CrossMark

Mathematics Teacher Professional Journals: What Topics Appear and How Has This Changed over Time?

Colin Foster[1] · Matthew Inglis[2]

Abstract

Mathematics teacher continuing professional development (CPD) is widely recognised to encompass more than attending courses and engaging in formal activities with colleagues in school. Teachers' professional reading is an under-researched aspect of CPD, which takes place out of view, but which has the potential to shape teachers' beliefs and practices. Mathematics teacher professional journals are relatively widely read by teachers and are a source of articles on a range of issues concerning the teaching and learning of mathematics. Such articles will to some extent reflect the interests of mathematics teachers and play a role in informing their teaching, thus indirectly affecting students' experiences in the classroom. But what topics do the articles in these journals focus on, and how has this changed over time? In this study, we examined the entire archive of the two leading UK mathematics teacher professional journals (*Mathematics Teaching* and *Mathematics in School*, published since 1957 and 1971, respectively; in total, almost 15 million words). We found an increasing prevalence over time of articles about classroom activities and people-centred discussions and a decreasing prevalence of articles focusing on textbooks. We discuss these and other trends, offer tentative accounts for them and consider ways in which the beliefs and practices of mathematics teachers may be reflected in, and have been informed by, these publications over time.

Keywords Continuing professional development · History of mathematics education · Mathematics teacher professional associations · Mathematics teacher professional journals · Topic modelling

✉ Colin Foster
  colin.foster@leicester.ac.uk

  Matthew Inglis
  m.j.inglis@lboro.ac.uk

[1] School of Education, University of Leicester, 21 University Road, Leicester LE1 7RF, UK

[2] Mathematics Education Centre, Loughborough University, Loughborough, Leicestershire LE11 3TU, UK

🙋 Springer

Introduction

Mathematics teachers' professional knowledge and skills have a critical effect on the quality of teaching and learning that takes place in their classrooms, and consequently on student achievement (Hill, Rowan, & Ball, 2005). However, substantial extended continuing professional development (CPD) is necessary in order to achieve meaningful gains in student achievement (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007), which is costly in time, effort and resources. In recent years, this has led to moves away from standalone out-of-school workshops for teachers towards finding ways of embedding effective CPD into teachers' everyday practices in their classrooms (for example, see Wake, Swan, & Foster, 2016). Since teacher learning "is often incremental, nonlinear, and iterative, proceeding through repeated cycles of inquiry outside the classroom and experimentation inside the classroom" (Goldsmith, Doerr, & Lewis, 2014, p. 20), it seems necessary to take a broad view of teachers' CPD and to explore factors which may operate behind the scenes over longer time periods in shaping mathematics teachers' beliefs and practices (Bernack-Schüler, Erens, Leuders, & Eichler, 2015).

One way in which teachers autonomously engage in CPD over extended periods of time is through the self-directed reading of professional books and articles (Terehoff, 2002). As Powell (2005) commented:

> Professional reading, while often overlooked, is an option for professional development that encourages teachers to investigate issues and problems that have risen in their own teaching experience and search for solutions that will enhance their knowledge and skill base. (Powell, 2005, p. 8).

Teacher professional journals are a plentiful source of articles about issues likely to be of interest to teachers (Smylie, 1989) and are relatively widely read (Littman & Stodolsky, 1998) and valued (Searls, 1985) by teachers. It is possible that the reading of professional journals may support a 'just-in-time' approach to teacher development (see Glazer, Hannafin, Polly, & Rich, 2009), where insights from articles are able to be digested and acted on in school at a moment of particular relevance, in contrast to more traditional, scheduled training courses.

In the UK, there are two leading mathematics teacher professional journals, which have both now been published for around 50 years. In the study reported in this paper, we examined the articles published over this period, with a particular focus on how the topics that have been discussed have changed over time. Examining the nature of the content of these journals is necessary if we are to understand their possible influences on mathematics teachers' beliefs and practices.

Mathematics Teacher Professional Journals

Professional journals are publications directed towards a particular professional audience, such as teachers, and usually published by a professional organisation. Teacher professional journals generally contain practical, classroom-focused articles, some of which may be informed by research, but they usually do not contain original research articles and are generally not peer-reviewed.

While some studies suggest that teachers engage in relatively little professional reading compared to other professionals (Rudland & Kemp, 2004), Littman and Stodolsky (1998) found that 52% of the US-based mathematics teachers in their study reported reading at least one professional journal "regularly". For almost 90% of them, this was *Mathematics Teacher*, published by the National Council of Teachers of Mathematics. Powell (2005) also found that US teachers reported reading professional journals. While 77% of the teachers in her study acknowledged that their time for professional reading was very limited, only 2.5% reported *not* reading professional materials. Teachers believed that professional reading materials were accessible, easy to understand and relevant, and over 80% of the teachers thought that professional reading materials helped them to grow in their profession, with 60% saying that professional magazines were their preferred type of professional reading material. Powell (2005) found that teachers preferred materials that discussed activities that they could use in the classroom to those that discussed trends and theories, and Rudland and Kemp (2004) also found that teachers predominantly read magazines and professional journals that were mainly pragmatic and application-oriented in nature.

In the UK, the two leading mathematics teacher professional journals are produced by the two major professional associations, the Mathematical Association and the Association of Teachers of Mathematics (Rogers, 2015), and received as a benefit of membership. The Mathematical Association (MA), formed in 1871, was the first teachers' subject association in England (Price, 1994), and aims "to effect improvements in the teaching and learning of mathematics and its applications" and "to provide means of communication among students and teachers of mathematics and other interested persons" (MA, 2015). To further these aims, it produces several regular publications for mathematics teachers, chief among them being *Mathematics in School*, published five times a year and targeted at secondary and further education college teachers of mathematics. The other main professional association for mathematics teachers in the UK is the Association of Teachers of Mathematics (ATM), which was established in 1952 "to encourage the teaching and learning of mathematics by relating more closely to the needs of the learner" (ATM, n.d.-a) and to cater for teachers in the less-academic 'secondary modern' schools rather than those in the more traditional 'grammar' schools (ATM, n.d.-b). The ATM sees itself as "a powerful and authoritative association which responds and speaks with authority on matters relating to the learning and teaching of mathematics and influences decisions to the benefit of all who are learning mathematics" (ATM, n.d.-a). Its journal, *Mathematics Teaching*, is published five times a year and seeks "a balance of articles that span the breadth of our membership, from the Foundation Stage to Higher and Further Education" (ATM, n.d.-c). The two associations have gradually become more similar to one another and now hold joint conferences and other events.

