'⁶. The Expert

Panel's experience in schools and colleges throughout the country convince us that this is not only an issue with the curriculum. In many cases how mathematics is discussed and explored in the classroom could be much deeper. Greater depth will only be achieved if teachers have the opportunity to develop deeper knowledge about mathematics and knowledge about teaching mathematics.

We hope that this document and additional online resources will be useful in helping teachers, senior leaders and those who commission and provide professional learning to consider the practical measures that they can put into place to prioritise mathematics-specific professional learning. Only by working together can change be achieved.

BOX 1

Challenges in the supply of teachers of mathematics requiring urgent attention

There are challenges in the recruitment, upskilling, professional development and retention of teachers of mathematics⁷.

- Most primary teachers have not studied mathematics post-16. The time dedicated to mathematics-specific education during ITE is typically much less than in high-performing jurisdictions.
- At secondary level, an estimated 5,500 extra specialist teachers are needed to teach the mathematics lessons currently taught by non-specialists, that is those without A level Mathematics.
- One quarter of those teaching 11 – 14 year olds do not have a mathematics-relevant qualification.

- The new larger GCSE Mathematics qualification and requirements for learners to continue taking GCSE Mathematics post-16 until they achieve a Grade C mean that there is an increased demand for teachers of mathematics in secondary schools and FE.
- There is a dire shortage of qualified teachers of mathematics in FE.

Different routes into teaching contain different quantity and quality of mathematics-specific training.

- There is no guarantee of high-quality, mathematics-specific content across ITE courses.
- Subject Knowledge Enhancement (SKE) courses provide an essential support for entry into mathematics secondary teaching for those with limited subject knowledge. There is, however, no quality assurance of these courses.

SECTION 2

Key elements to achieve the vision on professional learning for teachers of mathematics

Vision

Highly-effective teaching

Highly-effective teaching in the mathematics classroom rests on strong foundations of mathematics-specific knowledge that is gained through a mix of personalised and collaborative professional learning opportunities.

Schools and colleges supporting mathematics-specific professional learning

All schools and colleges prioritise subject-specific professional learning and senior leaders understand their role in supporting teachers to realise their entitlement to, and responsibility for, extending their mathematics-specific knowledge and continuing to update their critical evaluation skills.

Mathematics-specific professional learning framework

Teachers develop their mathematics-specific knowledge throughout their careers guided by a consistent and nationally-approved framework for subject-specific professional learning. Subject-specific professional learning is underpinned by quality assurance mechanisms.

Key elements

Mathematics-specific knowledge

Professional learning for those teaching mathematics should be designed and planned in such a way as to actively develop the full spectrum of teachers' mathematics-specific knowledge, that is knowledge about mathematics and knowledge about how to teach mathematics.

Critical evaluation skills

All those teaching mathematics should have the opportunity to reflect analytically on their practice, learn to critically evaluate research and develop strong inquiry skills from early in their career. This will maximise their engagement in, and benefit from, sustained personalised learning and collaborative learning groups.

Personalised professional learning

All those teaching mathematics should have a personalised plan that identifies the key opportunities needed to develop their subject-specialist knowledge throughout their career, which may, for example, include master's level study or other sustained courses. This is the basis for their discussions with their senior leaders and professional learning commissioners in their schools and colleges.

Collaborative professional learning

All those who teach mathematics should have the opportunity to continually work on their mathematics-specific knowledge and practice in collaborative settings throughout their career. Collaborative learning groups should be subject to external support and challenge.

A coherent framework on mathematics-specific professional learning

Schools and colleges, initial teacher education and professional learning providers, multi-academy trusts, local authorities and mathematics experts should together set the standards for the provision of coherent, career-long professional learning programmes for teachers at all stages of their career and demand quality assurance.

SECTION 3

Highly-effective teachers of mathematics and professional learning

A need for mathematics-specific guidance

Mathematics justifies specific attention given its importance across all phases of education and its centrality to other subjects⁸. It is also acknowledged that young people need to have mathematical and quantitative skills to be able to succeed in our data-driven world⁹. Mathematics is also distinctive given the lack of confidence held by many of those teaching and learning mathematics¹⁰.

