Chapter 22
Themes in Mathematics Teacher Professional Learning Research in South Africa: A Review of the Period 2006–2015

Mdutshekelwa Ndlovu

Abstract In this chapter, I review and identify themes in in-service mathematics teacher professional development/learning research in South Africa over a 10-year period from 2006 to 2015. No less than 92 journal articles were reviewed. Nine themes were identified as characterising research during this period. Mathematical knowledge for teaching and pedagogical content knowledge were the two most dominant themes. Subject matter knowledge was the fourth and closely aligned to the first two. Curriculum knowledge was the third most frequently occurring research theme and was also closely aligned to the first two. Together the first four themes constituted 54% of the research output for this period, an indication of the centrality of practising teachers' professional knowledge of school mathematics. Under-researched themes included the integration of ICTs in mathematics education as well as impact studies that were apparently constrained by lack of funding for large-scale research.

Keywords In-service training · Mathematics teacher · Professional development
Professional learning · Teacher knowledge

22.1 Introduction

The mathematics education situation in South Africa has been described as a crisis by many researchers based on the low performance and perception of the country in international benchmark studies. Principal examples of such studies include the Trends in Mathematics and Science Study (TIMSS), the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) and the World Economic Forum's (WEF) annual Global Competitiveness Reports. Various

M. Ndlovu (✉)
Stellenbosch University, Stellenbosch, South Africa
e-mail: mcn@sun.ac.za

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reasons have been proffered and chief among them is the apartheid legacy (e.g. Kaino et al. 2015) that has provided unequal educational resources and opportunities based on race, not only at school level but also at initial teacher education level. While the white minority received world-class education, the majority black underclass received substandard education that was dismissive of mathematics as it was being taught to the white master's hewers of wood and drawers of water. That psyche permeated the preparation of teachers in subtle ways. While white teachers were well prepared at universities to be graduates, black teachers were underprepared at under-resourced teacher education institutions that awarded mainly a three-year teaching diploma. There was no requirement for teacher education institutions to conduct research. In an effort to redress the imbalances of the past, the post-apartheid dispensation sought to upgrade historically underqualified teachers through formalized in-service teacher education programmes such as the Advanced Certificate of Education (ACE). It is no coincidence therefore that most of the in-service teacher education research in the period reported here is apparently dominated by involvement in this programme.

Initially, teacher education was incorporated into universities so that all newly qualified teachers could receive degrees (i.e., receive a relative educational qualification value of Level 14 [REQV-14], which consists of matriculation and 4 years of training) irrespective of where or who they were going to teach. Concomitantly, universities began to offer upgrading courses such as the ACE to those teachers who had received REQV-13 (Brown 2010). This provided an opportunity for universities to carry out systematic scrutiny (research) on teacher education programmes as part of their core business of research, teaching and service to the community. Apart from upgrading teachers in mathematics teaching skills, the ACE also became a vehicle for retraining in new subjects in the curriculum. Mathematical literacy was one such subject introduced in the Further Education and Training (FET) phase (Grades 10–12), as a compulsory alternative to pure mathematics in order to fulfil the mathematics for all policy adopted by the new democratic government. This subject was introduced with no experience around the world to draw from, thus attracting considerable research interest (e.g., Julie 2006; Bansilal et al. 2014).

Frequent changes in the school curriculum stimulated research interest in their own right in the broader education reform process. The rapid changes in the curriculum saw an evolution from the National Education Department (NATED) curriculum to outcome-based education (OBE) in the form of Curriculum 2005, the Revised National Curriculum Statements (RNCS) and the National Curriculum Statement (NCS) to the Curriculum and Assessment Policy Statements (CAPS). This is why I prefer to refer optimistically to a mathematics education system in transition or in search of an identity, rather than one in crisis, for a relatively young nation state.

The purpose of this paper is to analyse the research themes privileged in mathematics teacher professional development/learning (MTPD/MTPL) for the 10-year period from 2006 to 2015. To achieve this goal I will use some meta-analysis and the following overarching research question and sub-questions to guide the study:

22.1.1 Main Research Question

What were the main themes (issues) investigated by the researchers with respect to MTPL?

22.1.2 Sub-questions

(a) Where was the research surveyed published for the period under review?
(b) What volume of research was published in (accredited) journals over the period?
(c) Who were the research participants?
(d) What were the themes (issues) problematized in the research?