During the time period studied here, the MA has, in addition to the journal *Mathematics in School*, published *Equals, Primary Mathematics*, *The Mathematical Gazette*, *Mathematical Pie* and *SYMmetryplus*. The latter two publications are aimed primarily at students rather than teachers, and so were excluded from this study, since we were interested specifically in secondary mathematics teachers' professional reading. *Equals* (now *Equals Online*) focuses on special educational needs, and *Primary Mathematics* deals with the primary (age 5–11) phase, so these were also excluded as not being journals directed predominantly at mainstream secondary mathematics teachers. For similar reasons, *The Mathematical Gazette*, which focuses on the 15–20

age range, with a readership among school teachers and college and university lecturers, was also excluded. From 1985 until 2005, the ATM published *Micromath*, which addressed the use of ICT within mathematics teaching. Only an incomplete archive is available online, so we chose not to include *Micromath* in our analysis. From 2006, *Mathematics Teaching* 'incorporated' *Micromath* (Johnston-Wilder, 2006). For these reasons, we focused our study on the two principal professional journals: *Mathematics Teaching* and *Mathematics in School*.

The two associations currently have a combined membership of about 6000, and since their founding have between them published to date in these two journals around 9000 articles, the vast majority of which are now available online. These articles, written by both teachers and teacher educators/researchers, provide a window into issues presumed to be of interest to mathematics teachers in the UK since around the middle of the twentieth century. Understanding the topics discussed in these journals gives insight into one potentially important reflection of and influence on mathematics teachers' beliefs and practices and, in particular, how these may have changed over time. Neither journal adopts a formal peer-review process; instead, editors set the criteria for accepting submissions. Although these journals are published in England, both have a broad international scope, in terms of issues discussed in the articles, but also in terms of submissions and readership. So, the findings of this study are of broader significance beyond the UK.

In this study, we analysed all of the articles published in these two journals since their inception, with the aim of answering the questions: (1) What topics appear in mathematics teacher professional journals? and (2) How has the prevalence of these topics changed over time? We first outline our analytical approach, a computational technique known as *topic modelling*, before describing and discussing our findings in detail.

Topic Modelling

Topic modelling is a computational method which allows corpora (large collections of text) to be summarised by a small number of conceptual topics or themes (Blei, Ng, & Jordan, 2003; Grimmer & Stewart, 2013). Topic modelling may be thought of as being somewhat analogous to a statistical version of a grounded theory coding process, in which individual words are tagged with codes indicating the topics with which they are associated. It is entirely data-driven and there are no preconceived ideas about which topics will emerge from the corpus. Instead, the aim is to discover the main themes that are present in a large unstructured set of documents by examining the patterns with which words co-occur.

In order to understand the process of topic modelling, it may be helpful to imagine the reverse process of creating documents from pre-existing topics. Suppose that you started with a set of pre-defined topics, each one defined by the proportion of each word that it contains. For example, topic 1 might be defined by having a certain proportion of the word 'teacher', and so on for other words. Then imagine creating a document by selecting a distribution over the topics. For example, a specific document might be composed of 30% of words from topic 1, 20% from topic 2, 0% from topic 3 and so on. To create the document, you would simply select the appropriate proportion of words from each topic. Topic modelling may be thought of as carrying out this hypothetical

document construction process *in reverse*, starting with the documents, assuming that they were created in this way, and calculating what set of topics best fits them.

Of course, this process entirely ignores word order, a gross simplification known as the 'bag of words' model. Although this simplification may seem drastic, it is necessary to make the analysis computationally tractable. Nonetheless, topic modelling is a computationally demanding task that relies on latent Dirichlet allocation (LDA) algorithms (Blei et al., 2003). Once the topics are identified, the composition of each document can then be evaluated (e.g. document 3 might be made up of 40% of words from topic 1, 20% of words from topic 2, 10% of words from topic 3 and so on). Note that many words, such as 'teacher', will appear in more than one topic. By looking at the proportions of words in the document, the LDA algorithm seeks to identify the proportional composition of the document from the original topics. The topics obtained may be regarded as issues or themes, but might also reflect particular styles of writing in which the balance of different words used varies.

When conducting an analysis using a topic model approach, it is necessary to specify in advance how many topics the algorithm should find, and this determines the granularity of the analysis. Using a larger number of topics gives more detail at the price of greater complexity. One method to decide on an appropriate number of topics uses a statistical measure of a model's fit, known as its *perplexity*. The lower the perplexity of a model, with a given number of topics, the better the model's fit (Blei et al., 2003). To calculate the perplexity, we train an LDA model on a subset of the data. Then, the model is evaluated using the remaining data, and this is repeated for models with different numbers of topics. It is always possible to reduce the perplexity of a topic model by increasing the number of topics, but at some point, the gain in fit will not be worth the additional complexity from having extra topics. One way of assessing the number of topics to retain is to calculate the perplexity of models with different numbers of topics and then assess if there is a point at which the reduction in perplexity appears to 'level off', using a process analogous to a scree test in the context of a factor analysis (Cattell, 1966). As there, a major criterion for selecting the number of topics when producing a topic model is the interpretability of the resulting topics (Jacobi, van Atteveldt, & Welbers, 2016).

Topic modelling has been used to analyse newspaper coverage of nuclear technology (Jacobi et al., 2016) and messages from social networks, such as Facebook (Hong & Davison, 2010). It has also been applied to journal articles in research fields (Paul & Girju, 2009); in mathematics education, we have used topic modelling to analyse the content of leading international research journals (Inglis & Foster, 2018).

Method

We downloaded all of the *Mathematics Teaching* articles from the ATM website[1] and all of the *Mathematics in School* articles that were available on JSTOR.[2] Table 1 shows

---

[1] https://www.atm.org.uk/Mathematics-Teaching-Journal-Archive

[2] JSTOR http://www.jstor.org/ is a digital library of academic journals, books and primary sources. Because of the rolling wall on JSTOR, at the time of the study *Mathematics in School* articles were available only up to 2009.

Table 1 Descriptive statistics showing characteristics of the archive

	Mathematics Teaching	*Mathematics in School*
Years	1957–2015	1971–2009
Number of articles	3982	4865
Number of words	7,781,371	6,955,730
Number of word types	82,634	61,649
Mean number of words per article	1954	1430

the numbers of articles obtained for each journal, giving us a total of almost 15 million words, the number of word types (i.e. distinct words) in each journal and the mean number of words per article. We converted these pdfs into text files using ABBYY FineReader OCR Pro (v. 12.1.4). 'Non-content' (copyright statements, watermarks, etc.) was removed prior to the main analysis.

We used MALLET v. 2.0.8RC2 (a UNIX command-line topic modelling tool, McCallum, 2002) to calculate possible topic models. As is common in topic modelling, we removed all 'stop words'—very common English words, such as 'the' and 'and', which would not be topic-specific—that were included in MALLET's default list of English-language stop words. Inspection of the perplexity graph (explained above, Fig. 1) suggested that selecting 15 topics was a reasonable choice, and by experimenting with different numbers of topics, we found that the overall message did not seem to be highly sensitive to the number of topics.