In June 2016, the Department for Education's Teachers' Professional Development Standard was published, which provides a description of effective practice in professional development for teachers¹¹. However, there is no national guidance on the elements of mathematics-specific knowledge to be developed throughout teachers' careers. It can be difficult for teachers and senior leaders to identify mathematics-specific knowledge needed to become a highly-effective teacher and the professional learning required to develop this knowledge.

This document sets out key principles on mathematics-specific professional learning for teachers, senior leaders and professional learning commissioners, as well as professional learning providers. This principles document, as well as the online tools, can be used to reflect on a teacher's own learning journey, how senior leaders are supporting and fostering that learning and how schools and colleges are nurturing their teachers' learning. It should also provide a reflective tool for professional learning providers to consider what they offer. For example, it can provide the basis for conversations on knowledge about teaching, such as problem solving in the new curricula, or knowledge about teaching mathematics, such as the difficulties that learners face in learning about mathematics and their misconceptions.

BOX 2

Teachers of mathematics

The term teachers of mathematics encompasses all those who teach mathematics through all phases of education and those who teach mathematics within other subjects.

Progression of teachers of mathematics

All those teaching mathematics should have the opportunity to be involved in lifelong professional learning, always honing and deepening elements of knowledge about mathematics and knowledge about teaching mathematics as their roles evolve and the demands of the curriculum and learners change.

Each teacher will have their own distinct and individual learning journey. Those teaching mathematics require different support depending on the phase they are currently teaching, from early years to primary to secondary and FE. Individual and tailored approaches to professional learning are all the more important given the complexity and fluidity of teachers' careers and the diversity of entry points into teaching (see box 1).

An individual teacher's development will, therefore, be unique and cannot be categorised using predefined stages. To progress in a career and to become a highly-effective teacher of mathematics, teachers will need to develop, refresh or build on different elements of their mathematics-specific knowledge at different times. The principles set out should help with the decisions that they and their managers will need to make.

The focus of this guidance is on development as a teacher of mathematics. It does not chart a teacher's progression into leadership. Leadership involves a different set of skills^{12,13}. However, the knowledge and learning described here remain relevant for all teachers of mathematics, including those in leadership positions.

BOX 3

There are some online tools to support reflection on the development of mathematics-specific knowledge and how to foster mathematics-specific professional learning within schools and colleges. The tools include questions for reflection (expanding Table 1), case studies of teachers and senior leaders and an example of a lesson observation together with a lesson observation form designed to pick up the mathematical journey in a lesson¹⁴. See acme-uk.org.

SECTION 4

What mathematics-specific knowledge is needed to become a highly-effective teacher of mathematics?

BOX 4

Beliefs of highly-effective teachers of mathematics¹⁵

Highly-effective teachers of mathematics believe that:

- all learners are able to succeed in mathematics;
- it is the facilitation of deeper understanding that is effective rather than the transmission of methods;
- all learners develop strategies and networks of ideas by being challenged to think through explaining, listening and problem solving.

Highly-effective teachers of mathematics have a positive disposition towards the subject and are comfortable in exploring mathematical ideas with their learners. Teachers with such dispositions are more likely to engage in professional learning and develop their practice.

To achieve highly-effective teaching, those teaching mathematics should become expert in making decisions within a lesson or series of lessons, informed by learners' mathematical responses. This requires a deep understanding of the mathematical ideas of the lesson and the representations and language that support the development of the mathematical concept and a deep appreciation of the mathematical thinking that lies behind learners' responses. This is more likely to be achieved with a deep level of mathematics-specific knowledge. It also depends on the beliefs, identity and practice of a teacher of mathematics (see box 4).

Throughout a teacher's career there will be a need to extend mathematics-specific knowledge. Table 1 sets out some of the priority areas in terms of mathematics-specific knowledge for highly-effective teaching of mathematics¹⁶ (see box 5).

BOX 5

Knowledge about mathematics

The mathematics-specific knowledge set out in Table 1 is different in nature from the content of many degree courses in mathematics or degrees with substantial mathematical elements. The complexity of mathematics means that it is not feasible to cover the mathematics knowledge needed for highly-effective teaching during ITE.

Mathematics-specific knowledge includes knowledge about mathematics and knowledge about teaching mathematics.