22.2 Methodology

Firstly, I conducted a literature search on Google Scholar using the following search phrases: 'mathematics teacher professional development in South Africa', 'in-service training for mathematics teachers in South Africa', 'mathematics teacher professional learning in South Africa' etc. I ticked the box for articles and unticked the boxes for 'case law', 'include patents' and 'include citations'. I selected the custom range 2006–2015 to limit the search to article publications during that period. I repeated the same procedure for the other two search phrases, yielding results of approximately the same number of pages each time: 100, 99 and 100 respectively. Figure 22.1 below shows the top and bottom screenshots for page 2 of 100 Google Scholar pages that were prompted when the first phrase was used for searching within the 2006–2015 range. Each of the first 99 pages contained a list of about 10 publications (articles, books, conference proceedings papers, etc.). The last page only had one publication listed on it. Table 22.1 shows the total number of journal articles that spoke to research on mathematics teacher professional development in South Africa for the 10-year period 2006–2015. I repeated the same procedure for the other search phrases and specifically looked for articles that had not been prompted by the preceding searches.

Secondly, I searched for publications in South African databases (e.g., Sabinet and Ebscohost) for accredited journals. I excluded conference publications to narrow down the search and ensure only articles involving more rigorous peer review were included. I excluded book chapters, as most appeared to be drawing from prior published journal articles or unpublished thesis work. I also excluded unpublished theses from this study, as they were not rigorously peer-reviewed work. However, many of the published articles were based on thesis work and hence publishable thesis work was indirectly included in that sense.

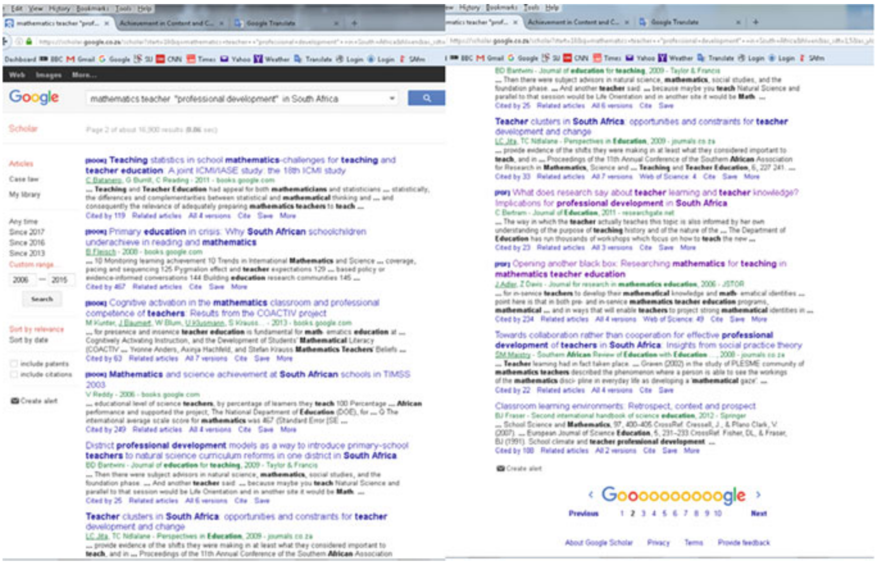

Fig. 22.1 Top and bottom screenshots of Google Scholar page 2 of 100 for the phrase 'mathematics teacher professional development in South Africa'

Table 22.1 Google Scholar results for the phrase 'mathematics teacher professional development in South Africa'

Pages	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	Total
Total	8	12	9	4	4	5	4	4	0	2	51

Thirdly, I scrutinized each article's title and abstract to confirm whether it was indeed about mathematics teacher professional development. Where details of participants were not clear from the title and abstract, I proceeded to the methodology section to confirm or refute whether it was a study on in-service teacher professional development/learning or not. I also discarded multidisciplinary studies that involved more than two subjects, as these tended to be more general and less specific to mathematics teaching. I included articles that involved mathematics and science teacher professional development/learning as the twin gateway subjects were frequently researched together (e.g., Mokhele and Jita 2012a, b; Jita and Mokhele 2012, 2014; Mokhele 2013). In the larger study, I categorised each article that related to teacher development or professional learning research according to the following sub-headings: author(s), year, journal, topic/theme, theoretical framework, purpose of research, research method, paradigm, participants and main findings. In this paper, I only deal with the main themes/issues explored. In all, 92 articles were included for analysis. Although this was not an exhaustive list, I considered it a representative sample of identified research studies.