It is important to emphasise that no a priori coding scheme was used, and the topics were found in a bottom-up process by the LDA algorithm. The two authors independently interpreted and named the 15 topics, based on the characteristic words (those in each topic that appear with the highest proportion). For example, the words with the highest proportions in one topic identified by the algorithm were *computer, data, calculator, program, time, machine, calculators, graph, computers, machines, model, simple, speed, programs, logo, screen, information, programming, figure* and *distance*. From this, it seemed clear that this topic is concerned with technology, and we gave it the name "technology". Minor disagreements in this process were resolved by discussion. We also examined some of the articles with the highest proportions of words from each topic to verify that these were consistent with our labels. As a check on the validity of our topics, several articles were chosen at random, and for each article, we used the model to calculate the extent to which it was composed of each topic.
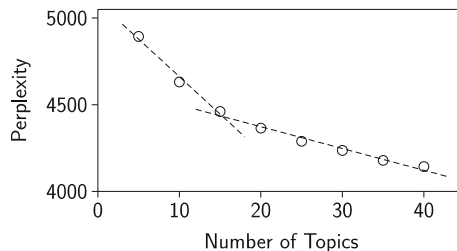
Fig. 1 The perplexity of topic models with varying numbers of topics. Dashed lines show our interpretation of where the graph 'levels off'

For example, one article (Heritage, 1972) consisted of 84% of the topic 'textbooks' and, upon inspection, was found to be a review of several textbooks. The other articles examined in this way also confirmed the reasonableness of the set of topics created.

Results

The 15 topics found are shown in Table 2, which includes their Pearson correlations with year of publication. Table 2 also shows, for each topic, the three articles with the highest proportions of words from that topic. Graphs of mean weight over time are given in Figs. 2, 3 and 4, where we have included cubic curves of best fit, as some of the trends were markedly non-linear.

The 15 topics obtained span three broad areas: mathematical content (6 topics), pedagogical issues and resources (6 topics), and administrative matters concerning (i) schools (1 topic) and (ii) the professional associations themselves (2 topics). The topics are described below under these three headings.

Mathematical Content

The six topics within this area all related to subject domain content and were named: advanced mathematics; counting and arithmetic; games and probability; geometry; history and culture of mathematics; and number (see Fig. 2).

Advanced mathematics was characterised by words relating to algebra, functions and trigonometry, and the three articles with the highest proportions of words from this topic came from *Mathematics Teaching* and concerned post-16 mathematics. Although *Mathematics in School* mainly deals with mathematics that is taught up to age 16, as can be seen from Fig. 2, there was a small but fairly constant profile of this topic over time in that journal, which contrasted with a U-shaped profile in *Mathematics Teaching*.

The topic *counting and arithmetic*, which was characterised by words such as 'children', 'units', 'addition' and 'apparatus', suggested a focus on young children's learning of number. The articles with the highest proportions of words from this topic concerned resources and activities to support young children's understanding of quantity, and the topic showed a decrease in prevalence over time.

Games and probability was characterised by words such as 'player', 'card', 'dice', 'move', 'board' and 'counters', and the articles with the highest proportions of words from this topic were all cut-out nets for calendars. It showed a flat profile over time.

The *geometry* topic was characterised by words referring to shapes, and the articles with the highest proportions of words from this topic were concerned with 3D solids and their nets. This topic showed a small increase in prevalence over time in *Mathematics in School* but not in *Mathematics Teaching*.

History and culture of mathematics was characterised by words such as 'mathematicians', 'film' and 'life', and the three articles with the highest proportions of words from this topic were one about mathematicians who have appeared on postage stamps, one about Halley's comet and one concerning different kinds of calendars. This topic showed a low flat profile over time.

Table 2 The 15 topics, their Pearson correlations with year for each journal, their most characteristic words and details of the three articles with the highest proportions of words from each topic

Topic	Linear correlation with year		Characteristic words (in order of weighting)	The three articles with the highest proportions of words from the topic	
	MiS	MT		Percentage of words in the article from the topic	Article
1 Mathematical content					
Advanced mathematics	−.19	−.57	set point equation points equations line function functions algebra graph sin students solution cos sets lines values method theorem form	92%	Leng, N. W., & Him, H. F. (2012). On solving the equation $f(x) = f^{-1}(x)$. *Mathematics Teaching, 228,* 39–42.
				87%	Burn, R. P. (1967). Transformations of finite planes. *Mathematics Teaching, 40,* 22–25.
				86%	Choquet, G. (1962). A pedagogically satisfactory axiomatic basis for elementary geometry. *Mathematics Teaching, 20,* 55–59.
Counting and arithmetic	−.74	−.70	children number counting child set numbers rods units make made stage red ten addition apparatus length count materials sets paper	81%	Materials for mathematics 3 (1972). *Mathematics Teaching, 60,* 22–23.
				80%	Work cards (1972). *Mathematics in School, 1*(4), 18–19.
				79%	Elliott, P. H. (1964). Materials for early concepts of weighing and measuring. *Mathematics Teaching, 26,* 17–19.
Games and probability	.40	−.10	game games player number cards probability card dice moves players move board play counters make score playing played total rules	100%	Dodecalendar 1991 (1990). *Mathematics in School, 19*(4), 34–37.
				98%	Tetrahedron 1990 (1989). *Mathematics in School, 18*(5), 34–37.
				98%	Dodecalendar 1988 (1987). *Mathematics in School, 16*(5), 23–26.
Geometry	.58	.16	triangle square area triangles figure circle angle sides angles fig line shape lines shapes point squares make symmetry side length	94%	Lulli, H. (1977). The cuboctahedron. *Mathematics in School, 6*(1), 23.
				94%	Parker, J. (1998). The rhomboid and its parts. *Mathematics in School, 27*(1), 13–15.
				94%	Lulli, H. (1977). Constructing the cube. *Mathematics in School, 6*(5), 11.

Table 2 (continued)