• Knowledge about mathematics

Teachers of mathematics need to have a deep mathematics knowledge. Highly-effective teachers of mathematics will know the connections between different areas of mathematics, the underlying structure of the subject, representations of mathematical ideas, how mathematics is used in the world of work and the historical and cultural roots of mathematics.

• Knowledge about teaching mathematics

Teachers of mathematics need to understand how learners learn mathematics and why this subject is useful for their learning and career progression. Highly-effective teachers will know how to communicate key mathematical ideas and the connections between them, understand the structure of and changes to the curriculum, enable learners to see the big picture and predict, identify and address their misconceptions.

TABLE 1

Mathematics-specific knowledge

This table is not exhaustive. It identifies some of the priority areas for those teaching mathematics. An online tool, which extends the table below and provides some examples of the knowledge, is available at acme-uk.org and can be used to prompt and support reflection by teachers, senior leaders and professional learning commissioners.

| Knowledge about mathematics | Knowledge about teaching mathematics |
|--|--|
| <p>Teachers continue to develop proficiency in the mathematics relevant to the phase they teach and have:</p> <ul style="list-style-type: none"> • conceptual understanding; • procedural and factual knowledge; • the ability to reason; • the ability to solve and pose problems. <p>Teachers continue to develop specialist mathematical knowledge required for teaching including:</p> <ul style="list-style-type: none"> • the underlying structure of mathematics; • the connections between different areas; • how mathematical ideas build upon and lead to others; • ways of modelling and representing mathematical ideas; • specific and consistent use of mathematical language and notation. <p>Teachers continue to develop understanding and appreciation of mathematics as a discipline including:</p> <ul style="list-style-type: none"> • the way mathematics is used within other subjects and different terminology that might be used; • the way mathematics is used beyond the classroom, for example in work; • the history of mathematics; • the role of mathematics in society. | <p>Teachers continue to develop and evaluate their knowledge about the teaching of mathematics including:</p> <ul style="list-style-type: none"> • effective ways of explaining, representing and exemplifying mathematics; • knowing how to use particular resources, equipment and tools to support the learning of mathematics; • mathematical tasks and activities to use with learners; • ways of encouraging mathematical discussion and use of mathematical language. <p>Teachers continue to develop and evaluate their knowledge about mathematical learning including:</p> <ul style="list-style-type: none"> • planning mathematical journeys that build on learners' prior knowledge and experience, making connections and developing strong foundations for future study; • knowing how to motivate learners of mathematics; • knowing ways of listening to and observing learners as they carry out mathematics and understanding and responding flexibly to their learning needs; • knowing common difficulties learners can face and common errors and misconceptions that they make in mathematics and ways of responding to them; • knowing how to continually assess learners and to adapt questioning to support this and respond to answers given. <p>Teachers continue to develop and evaluate their knowledge about the mathematics curriculum that they are teaching and other phases of the curriculum including:</p> <ul style="list-style-type: none"> • the structure and sequencing within the mathematics curriculum; • the formal assessment and qualifications linked to the curriculum; • how and when mathematics is used in other areas of the curriculum; • how the mathematics curriculum is developed and the influences on it. |

SECTION 5

Professional learning provision – personalised and collaborative learning

How can it be ensured that teachers of mathematics have the opportunity to develop mathematics-specific knowledge?

High-quality professional learning for teachers of mathematics needs to rest on a culture of learning, openness and reflection within all schools and colleges. Senior leaders need to cultivate the link between teacher knowledge (set out in Table 1) and learner outcomes in the classroom. Schools and colleges will need to ensure that teachers have dedicated time for professional learning, both individually and in groups.

There also needs to be a commitment to a coherent and well-funded framework for professional learning provision across England¹⁷. This can only emerge through collaborative action. Systematic provision of professional learning would mean that schools and colleges and the teachers, senior leaders and professional learning providers are all aware of how, where and when to attain high-quality professional learning¹⁸. Quality assurance of provision must be a cornerstone of such an approach¹⁹. Schools and colleges would be better able to consider how to help teachers to identify, understand and map their needs.