22.3 Results

22.3.1 Main Journals Surveyed

Figure 22.2 shows the distribution by journal of the 92 articles reviewed. The journal that contained the largest share (32%) of mathematics teacher professional learning research articles was *Pythagoras*. This accredited journal is exclusively dedicated to mathematics education and the only one of its kind is South Africa. It is published by the Association of Mathematics Education of South Africa (AMESA), the largest mathematics education research association in the country and one of only two accredited mathematics education conferences. The second largest contributing journal is the *African Journal of Research in Mathematics, Science and Technology Education* (*AJRMSTE*) which contributed 21% of the total number of articles from the journals surveyed. This journal is published by the Southern African Association of Mathematics, Science and Technology Education (SAARMSTE). The SAARMSTE annual conference is the only accredited conference dedicated to mathematics, science and technology education. It draws its membership from the Southern African region.

The *South African Journal of Education* and the *South African Journal of Higher Education* respectively contributed 13 and 9% to the total number of articles selected for review. The category 'Other' included any other journal from which articles on MTPL in the sample were obtained, such as *Perspectives in Education* (*PiE*), *Acta Academica*, *Education as Change*, *Journal of Educational Studies*, *Journal of Social Sciences*, and *Anthropologist*.

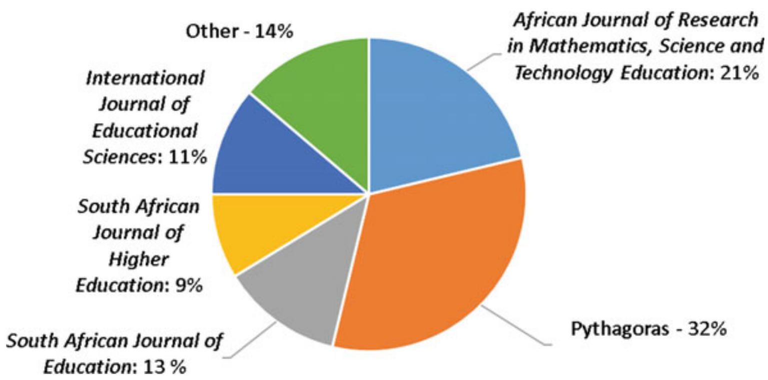

Fig. 22.2 Distribution of journals surveyed

22.3.2 Volume of Journal Publication Output

The graph in Fig. 22.3 shows the volume of publication output from year to year in this sample.

The graph shows that the research output experienced erratic growth from 2006 to 2010 before an acceleration or exponential growth pattern from 2010 to 2015. The overall picture is one of steady growth during the 10-year period.

22.3.3 Distribution of Research Participants

Figure 22.4 shows the distribution of research participants.

Almost three quarters of the research (72%) involved secondary school mathematics teachers as participants. Only 11% was on primary school teachers. In 11% of the articles, the research participants were both primary and secondary school teachers. In 6% of the articles, it was unclear at what level the participants were. There was not much evidence of Foundation Phase (Grades R-3) or Intermediate Phase (Grades 4–6) teachers participating in the research.

22.3.4 Main Research Themes

Figure 22.5 shows distribution of main research themes.

Nine themes were identified:

1. Pedagogical content knowledge (PCK; 14%)
2. Mathematical knowledge for teaching (MKT; 14%)
3. Subject matter knowledge (SMK; 13%)