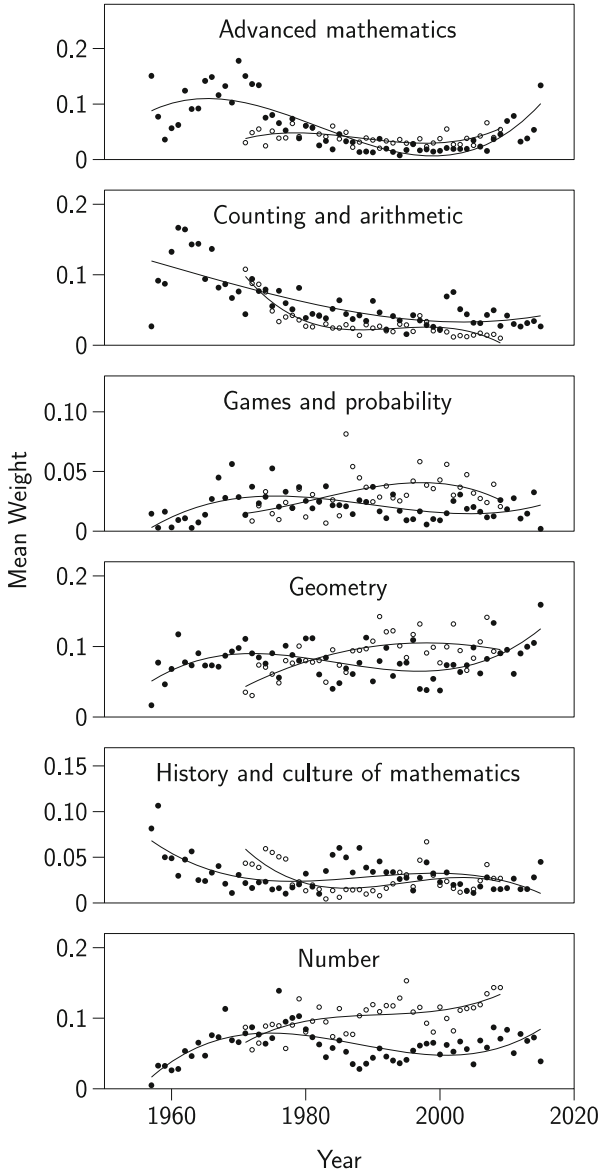| Topic	Linear correlation with year		Characteristic words (in order of weighting)	The three articles with the highest proportions of words from the topic	
	MiS	*MT*		Percentage of words in the article from the topic	Article
History and culture of mathematics	− .24	− .37	mathematics history geometry time mathematicians world years century great film art mathematical films mathematician year made university man book life	70%	Dodd, A. (1972). More mathematics on stamps. *Mathematics in School,1*, 6–21.
				69%	Halley's comet (1985). *Mathematics Teaching, 113*, 10–11.
				65%	Oliver, J. (1998). How we try to measure time: calendars. *Mathematics in School, 27*(5), 2–6.
Number	.62	.04	number numbers square sum find add fractions digits method odd table sequence multiplication digit prime row mathematics column answer pattern	95%	Magic square proof (1995). *Mathematics in School, 24*(3), 27.
				93%	Clements, M. G. (1974). Hexagonal numbers. *Mathematics in School, 3*(3), 32.
				91%	Eperson, C. D. (1998). Another conjecture. *Mathematics in School, 27*(2), 32.
2 Pedagogical issues and resources					
People-centred	.28	.64	time work people maths children it's things asked class good make back don't school teacher find problem day working put	91%	Dunn, G. (1995). Hit or miss. *Mathematics Teaching, 153*, 13.
				85%	Atkin, A. M. (1976). A story from the other side of the moon. *Mathematics in School, 5*(1), 4–6.
				82%	Clausen-May, T. (1999). Out of another Africa. *Mathematics Teaching, 169, 28–32.*
Questions and assessment	− .11	.62	pupils children work class questions problem question school group answer teacher pupil year asked number results test problems ability answers	79%	Lofthouse, M. (2004). Confident with algebra: true or false? *Mathematics in School, 33*(1), 36–40.
				69%	Ruddock, G., Mason, K., & Foxman, D. (1984). Assessing mathematics 2: concepts and skills: decimal place value. *Mathematics in School, 13*(1), 24–28.

Table 2 (continued)

Topic	Linear correlation with year		Characteristic words (in order of weighting)	The three articles with the highest proportions of words from the topic	
	MiS	*MT*		Percentage of words in the article from the topic	Article
Teaching and learning	.91	.94	mathematics students teaching learning teachers mathematical curriculum teacher classroom atm activities national research student ideas working thinking education provide skills	69%	Matthews, J. (1983). Will the penny really drop? *Mathematics in School, 12*(1), 32–34.
				82%	Pope, S. (2009). Welcome to the Engaging Mathematics Project. *Mathematics Teaching, 216*, 3.
				73%	Townsend, V. (2014). GC Reports: Working with the new National Curriculum for primary mathematics. *Mathematics Teaching, 239*, 5.
				72%	Ball, B. (1998). Editorial. *Mathematics Teaching, 164*, 2.
Technology	− .30	− .60	computer data calculator program time machine calculators graph computers machines model simple speed programs logo screen information programming figure distance	78%	Dutton, P. E. (1974). Computer page. *Mathematics in School, 3*(2), 26–28.
				75%	Dutton, P. E. (1974). Computer page. *Mathematics in School, 3*(1), 19–20.
				71%	New, P. J. (1977). Choosing an electronic calculator. *Mathematics in School, 6*(1), 12–13.
Textbooks	− .87	− .92	Book mathematics books work teachers mathematical series pupils ideas chapter material topics school examples pages level teacher set text section	94%	Book reviews (1984). *Mathematics in School, 13*(3), 39.
				93%	Book reviews (1976). *Mathematics in School, 5*(1), 32–34.
				93%	Book reviews (1976). *Mathematics in School, 5*(1), 32–34.
Understanding	− .71	− .74	Mathematics mathematical children teaching understanding learning teacher important language proof experience problem words situation process sense knowledge make problems fact	86%	Golby, M. (1973). 'Drills and skills' and understanding. *Mathematics in School, 2*(2), 23–24.
				83%	Pople, K. F. (1964). Letters to the editor. *Mathematics Teaching, 29*, 30–31.

Table 2 (continued)

| Topic	Linear correlation with year		Characteristic words (in order of weighting)	The three articles with the highest proportions of words from the topic	
	MiS	*MT*		Percentage of words in the article from topic	Article
				79%	Skemp, R. R. (1979). Goals of learning and qualities of understanding. *Mathematics Teaching, 88*, 44–49.
3 Administrative matters					
Curriculum and assessment	−.83	−.68	Mathematics teachers school schools education teaching work curriculum secondary years primary pupils year subject time report courses mathematical project level	90%	New system of examinations at 16 plus (1984). *Mathematics in School, 13(5)*, 9.
				83%	Editorial: The other seventy-five per cent (1963). *Mathematics Teaching, 23*, 3.
				80%	M.M.E. The Midlands Mathematical Experiment: future development (1968). *Mathematics Teaching, 43*, 53–54.
Association issues	−.69	−.66	School mathematics mathematical association college london road dear subscription members published education year longman university issue editorial group journal annual	98%	Mathematical Association annual conference (1990). *Mathematics in School, 19(1)*, 52.
				98%	National mathematics contest results 1984 (1985). *Mathematics in School, 14(3)*, 27.
				97%	National mathematics contest results 1985 (1985). *Mathematics in School, 14(5)*, 22.
Journal administration and website	.89	.76	Mathematics site school web maths mathematical www.m-a.org.uk reviews students e-mail isbn association software key pupils article teachers gcse articles keywords	96%	Authors' notes (2007). *Mathematics in School, 36(3)*, 36.
				91%	Authors' notes (2007). *Mathematics in School, 36(2)*, 36.
				91%	Authors' notes (2009). *Mathematics in School, 38(2)*, 44.