BOX 6

High-quality professional learning environments

In ACME's 2013 report *Empowering teachers: success for learners*, the ideal is set out: 'Schools and colleges are vibrant learning communities in which learners thrive because teachers are actively collaborating in professional learning networks, inquiry groups and with experts...institutional commitment and local infrastructure support the career-long professional development of all teachers. Activities are purposeful, engaging and high quality, occurring formally and informally in a variety of ways.'

What skills do teachers of mathematics need for the most effective professional learning?

Throughout their careers as teachers of mathematics, all teachers should have the opportunity to develop critical evaluation skills, which can involve evaluation of research, analytical reflection, enquiry skills, lesson study and action research. These skills should allow teachers to reflect on and evaluate their knowledge about mathematics and knowledge about the teaching of mathematics and enable them to explore their own practice and that of others. Currently in England, the place of research and critical evaluation varies across ITE routes and not all trainee teachers have the opportunity to develop the critical evaluation skills needed to mature as effective teachers²⁰. It is essential that teachers have the opportunity to develop and build on those skills during their career both individually and collaboratively.

These two elements, personalised and collaborative, need to run side by side.

- Personalised and sustained professional learning within a supportive professional environment, with time for self-reflection, is key. (Element 1)
- International best practice and research indicate that mathematics-specific knowledge to bring about changes in classroom practice are most effectively embedded through collaborative learning groups. (Element 2)²¹

BOX 7

Critical evaluation skills

In ACME's 2015 report *Beginning teaching: best in class?* it was set out that 'Critical evaluation skills represent a teacher's facility to explore their own practice and that of others. It can involve the evaluation of research, analytical reflection, enquiry skills, lesson study or action research applied to the teacher's own practice.'

Element 1

Personalised and sustained provision

Effective, powerful and high-quality professional learning for those teaching mathematics can take different forms. However, at its best, mathematics-specific professional learning is sustained and personalised.

One-off courses and those that cover generic pedagogy are very limited in value. Sustained mathematics-specific professional learning may be gained through postgraduate study such as diploma, master's level or doctoral research or sustained courses that develop subject knowledge. It may also include in-school or college bespoke support over a period of time working on identified needs. To ensure the highest quality of development, where a school or teacher accesses a professional learning course, it is imperative there is nationally-recognised quality assurance of such courses.

Personalised development plans, which should be an entitlement for each teacher, should set out the subject-specific areas on which to focus, depending on their teaching responsibilities, and should be regularly updated, as responsibilities change, new curricula are introduced, or teachers move to different phases.

Lesson observations and audits are useful in highlighting individual teachers' needs. Lesson observations can inform conversations with senior leaders in schools, aiding the creation of mathematics-specific personalised development plans for teachers. In good practice the colleague observing will focus on the development of the mathematics learning throughout the lesson and this will form the basis of the post-observation feedback conversation.

The Chartered Mathematics Teacher (CMathTeach) designation is a valuable, but underused, way of recognising an individual teacher's professional learning in a formal way²².

Element 2

Collaborative learning groups

An essential crucible to professional learning is collaborative working. It can provide a way for teachers of mathematics to continually develop and build knowledge about mathematics and knowledge about teaching mathematics²³.

Collaborative learning groups²⁴ involve teachers working together, reviewing and working on their mathematics, reflecting on their mathematics practice within lessons and the learning that took place (see box 8). This goes far beyond focus on administrative tasks or reflection on generic pedagogy²⁵. One of the strengths of such groups is that is that they can simultaneously meet the needs of those new to the profession and those with significant experience. As well as collaborative learning groups fostering peer support, they should be supported by appropriate expertise which may be internal or external, involving higher education institutions, subject associations, professional learning providers and other schools and colleges.

Collaborative learning groups will function best if all teachers have developed critical evaluation skills during initial teacher education or professional learning²⁶ (see box 7).

BOX 8

Reflecting on learning and working on mathematical problems

It is important that teachers work on mathematical problems that are new to them. There were many examples in the teacher survey undertaken by the Expert Panel of the opportunities that sustained professional learning offered to reflect on their learning and that of others. Those who identified that they had a low level of mathematics knowledge, in particular, noted that through developing their own mathematical knowledge, they gained a greater sense of the challenges faced by learners.