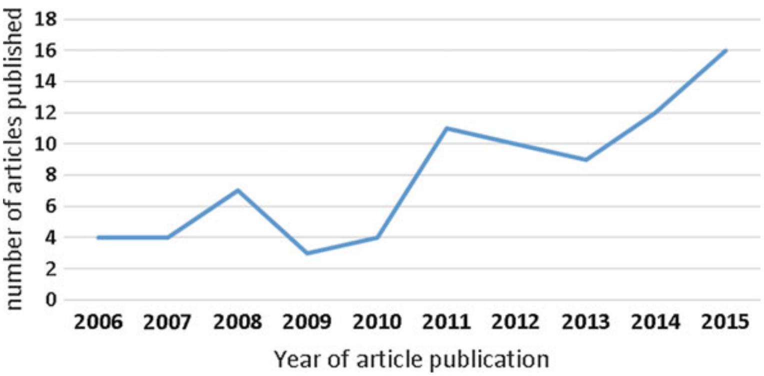

Fig. 22.3 Journal article output 2006–2015

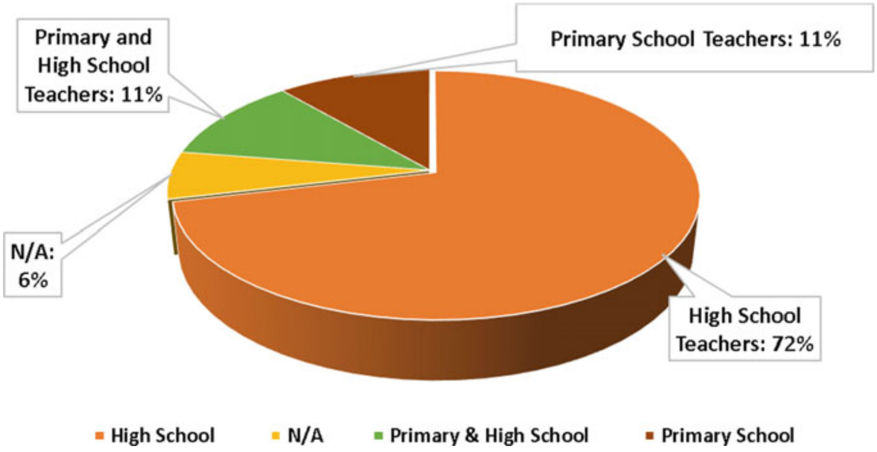

Fig. 22.4 Distribution of research participants

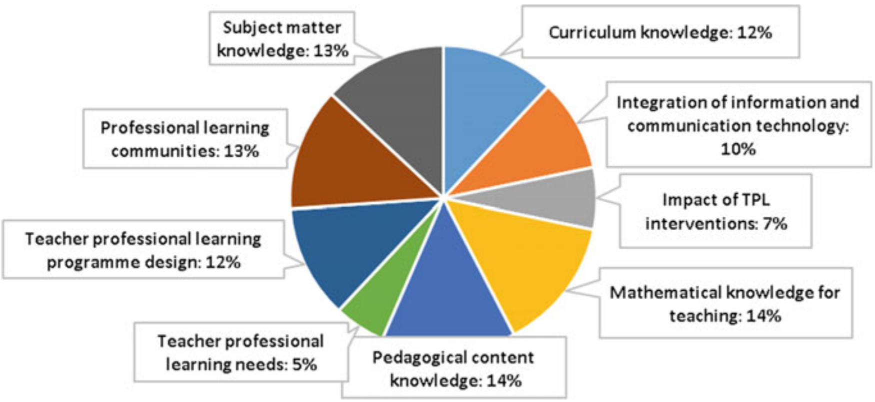

Fig. 22.5 Main research themes privileged

4. Curriculum knowledge (12%)
5. Teacher professional learning (TPL) programme design (12%)
6. Integration of information and communication technologies (ICTs; 10%)
7. Impact of TPL interventions (7%)
8. Professional learning communities (PLCs; 13%)
9. Professional learning needs (5%).