Fig. 2 Mathematical content topics. The mean proportion of words (excluding stop words) from each topic published by each journal per year. Curves show cubics of best fit

Finally, the *number* topic was characterised by words such as 'sum', 'add', 'digits' and 'prime', and the articles with the highest proportions of words from this topic were about magic squares, hexagonal numbers and prime numbers. This topic showed a small increase in prevalence over time in *Mathematics in School* but not in *Mathematics Teaching*.

○ Mathematics in School　　● Mathematics Teaching
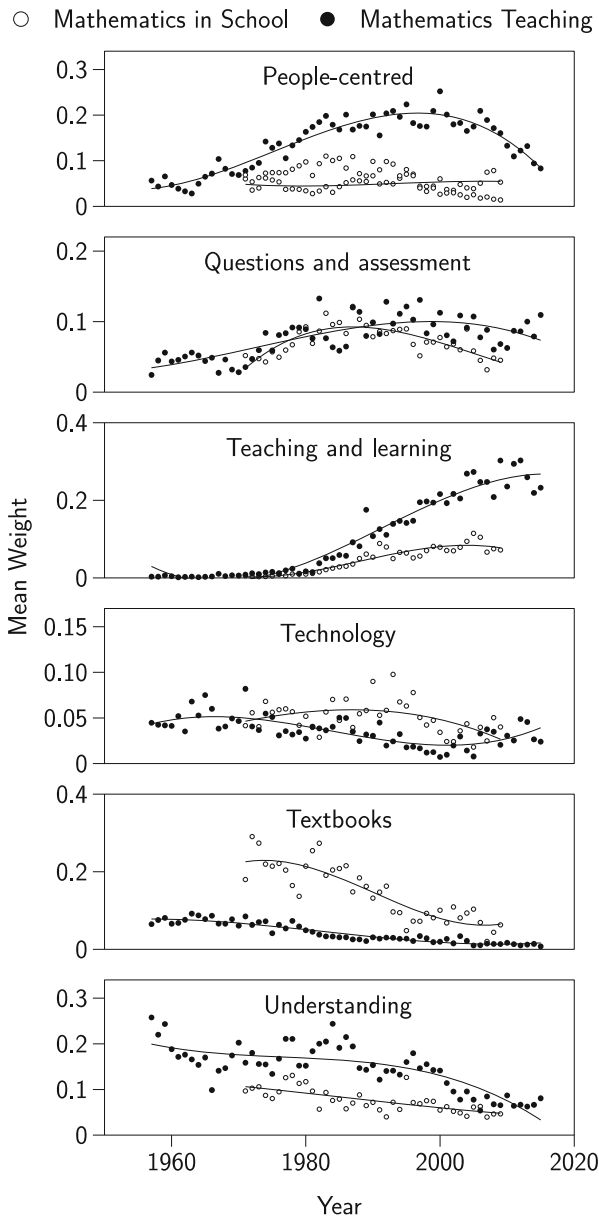
Fig. 3 Pedagogical issues and resource topics. The mean proportion of words (excluding stop words) from each topic published by each journal per year. Curves show cubics of best fit

Pedagogical Issues and Resources

The six topics within this area were named: people-centred; questions and assessment; teaching and learning; technology; textbooks; and understanding (see Fig. 3).

The *people-centred* topic seemed to focus on children and teachers and their interactions in the classroom and was characterised by words such as 'people',
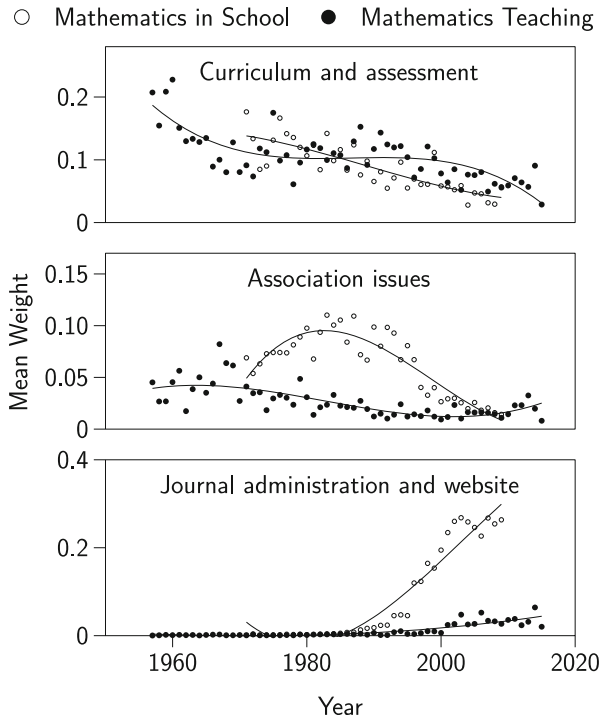
Fig. 4 Administrative matters topics. The mean proportion of words (excluding stop words) from each topic published by each journal per year. Curves show cubics of best fit

'children', 'class' and 'teacher'. The articles with the highest proportions of words from this topic were narrative accounts of classrooms. As can be seen in Fig. 3, this topic showed a peak in *Mathematics Teaching* in the 1980s–1990s, which seems more recently to have returned to the (fairly constant and low) *Mathematics in School* level.

Questions and assessment was characterised by words such as 'question', 'answer', 'asked' and 'test', and the articles with the highest proportions of words from this topic were about assessing pupils' mathematics. This topic showed no clear trend over time.

The topic named *teaching and learning* was characterised by words such as 'classroom', 'activities' and 'working', and the articles with the highest proportions of words from this topic described the practical classroom implications of changes to the curriculum. This topic showed a steep increase over time in *Mathematics in School* and a smaller increase in *Mathematics Teaching*.

The topic named *technology* was characterised by words such as 'computer', 'data', 'program' and 'calculators', and the three articles with the highest proportions of words from this topic (all from the 1970s) were about computers and calculators. This topic showed a small decline over time in both journals.

The topic *textbooks* was characterised by words such as 'book', 'chapter' and 'pages' and consisted largely of book reviews. This topic showed a steep decline over time, especially in *Mathematics in School*.

Finally, the topic *understanding* was characterised by words such as 'learning', 'language' and 'proof', and the articles with the highest proportions of words from this topic were discussions about the nature of understanding. This topic showed a steady decline in both journals.

Administrative Matters

Finally (see Fig. 4), three topics were related to administrative matters concerning both schools (curriculum and assessment) and the professional associations themselves (association issues, and journal administration and website).

Curriculum and assessment was characterised by words such as 'teachers', 'school' and 'curriculum' and related to broader curriculum innovations and new examination systems. Articles with the highest proportions of words from this topic discussed curricular change and the details of new syllabuses and examinations. This contrasted with the *teaching and learning* topic, where the emphasis was much more on classroom activities, although still with some discussion of administrative issues, where the authors generally considered the implications of changes in administration on the classroom. The *curriculum and assessment* topic showed a decline in both journals over time.