Models of collaborative learning groups

Different collaborative learning models are already well established in high-performing jurisdictions. International practice cannot be simply transferred into the English context as there are cultural differences and significant differences in educational structures, including class size, pay and contact time. However, research and international experience show that there are some guiding principles that are essential to any well-functioning collaborative learning group (see box 9).

The Expert Panel recommends that schools and colleges²⁷ develop their own robust systems building on the good practice that currently exists. Development would be faster with coherent national guidance that may emerge from the College of Teaching²⁸. For schools, models could emerge from consensus between ITE and professional learning providers, multi-academy trusts, subject associations and other stakeholders. Such a coalition is also required in FE, bringing together colleges with professional learning providers, employers and others. In FE there are additional challenges in that some lecturers in FE colleges only teach a relatively small number of lessons of mathematics each week and their subject focus may lie elsewhere. The structural changes in the FE sector and the increasing number of students taking mathematics post-16 means that there is a need for investment in creating and sustaining collaborative learning groups in FE.

School and college support for collaborative learning groups

Teachers already meet regularly in schools and colleges. At the moment many meetings will be focused on administrative tasks. Some of these meetings can develop into collaborative learning groups. Some schools and colleges are developing systems where their teachers can develop their subject-specific knowledge in collaborative learning groups. There are also some emerging cross-institution collaborative learning groups, such as the Teacher Research Groups within the regional Maths Hubs²⁹, groups set up by multi-academy trusts and learning groups within subject association branches.

The teacher survey undertaken by the Expert Panel illustrated some interesting pockets of good practice, for example where universities worked over a sustained period with schools and colleges to integrate elements learned from collaborative learning group models seen in other countries³⁰. These developments may provide some insight into how mathematics-specific collaborative learning groups can flourish between schools and across regions. In best practice, these collaborative teacher groups fulfil the conditions in box 9.

- In **primary schools**, collaborative learning groups may be in embryonic form, for example when teachers meet to discuss approaches to calculation in a staff meeting. The challenge is to develop the depth and effectiveness of such groups. Given the range of subjects that primary schools teachers cover, consideration will need to be given to the time allocation for each subject and its importance in the school development plan.
- In **secondary schools**, collaborative learning groups could be based in the mathematics department and can build on the current mathematics department meetings. There is also a potential to develop such groups across departments if teachers of other subjects have to cover mathematical elements as part of their course³¹. In most schools considerable development is needed for these groups to become highly-effective collaborative learning groups.
- In **FE**, those teaching mathematics may be meeting to discuss preparation for Level 2 and 3 mathematics teaching and assessment and the varied needs of learners. Although mathematics and English are both key subjects for many FE colleges, the different subject needs may mean that teacher groups may focus on administration rather than subject-specific pedagogy. In best practice they would work across departments and also across disciplines given the diversity in courses being taught in FE colleges and the needs of learners³². The challenges faced by colleges given increasing numbers taking post-16 mathematics makes the development of these groups imperative³³.

Conclusion

There is a shared vision in England for a nation of learners that have the mathematical knowledge and skills needed to move into chosen careers and are able to excel in a world where mathematical and quantitative demands are ever increasing. To achieve this vision, prioritising the mathematics-specific knowledge of teachers and providing the opportunities to develop that knowledge is essential. All of those involved in mathematics education, whether in governance, teaching, initial teacher education and professional learning provision have a very important role to play in making this a reality.



BOX 9

Effective collaborative learning groups³⁴

1. Collaborative learning groups are part of wider school initiatives and programmes on professional learning.
2. Schools and colleges consider how best to help teachers to identify, understand and map their needs.
3. There is allocated time within all teachers' working weeks for collaborative learning on mathematics.
4. Collaborative learning groups provide a space for mentor support as more experienced teachers guide other teachers in reflecting on their practice. More experienced teachers are not only supporters of these groups and mentors to experienced teachers, but also share with others and learn from their peers.
5. In collaborative learning groups there is a focus on both teachers' and learners' development.
6. Collaborative learning groups have clear objectives and a format tailored to teachers' needs, which support learning within them.
7. Collaborative learning groups are strengthened by external support and challenge. Without such external support, groups entrench less effective strategies rather than develop deep learning and optimal strategies.