MKT (e.g., Adler and Davis 2006; Adler and Pillay 2007; Aldridge et al. 2009; Brijlal et al. 2012; Gierdien 2008; Mhlolo et al. 2012; Mudaly and Moore-Russo 2011; Tosavainen et al. 2013; Kazima et al. 2008; Kazima and Adler 2006; Bansilal 2014a, b; Lampern 2015) and PCK (e.g., Mhlolo and Schafer 2012; Brijlal 2014; Brodie and Sannie 2014) were the two most researched themes. SMK (e.g., Likwambe and Christiansen 2008; Bansilal 2011; Ndlovu and Mji 2012; Berger 2013; Wessels and Nieuwoudt 2013), a theme closely related to the first two, was tied for third most frequently researched (with PLCs). Taken together these three closely intertwined themes (or domains) constituted 41% of the research output. Curriculum knowledge (e.g., Khuzwayo and Mashiya 2015; Mwakapenda and Dhlamini 2009; Bansilal 2015; Shalem et al. 2013; Biccard and Wessels 2015) was tied for fifth most frequently researched theme (with TPL programme design) and closely aligned to MKT, SMK and PCK. Curriculum knowledge helps teachers to align their mathematics content knowledge and mathematics for teaching to the syllabus (intended curriculum) and the assessment (assessed curriculum). Together, the first four themes constituted 54% of the research output, which conveys the importance placed on practicing teachers' knowledge of mathematics required for the successful teaching of school mathematics. Although so much emphasis has been placed on these fundamental professional knowledge domains of the mathematics teacher, there still seems to be a long way to go in the attempts to solve the teacher knowledge problem, more so in an environment where the mathematics curriculum itself keeps on evolving (Paulsen 2015; Phoshoko 2015).

Formalised TPL programme design (e.g., Julie 2006; Adler and Davis 2006; Brown and Schafer 2006; Fricke et al. 2008; Plotz et al. 2012; Owusu-Mensah 2014) was tied for fifth in prevalence together with curriculum knowledge (e.g. Graven and Venkat 2014; Khuzwayo and Mashiya 2015; Molefe and Brodie 2010; Webb 2015). If we add PLC research, together with alternative non-formalised programme designs such as lesson study, cluster programmes and communities of practice, research (e.g., Brodie 2007, 2013; Brodie and Shalem 2011; Posthuma 2012; Pausigere and Graven 2014; Singh 2011; Ono and Fereira 2010) to formalised TPL programme design, we see that these two closely related themes combine to make 25% of the research output. This is understandable in the context of a research community seeking more sustainable models of teacher professional development and learning.

The integration of information and communication technologies into mathematics teaching (e.g., Stols et al. 2008, 2015a, b; Van der merwe and Van der Merwe 2008; Berger 2011; Van Staden and Van Westhuizen 2013; Gierdien 2014; Leendertz et al. 2015; Stols and Kriek 2011) came in seventh but with increasing intensity in the second half of the period under review. With the proliferation of ICTs in numerous forms and platforms, this is an encouraging sign. However, it still falls short of the rate at which ICT tools themselves are becoming increasingly ubiquitous. To this end, Blignaut et al. (2010) lament the lack of ICT competency among teachers in terms of basic ICT, as revealed by the Second International Technology Education Studies (SITES) of 2006.

Studies relating to the impact/effectiveness of TPL programme interventions, notably on student learning outcomes, were few (e.g., Frick et al. 2008; Ndlovu 2011a, b, c, d; Ndlovu 2014; Pourana et al. 2015). Similarly, studies that specifically focused on TPL needs were few and far between (e.g., Rakumako and Laugksch 2010; Wessels and Nieuwoudt 2011; Julie et al. 2011).

22.4 Discussion of Results

It is clear that the research emphasis focussed sharply on teachers' mathematical knowledge, be it as pure SMK or fused with pedagogy as in PCK or more specialised as mathematics for teaching (MFT) or mathematical knowledge for teaching (MKT/MKfT). Mathematical knowledge for teaching also re-appeared as mathematical literacy knowledge for teaching (MLK), Statistical knowledge for teaching (SKT) and more recently as mathematical discourse in instruction (MDI; e.g., Adler and Ronda 2015; Venkat and Adler 2012). Although this might be taken for granted in other countries, it appeared to be the core problem vexing the quality of mathematics teaching to the extent that teachers' mathematical discourses in action needed to be analysed in context—some form of situated cognition—and acted upon relevantly.

Lack of resources in disadvantaged schools included knowledge resources such as mathematics for teaching abilities of teachers and cultural resources such as the undermined/underutilised potential of indigenous languages in the teaching of mathematics, requiring re-sourcing of teachers (e.g., Adler 2012; Dicker 2015; Setati 2008). Research on the integration of ICT in mathematics education might have been impeded by the novelty of the technology itself, which caused in-service providers to also be co-learners in most instances. The paucity of research on ICT integration pointed to the possibility that very few in-service teacher educators were comfortable (i.e., digital natives) with the new tools. For example, Stols and Kriek (2011) asked the question 'why don't all maths teachers use dynamic geometry software in their classrooms?' They postulate that their beliefs could initially hinder their intention to use technology, but once exposed, the intention and the actual use of technology actually increases. However, more research is needed to establish the full range of impediments. For example, a strong possibility exists that as ICT proliferates, there may be many more practitioners who use technology than researchers think—it just has not been written about in journal articles.