The topic *association issues* had its highest proportions of words in articles which were advertisements for MA events, such as annual conferences, and the results of national mathematics competitions. This topic showed a peak in the 1980s.

Finally, the topic *journal administration and website* had its highest proportions of words in articles which were information pages detailing how to submit articles to the journal *Mathematics in School*. This topic showed a large increase from the 1990s in *Mathematics in School* and a smaller increase in *Mathematics Teaching*.

Although these latter two topics are more narrowly concerned with issues relating to the details of the two associations—rather than to wider issues within mathematics education—it is noteworthy that the topic modelling method successfully identified them as distinct topics, which is reassuring with regard to the efficacy of the method.

In terms of the trends over time, our main findings were:

1. A major change over the years across both journals in the nature of discussions about teaching and learning, with a decrease over time in discussions relating to *administrative aspects* of teaching and learning and a concomitant increase in discussions of *activities* relating to teaching and learning.
2. A dramatic decline across both journals in the space given to discussion of textbooks.
3. A smaller decline across both journals in discussions relating to understanding, counting and arithmetic, and technology.
4. A trend in *Mathematics in School*, but not in *Mathematics Teaching*, to discuss more issues related to number and geometry.
5. A peak of 'people-centred' discussions in *Mathematics Teaching* in the 1980s–1990s, which seems more recently to have returned to the lower *Mathematics in School* level.

Discussion

We now consider possible factors which might account for our findings, before reflecting on some necessary cautions when interpreting the results of this study. The data for this study relate only to the *content* of the journals, and we do not have data on the reasons why any particular article was submitted to the journal or accepted for publication by the editors. Nor do we have evidence concerning the effects that any particular article may have had on any reader or students in any classroom. Journals publish articles for many reasons, and we expect that to some extent the articles reflect issues presumed to be of interest to mathematics teachers at the time. Where similar trends were seen across both journals, we felt more secure in hypothesising a wider phenomenon within mathematics education, rather than something specific to one journal or association. Our discussion below is informed by informal conversations with present and former editors of the two journals we analysed, as well as with other members of both associations, who commented on the findings.

We found a mixture of topics covering different areas of mathematical content, as well as topics relating more specifically to pedagogical issues. We also found three topics concerned with administrative issues, two of which turned out to be unrelated to the substantive content of the journals. Finding a balance of topics addressing mathematics content and topics more closely focused on the experience of students in the mathematics classroom reflects our impression (and the views expressed in informal conversations with current and past editors of these journals) that these are the two main types of article published in the journals. These two general areas appear consistent with previous findings, summarised earlier, that teachers generally prefer pragmatic articles that discuss classroom activities to more theoretical or abstract pieces (Powell, 2005; Rudland & Kemp, 2004).

Among the mathematical content topics, most main areas of the current and recent national curricula for England are present as topics. However, the absence of an 'algebra' topic might be considered surprising. One possible explanation could be that algebra has a more pervasive influence throughout the topics, rather than appearing separately, with the more advanced algebra being contained within *advanced mathematics*, while more basic pre-algebra appears within *number*.

Within the pedagogical topics, tasks and ideas from the classroom appear in *teaching and learning*, and also to some extent within *textbooks*. There are also practical articles about the use of *technology* and *questions and assessment*. More reflective discussions about classrooms appear (particularly in *Mathematics Teaching*) in the two topics *people-centred* and *understanding*. *Curriculum and assessment* addresses policy and curriculum issues. Strongly theoretical topics in education are not present, again consistent with the believed preferences of teachers (Powell, 2005; Rudland & Kemp, 2004).

We consider these trends in more detail below and suggest possible accounts for them.

Teaching and Learning

The results indicate that, across both journals, there has been a major change over the years in the kinds of discussions taking place about teaching and learning, with a

decrease in discussion relating to administrative aspects of teaching and learning (*curriculum and assessment*), and an increase in discussion of classroom activities relating to teaching and learning (*teaching and learning*), including how these might be affected by wider changes to curriculum and assessment. It is possible that such a shift might have been encouraged by the publication of the *Cockcroft report* in 1982 (Department for Education and Science [DES], 1982), with its emphasis on a connected understanding of mathematical concepts and on student problem-solving (Brown, 2014). This could have led to increased discussion regarding the kinds of tasks and resources needed to address conceptual understanding and promote problem solving in the classroom.

This trend would seem to reflect the stated aims of both associations, in being focused on the practical needs of the classroom practitioner (e.g. see ATM, n.d.-a). The increasing outside pressures on teachers over time (Perryman, Ball, Maguire, & Braun, 2011) may have contributed to a climate in which teachers have less time and energy for 'abstract' discussion and want practical materials that they can take into the classroom and use immediately. The increase in discussion of activities for teaching and learning could also reflect wider changes in the mathematics education landscape during this period, away from rigid adherence to textbooks to determine what is taught and how, and towards providing pupils with more open and exploratory mathematics tasks (see below).

Textbooks

There appears to have been a dramatic decline across both journals, but particularly in *Mathematics in School*, in the amount of discussion about textbooks. This might be associated with diminishing interest among teachers in using them as classroom resources, at least in the UK. According to the Trends in International Mathematics and Science Study (TIMSS) data, textbook use in mathematics classrooms in England is low compared to other countries (Askew, Hodgen, Hossain, & Bretscher, 2010). Concerns have recently been expressed about the general quality of textbooks used in England, when compared with those used in higher-performing countries, and the perceived decline in their use in England, particularly in primary schools (Oates, 2014). Our findings support Oates's (2014) suggestion, and, as far as we know, this study represents the first (indirect) evidence of a decline in interest in textbooks among UK mathematics teachers.

Bokhove and Jones (2014) found that Ofsted[3] reports made frequent negative references to 'over-reliance' on textbooks, which could have contributed to a decline in their use, at least in the period since the year 2000. There has long been a reluctance by both associations to allow the curriculum to be dominated by textbooks, which has often been equated with a 'transmission' approach to teaching (Askew, Brown, Rhodes, Wiliam, & Johnson, 1997). The publication by the ATM of books such as *Learning and Teaching Mathematics Without a Textbook* (Ollerton, 2002) and the *Without a Worksheet* series (ATM, 2004, 2006) illustrate this tendency within ATM, as well as MA. However, other

---

[3] *Ofsted*, the *Office for Standards in Education, Children's Services and Skills*, is a non-ministerial department of the UK government, with the responsibility for inspecting schools and producing reports.

possible reasons for a decline in textbook use could include tightening school budgets, the fast pace of curriculum change and the rise of online homework resources.

Understanding

The decline in both journals in discussions of 'understanding' is hard to account for. Skemp's classic article in *Mathematics Teaching* on relational and instrumental understanding (Skemp, 1976) may have contributed to a peak in the early 1980s in *Mathematics Teaching*, which subsequently declined. Although 'teaching for understanding' has probably been a perennial concern for both journals since their inception, it may be that the decline reflects a move away from more theoretical articles discussing aspects of understanding in more abstract terms and towards more classroom-activity-focused articles (see above), in which discussion of learners' understanding takes place within specific teaching and learning contexts.