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Endnotes

1. <https://www.gov.uk/government/publications/2010-to-2015-government-policy-school-and-college-qualifications-and-curriculum/2010-to-2015-government-policy-school-and-college-qualifications-and-curriculum>
2. <http://www.acme-uk.org/policy-advice/teacher-education-and-development/professional-development/professional-development-learning-journeys>
3. See box 1.
4. Currently, there is focus on the policies and practices in Asian Pacific Rim countries. See <http://www.acme-uk.org/media/20269/internationalcomparisons.pdf>
5. See <https://www.ifs.org.uk/uploads/publications/comms/R118.pdf>
6. <http://www.telegraph.co.uk/news/uknews/12192892/UK-children-falling-behind-in-maths-due-to-superficial-learning.html>; <https://www.gov.uk/government/speeches/nick-gibb-building-a-renaissance-in-mathematics-teaching>
7. See <http://www.acme-uk.org/media/33228/beginningteachingbestinclass2015.pdf>; <http://www.gatsby.org.uk/uploads/education/reports/pdf/profile-of-the-maths-teaching-workforce.pdf>; <http://www.publications.parliament.uk/pa/cm201617/cmselect/cmpubacc/73/73.pdf>.
8. <https://www.gov.uk/government/speeches/michael-gove-speaks-to-the-royal-society-on-maths-and-science>
9. [http://www.acme-uk.org/media/7624/acme_theme_a_final%20\(2\).pdf](http://www.acme-uk.org/media/7624/acme_theme_a_final%20(2).pdf)
10. <http://www.yourlife.org.uk/>; <http://www.et-foundation.co.uk/wp-content/uploads/2014/12/Effective-Practices-in-Post-16-Vocational-Maths-v4-0.pdf>
11. See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/537030/160712_-_PD_standard.pdf. In the implementation guidance for the standard it is stated that “the standard should be used by everyone working in, and with, schools to raise expectations for professional development, to focus on achieving the greatest improvement in pupil outcomes, and to develop our teachers as respected members of the profession. In particular, the standard should be used to support regular reflection on existing practice and discussion between teachers, headteachers and leadership teams, and those providing and supporting professional development.”
There are five parts to the standard, which all need to be acted upon together to ensure effective professional development.
 1. Professional development should have a focus on improving and evaluating pupil outcomes.
 2. Professional development should be underpinned by robust evidence and expertise.
 3. Professional development should include collaboration and expert challenge.
 4. Professional development programmes should be sustained over time.And all this is underpinned by, and requires that:
 5. Professional development must be prioritised by school leadership.
12. <https://www.gov.uk/guidance/specialist-leaders-of-education-a-guide-for-potential-applicants>
13. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/508447/Educational_Excellence_Everywhere.pdf
14. Intellectual Property of School of Education, University of Nottingham.
15. Askew, Mike, Rhodes, V., Brown, M., Wiliam, D. & Johnson, D. (1997). *Effective Teachers of Numeracy: Report of a study carried out for the Teacher Training Agency*. London: King’s College, University of London.
16. See the work of Ball, Deborah Loewenberg, Hoover, Mark, and Geoffrey Phelps (2008). *Content knowledge for teaching: what makes it special?*, Journal of Teacher Education, Vol. 59 no. 5 389-407.
17. See <http://www.acme-uk.org/media/14054/acmepdreport2013.pdf> for ACME’s 2013 report on professional development where it was set out that ‘National guidelines can support senior leaders, governors, heads of department and subject leaders in structuring the provision of coherent, career-long professional development programmes for teachers at all stages of their career. Such guidelines should synthesise and review existing resources, and include:
 - exemplification of good mathematics teaching
 - clear quality criteria for mathematics professional development
 - exemplification of a broad range of professional development activities and programmes for teachers of mathematics in different phases and career stages
 - strategies for managing mathematics professional development, developing professional learning communities and establishing strategic partnerships
 - guidance on how to learn from research and cultivate practitioner inquiry
 - guidance on how to evaluate the effectiveness of professional development.The exemplification of professional development as part of these guidelines would enable schools and colleges to assess their staff development strategy. It should also encourage the cross-fertilisation of innovative and effective professional development strategies’.
18. In the Standard for Teachers’ Professional Development, it was noted that ‘In a complex system, greater understanding about what constitutes high-quality professional development can break the spiral of poor CPD. Schools need greater expertise in commissioning support and training, and providers should respond with depth, rigour and scholarship’, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/537031/160712_-_PD_Expert_Group_Guidance.pdf
19. See <http://www.acme-uk.org/media/14054/acmepdreport2013.pdf> for ACME’s 2013 report on professional development, where it was set out that a ‘good professional development kite-mark needs to: provide independent, third party endorsement of the quality of the provision; have trained assessors who apply those criteria uniformly across the sector; provide a freely accessible database of endorsed providers; have transparent, clearly referenced evidence-based quality criteria; provide substantial, constructive and developmental feedback to providers; review providers on a regular basis, including through random sampling; have a robust complaints procedure’.