Many mathematics teachers appeared to be out of their depth, especially in the secondary school sector. The majority of the studies sought to describe or unpack the nature of mathematical knowledge required for teaching and what mathematical difficulties underqualified teachers encountered even as they were being upgraded. Given the long history of neglect of the education of the majority, it was understandable that unless a completely new breed of teachers was trained overnight to replace the old cadres, the problems of under-equipped and inappropriately deployed teachers would persist.

The rapid changes in the curriculum made the design of teacher professional programmes a rather messy issue, as researchers had to attempt to fix a system that in itself was a moving target. Very often, changes in policy outstripped the supply of appropriately qualified or appropriately retrained teachers, as Mbekwa (2006) and other researchers highlighted, for example, in the case of mathematical literacy. A constant shortcoming of in-service teacher education was its general failure to influence the quality of education positively. The very few studies on impact may suggest a persistent lack of capacity or competencies as well as funding constraints among researchers to conduct large-scale randomised control trial (RCT) projects. Following the success of the East Asian countries in international benchmark tests, some research on professional learning communities and lesson study has surfaced as a prospectively more sustainable, teacher-driven (bottom-up) alternative. The notion of PLCs has been embraced at the policy level by both the Department of Basic Education (DBE) and the Department of Higher Education and Training (DHET) in the integrated strategic planning framework for teacher education and development (DBE and DHET 2011). However, the initiation of such communities of practice might still be a challenge as there may not be enough skilled personnel (e.g., professors) to stimulate them all over the country with equal zeal and skill as in the reported research. There might also not be enough resources nor enough time and incentives for participating teachers to embrace them wholeheartedly.

22.4.1 Implications for the Way Forward

The research has on balance led to greater local understanding and interpretation of pedagogical problems affecting the South African mathematics education conundrum. Whereas some researchers appear to bemoan the ineffectiveness of one-off or hit-and-run approaches to teacher professional learning (e.g., Jita and Mokhele 2012), formal in-service teacher education programmes such as the ACE reported here have also lacked consistency in standardising what is taught. The broad consensus appears to be that more long-term formats of teacher professional learning programmes may yield more long-lasting improvements. Whereas the pace of curriculum change has to be moderated, there is also the challenge for initial teacher education to produce more adaptable educators, perhaps partly by extending teaching experience and partly by investing in ICT infrastructure at higher education institutions so that the integration of ICT in mathematics can be more easily and naturally embraced in the field. This could be backed by improved research funding for its integration in schools, not only for mathematics but for all other subjects as well.

Figure 22.6 highlights the need for constant interaction between initial teacher education, continuous teacher professional learning and student learning outcomes.

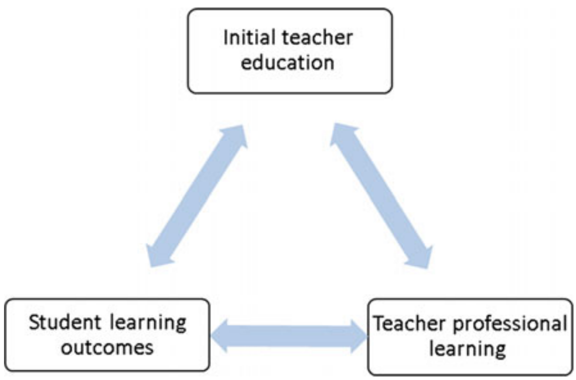

Fig. 22.6 The interrelationship between TPL, student learning outcomes and initial teacher education

Furthermore, looking at the comparatively extensive volume of research on in-service mathematics teacher professional development and learning that South Africa has produced, it is worth recommending the consolidation of the funding model for higher education research that has been a major catalyst for research productivity. Since most research emanates from the higher education sector, it raises the prospects of the researchers to influence the re-curriculation of initial teacher education (ITE) so that the gap between ITE and the realities of the practicing South African mathematics teacher can be as narrow as possible.

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