Counting and Arithmetic

Articles discussing counting and arithmetic (i.e. the teaching and learning of number in relation to young children) showed a peak in *Mathematics Teaching* in the 1960s, followed by a fairly steady decline. This perhaps reflects a decreasing emphasis on primary teaching more generally within the journals. The MA journal *Primary Mathematics* began in 1997 and deals specifically with that phase, and this may have led to a reduction in the number of such articles in *Mathematics in School*, which also shows a decline in this topic (although *Mathematics in School* is chiefly aimed at ages 11–16). In terms of individual membership, both associations have increasingly struggled to recruit primary teachers (ATM, 2015); however, the total reach to primary teachers is hard to assess, since institutional (school) membership has fluctuated, and it is impossible to determine the number of teachers who may read a single institutional copy of the journal for each institutional subscription.

Technology

The slow but steady decline in the discussion of technology over time is perhaps surprising given the increasing role of technology in society during this period. One possible explanation could be that technology has become more routinely embedded into mathematics teaching, so that it does not stand out so clearly as a separate topic (this trend is reflected in the incorporation of the technology-specific ATM journal *Micromath* into the main journal, *Mathematics Teaching,* in 2006, as mentioned above). It might also reflect a decline in articles specifically discussing (graphical) calculators, which have become much less prominent over time (the three articles most representative of this topic were all from the 1970s). In addition, since the later years of the twentieth century, many other fora have appeared in which mathematics teachers can engage in professional discussion, such as blogs, wikis, chatrooms and twitter. It may be that certain topics of discussion (for

example, those heavily related to ICT) have disproportionately shifted to these, reducing their prevalence in the journals.

Number and Geometry in *Mathematics in School*

We found a trend in *Mathematics in School*, but not in *Mathematics Teaching*, for there to be more discussions of issues related to number and geometry. A trend in just one of the journals is less likely to be a consequence of wider change (e.g. initiatives such as the National Numeracy Strategy) and might be more likely to reflect changing priorities and emphases within a particular journal, such as when an editorial team changes its composition. For example, Chris Pritchard, the current co-editor of *Mathematics in School*, commented: "I remember John [the co-editor] saying when I was appointed in 2005 that he expected geometry articles to gain some prominence because I'd produced a geometry book a couple of years earlier" (C. Pritchard, personal communication, 26 May 2016).

'People-Centred' Discussions

We observed a peak of 'people-centred' discussions in *Mathematics Teaching* in the 1980s–1990s, which declined thereafter to the *Mathematics in School* level. This could be related to the impetus provided by the *Cockcroft report* (DES, 1982), which focused on the need for a connected understanding of mathematics that would enable successful problem solving in real-world contexts (Brown, 2014). This played an important part in placing the focus on the learner, which was already a strong theme, particularly within the ATM (the second of the ATM Guiding Principles states that "The power to learn rests with the learner. Teaching has a subordinate role" ATM, n.d.-d). Such an emphasis was very much in line with the recommendations of the *Plowden report* (Central Advisory Council for Education, 1967), which encouraged a learner-centred approach to education and had a dramatic impact on the prevailing philosophy of education at the time (Sugrue, 2010).

Cautions

Clearly, we must be cautious about ascribing any of the trends that we have identified to changes in teachers' interests. A complex set of factors will influence the particular articles that are published in a teacher professional journal at any particular time, including changes of editorship and editorial policy. Further, some articles will be read more than others and may be much more influential, and we have no data on the extent to which any of these articles was read by teachers. Only a small minority of mathematics teachers are members of these professional associations, so our findings cannot be used to draw firm conclusions about the interests of mathematics teachers more widely. Indeed, members of these associations may be atypical mathematics teachers—perhaps tending to be more enthusiastic, and possibly having views reflecting the child-centred perspectives of the associations.

Nevertheless, these journals' survival (and that of the associations that they represent) relies on their continuing relevance to mathematics teachers, both as authors of articles and as readers of the journals and members of the associations. Given this, we believe that the topics that have appeared do tell us something about the changing interests over the years within the community of mathematics teachers who belong to these associations.

Conclusion

Many teachers engage autonomously in CPD through the self-directed reading of professional books and articles in teacher professional journals (Littman & Stodolsky, 1998; Searls, 1985; Terehoff, 2002). Doing so has the potential to promote and support teacher reflection on issues that arise in the mathematics classroom and so contribute to developing teacher practice and improving students' experience of learning mathematics (Powell, 2005). The content of the MA and the ATM journals is likely to reflect changing interests among mathematics teachers over time, and so warrants investigation. In this study, we have identified the main topics of discussion in *Mathematics in School* and *Mathematics Teaching* since their inception and examined how these have varied over time. Although the topic modelling method used in this study entails some major simplifications, the topics that emerged from the model were interpretable. We believe that the fact that we were able to include the text from all of the issues of both journals (almost 15 million words altogether) significantly enhanced the robustness of the study.

We found a decrease over time in discussions relating to administrative aspects of schools combined with an increase in discussions of teaching activities. We have found what we believe is the first (indirect) evidence of a decline in teacher discussion of textbooks, as well as a smaller decline in discussions relating to understanding, counting and arithmetic, and technology. We also found journal-specific trends for increasing number and geometry (in *Mathematics in School*) and a peak of 'people-centred' discussions in *Mathematics Teaching* in the 1980s–1990s.

The impact of any of these changes on teachers' beliefs and classroom behaviour, and consequently on student learning, is critical but cannot be answered by this study. Further work in the history of mathematics education may allow more confident accounts for the patterns that we have identified here. It is also necessary to study the ways in which teachers read these journals, how much different categories of articles are read, how teachers choose which articles they read and how teachers' beliefs and practices might be influenced as a result of their reading of professional journals. Eliciting the topics and their trends over time is clearly only a starting point.

References

Askew, M., Brown, M., Rhodes, V., 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.

Askew, M., Hodgen, J., Hossain, S., & Bretscher, N. (2010). *Values and variables: Mathematics education in high-performing countries*. London: Nuffield Foundation.

Association of Teachers of Mathematics [ATM]. (2004). *Number without a worksheet for reception and year 1*. Derby: Association of Teachers of Mathematics.

Association of Teachers of Mathematics [ATM]. (2006). *Shape and space without a worksheet for reception and year 1*. Derby: Association of Teachers of Mathematics.

Association of Teachers of Mathematics [ATM]. (2015). *Minutes of 31st Annual General Meeting, 31 March 2015, Staverton Park, Daventry*. Derby: Association of Teachers of Mathematics Retrieved from https://www.atm.org.uk/write/MediaUploads/Governance/Annual%20Reports/Combined_Final_2015.pdf.