20. <http://www.acme-uk.org/media/33228/beginningteachingbestinclass2015.pdf>
21. Vescio, Ross & Adams (2008). *A review of research on the impact of professional learning communities on teaching practice and student learning*, Teaching and Teacher Education Volume 24, Issue 1.
22. CMathTeach is designed to provide recognition of the teaching skills (pedagogy) and mathematics knowledge for a professional teacher to educate and inspire. The CMathTeach designation is incorporated within the Royal Charter of the Institute of Mathematics and its Applications and is awarded by the Chartered Mathematics Teacher Registration Authority. The Authority is composed of representatives from the following organisations: ATM, IMA, MA and NANAMIC.
23. Collaborative learning models that support teachers' knowledge development in profound ways can be found in countries like Japan, Singapore and China and the model has become the engine room for mathematics teacher development. In Shanghai Teacher Research Groups (TRG) are well established. On a weekly basis, teachers of mathematics work together planning lessons, engaging in small-scale action research and incorporating the insights of other research. In Japan there is a very well established systematic approach to developing teacher knowledge called Lesson Study.
24. In the academic literature these are often referred to as professional learning communities. See Vescio, Ross & Adams (2008). *A review of research on the impact of professional learning communities on teaching practice and student learning*, Teaching and Teacher Education Volume 24, Issue 1.
25. See <http://www.sec-ed.co.uk/best-practice/how-to-effectively-evaluate-our-cpd/> where David Weston gives worked examples of effective professional learning.
26. Robutti, Ornella, Cusi, A., Clark-Wilson, A. et al. (2016). *ICME international survey on teachers working and learning through collaboration: June 2016*, ZDM Mathematics Education, Vol. 48, 651.
27. Many colleges do not have a connection with Maths Hubs. The Expert Panel during this project heard many times about a desire to create networks of teachers both in English and mathematics.
28. A new, independent College of Teaching – a professional body along the lines of the Royal Medical Colleges – is under development and there is an aim that it will help spread good practice in areas like professional development and the effective use of evidence in education. The College of Teaching aims to be an independent, evidence-led, member-driven and voluntary body run by teachers for teachers in order to best meet the needs of learners. The new, chartered College has the stated aims of supporting teacher development and recognising excellence in teaching. See <https://www.collegeofteaching.org/teachers>. The College of Teaching may provide Chartered Teacher Status, building on subject designations such as CMathTeach. See 21. See <http://www.cmathteach.org.uk/>.
29. <http://www.mathshubs.org.uk/what-maths-hubs-are-doing/>
30. Expert Panel survey of teachers on their professional learning journeys, spring 2016.
31. For example, Core Maths teachers may not be in the mathematics department, <http://www.core-maths.org/about-core-maths/teachers/> ; Many recently introduced A levels have mathematical requirements, which means that there are increased quantitative demands for many teachers, <http://www.rss.org.uk/Images/PDF/publications/embedding-statistics-at-a-level.pdf>
32. See <http://www.et-foundation.co.uk/wp-content/uploads/2014/12/Effective-Practices-in-Post-16-Vocational-Maths-v4-0.pdf>
33. <http://www.acme-uk.org/media/20266/mathsto18.pdf>
34. Timperley, Helen (2008). *Teacher Professional Learning and Development*. Educational Practices Series-18. UNESCO International Bureau of Education.

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