Association of Teachers of Mathematics [ATM] (n.d.-a). Retrieved from http://www.atm.org.uk/Association-of-Teachers-of-Mathematics.

Association of Teachers of Mathematics [ATM] (n.d.-b). *An account of the first decade of AT(A)M*. Retrieved from https://www.atm.org.uk/write/MediaUploads/About/History_Gattegno/an_account_of_the_first_decade_of_AT(A)M.pdf.

Association of Teachers of Mathematics [ATM] (n.d.-c). *Mathematics Teaching (MT) Article Submission*. Retrieved from http://www.atm.org.uk/write/MediaUploads/Journals/Mathematics_Teaching_(MT)_Article_Submission.pdf.

Association of Teachers of Mathematics [ATM] (n.d.-d). *Aims and Guiding Principles*. Retrieved from https://www.atm.org.uk/ATM-aims-principles.

Bernack-Schüler, C., Erens, R., Leuders, T., & Eichler, A. (Eds.). (2015). *Views and beliefs in mathematics education: Results of the 19th MAVI Conference*. Germany: Fachmedien Wiesbaden, Springer.

Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent Dirichlet allocation. *The Journal of Machine Learning Research, 3*, 993–1022.

Bokhove, C., & Jones, K. (2014). Mathematics textbook use in England: Mining Ofsted reports for views on textbooks. In K. Jones, C. Bokhove, G. Howson, & L. Fan (Eds.), *Proceedings of the International Conference on Mathematics Textbook Research and Development (ICMT-2014)* (pp. 159–166). Southampton: University of Southampton.

Brown, M. (2014). The Cockcroft report: Time past, time present and time future. *Mathematics Teaching, 243*, 5–9.

Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research, 1*, 245–276.

Central Advisory Council for Education. (1967). *Children and their primary schools ('the Plowden report')*. London: HMSO.

Department for Education and Science [DES]. (1982). Mathematics counts. In W. H. Cockcroft (Ed.), *Report of the committee of inquiry into the teaching of mathematics in schools*. London: HMSO.

Glazer, E. M., Hannafin, M. J., Polly, D., & Rich, P. (2009). Factors and interactions influencing technology integration during situated professional development in an elementary school. *Computers in the Schools, 26*(1), 21–39.

Goldsmith, L. T., Doerr, H. M., & Lewis, C. C. (2014). Mathematics teachers' learning: A conceptual framework and synthesis of research. *Journal of Mathematics Teacher Education, 17*(1), 5–36.

Grimmer, J., & Stewart, B. M. (2013). Text as data: The promise and pitfalls of automatic content analysis methods for political texts. *Political Analysis, 21*(3), 267–297.

Heritage, R. S. (1972). SME and mathematics teaching: Past and future. *Mathematics in School, 1*(5), 9–11.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371–406.

Hong, L., & Davison, B. D. (2010). Empirical study of topic modeling in twitter. In *Proceedings of the first workshop on social media analytics* (pp. 80–88). Washington D.C.: ACM.

Inglis, M., & Foster, C. (2018). Five decades of mathematics education research. *Journal for Research in Mathematics Education, 49*(4), 462–500. https://doi.org/10.5951/jresematheduc.49.4.0462.

Jacobi, C., van Atteveldt, W., & Welbers, K. (2016). Quantitative analysis of large amounts of journalistic texts using topic modelling. *Digital Journalism, 4*(1), 89–106.

Johnston-Wilder, S. (2006). Reflections. *Mathematics Teaching Incorporating Micromath, 194*, 2.

Littman, C. B., & Stodolsky, S. S. (1998). The professional reading of high school academic teachers. *The Journal of Educational Research, 92*(2), 75–84.

Mathematical Association [MA]. (2015). *Memorandum of the Mathematical Association. Amended January 2015*. Leicester: Mathematical Association Retrieved from http://www.m-a.org.uk/pdf/MemorandumConfirmedFinalDec08.pdf.

McCallum, A. K. (2002). *MALLET: MAchine Learning for LanguagE Toolkit*. Retrieved from http://mallet.cs.umass.edu/.

Oates, T. (2014). *Why Textbooks Count: A policy paper*. Retrieved from http://www.cambridgeassessment.org.uk/images/181744-why-textbooks-count-tim-oates.pdf.

Ollerton, M. (2002). *Learning and Teaching Mathematics Without a Textbook*. Derby: Association of Teachers of Mathematics.

Paul, M., & Girju, R. (2009). Topic modeling of research fields: An interdisciplinary perspective. In *Proceedings of the International Conference RANLP-2009* (pp. 337–342). Borovets, Bulgaria: RANLP.

Perryman, J., Ball, S., Maguire, M., & Braun, A. (2011). Life in the pressure cooker–school league tables and English and mathematics teachers' responses to accountability in a results-driven era. *British Journal of Educational Studies, 59*(2), 179–195.

Powell, M. (2005). *Teachers and professional reading: A study of reading experience and administrative support across traditional, paideia, and PDS schools* (Doctoral dissertation). Texas: Baylor University. Retrieved from http://beardocs.baylor.edu/xmlui/bitstream/handle/2104/3001/MichellePettijohn.phd.pdf?sequence=4.

Price, M. H. (1994). *Mathematics for the multitude? A history of the Mathematical Association*. Leicester: The Mathematical Association.

Rogers, L. (2015). Epistemology, methodology, and the building of meaning in a new community of mathematics educators in England, 1950–1980. In K. Bjarnadóttir, F. Furinghetti, J. Prytz, & G. Schubring (Eds.), *Proceedings of the Third International Conference on the History of Mathematics Education* (pp. 345–360). Uppsala: Department of Education, Uppsala University.

Rudland, N., & Kemp, C. (2004). The professional reading habits of teachers: Implications for student learning. *Australasian Journal of Special Education, 28*(1), 4–17.

Searls, E. F. (1985). Do you, like these teachers, value reading? *Reading Horizons, 25*(4), 233–238.

Skemp, R. R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching, 77*, 20–26.

Smylie, M. A. (1989). Teachers' views of the effectiveness of sources of learning to teach. *The Elementary School Journal, 89*(5), 543–558.

Sugrue, C. (2010). Plowden: Progressive education – A 4-decade odyssey? *Curriculum Inquiry, 40*(1), 105–124.

Terehoff, I. I. (2002). Elements of adult learning in teacher professional development. *NASSP Bulletin, 86*(632), 65–77.

Wake, G., Swan, M., & Foster, C. (2016). Professional learning through the collaborative design of problem-solving lessons. *Journal of Mathematics Teacher Education, 19*(2), 243–260. https://doi.org/10.1007/s10857-015-9332-9.

Yoon, K. S., Duncan, T., Lee, S. W.-Y., Scarloss, B., & Shapley, K. L. (2007). *Reviewing the evidence on how teacher professional development affects student achievement (Issues and Answers Report, REL 2007–No. 033)*. Washington, DC: US Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest.