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Routledge
Taylor & Francis Group

African Journal of Research in Mathematics, Science and Technology Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rmse20

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To cite this article: Samantha Morrison, Mellony Graven, Hamsa Venkat & Pamela Vale (2023) A 20-year review of South African Early Grade Mathematics Research Articles, African Journal of Research in Mathematics, Science and Technology Education, 27:3, 304-323, DOI: 10.1080/18117295.2023.2226547

To link to this article: https://doi.org/10.1080/18117295.2023.2226547

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Published online: 23 Aug 2023.

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African Journal of Research in Mathematics, Science and Technology Education, 2023
Vol. 27, No. 3, 304–323, https://doi.org/10.1080/18117295.2023.2226547
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A 20-year review of South African Early Grade Mathematics Research Articles

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In this article we share the findings emanating from a 20 year (2003–2022) review of South African Early Grade Mathematics (EGM) research articles published in key international and local/regional journals. The review shows a substantial increase in the volume of published EGM articles in the second decade (2013–2022), nationally and internationally. These increases are marked across the key clusters of articles seen in our analysis: Teachers and Teaching, Learners and Learning, Language and Multilingualism, and Assessment. The emergence of the *South African Journal of Childhood Education* as a phase-specific journal in 2011 has been a particularly important factor within the increasing volume of publication. We note too, that whilst the base of publication across institutions has broadened in the local/regional publication space, international publications are tied primarily to projects linked with established South African Research Chairs.

Keywords: *Early grade mathematics; South Africa; teachers and teaching; learners and learning; language and multilingualism*

Introduction

This article presents a review of early grade mathematics (EGM) research in South Africa across the last two decades: 2003–2022. Our review is based on articles with an overt emphasis on early grade mathematics published in selected mathematics education journals accredited by the national Department of Higher Education and Training (DHET) in the local space, and in what have been identified as the top 20 mathematics education journals in the international research space (Williams & Leatham, 2017).

Adler et al. (2016) comment on substantial growth in writing on primary mathematics in their review of the Southern African literature in the period between Venkat et al.'s (2009) overview article and their review. In this article, we seek to nuance this finding of growth in publication, with a particular focus on Foundation Phase (Grades R–3) mathematics education research focused on South Africa. Through looking at leading peer-reviewed South African, Southern African and international journals publishing writing on early grade mathematics over a 20 year period, we probe questions relating to changes, over time, in:

- the balance of publications across national/regional and international journals;
- the base of publications across institutions; and
- the focus of publications in early grade mathematics.

This analysis offers insight into shifts in the nature of the problems that have motivated research in early grade mathematics in the last 20 years, and probes whether the growth in publication levels is underpinned by a broad-based national shift in attention to the early grades as key sites for intervention to improve mathematical outcomes. Several studies have argued that early intervention is key for addressing the disparities in mathematics performance seen at school entry levels and the widening of these performance gaps with associations to socioeconomic backgrounds as learners move up the grades (e.g. Atweh et al., 2014; Spaull & Kotze, 2015). Motivating this review in South Africa are landscape shifts that the work has grappled with during the focal period: growing attention to Foundation Phase across a range of government-led (e.g. the Foundations for Learning policy) and research-led initiatives (e.g. Funda Wande/Bala Wande). An important further influence on this review article has been the growing attention in the education policy research field to early grade mathematics as a critical site for intervention. Ursula Hoadley's writing has drawn attention to the nature of pedagogy in schools serving historically disadvantaged learners (Hoadley, 2017) and Brahm Fleisch has pointed to the 'triple cocktail' approach (involving high-quality training for teachers, teaching and learning materials and instructional coaches) as a model combination that can support improved learning (Fleisch, 2018). While these writers have focused on Foundation Phase across language and mathematics, their writing has served to sustain policy attention on the early grades over the last decade. Thus, this review also seeks to understand the extent to which the urgency of calls to work on development in Foundation Phase has been taken up through a review of articles published in a wide range of journals focused specifically on mathematics in this phase.

We start this review by sharing the methods we used to search for and analyse articles relevant to EGM South African research published in selected international and local journals over our 20 year review period (2003–2022). We then go on to answer the first two research questions which focused on the balance of publications across national and international journals and the base of publications across institutions. Thereafter we answer the third research question by discussing the broad focus areas emerging across the EGM articles published within our review window, namely, *Teachers and Teaching*, *Learners and Learning*, *Language and Multilingualism* and *Assessment*.

Methodology

Our aim was to review South African research in EGM across the Reception to Grade 3 years which caters to 5–9 year olds. We used Williams and Leatham's (2017) list of the top 20 international education journals and established local/regional accredited journals that have published work in mathematics education to see how South African research features within local and international spaces across our review period. As authors we divided the journals amongst ourselves and searched all volumes of each journal for the period 2003–2022 using the following search terms: early grade/early years/elementary/primary mathematics; numeracy; South Africa; foundation phase; and number and counting. The authors used each of these search terms to search journals sequentially and independently until no additional articles were picked up. We made a list of the local education journals accredited by the DHET and followed the same search process as for the top 20 international journals. For every journal article (local and international) that met our search criteria we captured the key article details using the headings reflected in Figure 1 in our data collation spreadsheet.

Once we had populated our initial spreadsheet, we checked each entry for salience to the focus of our review. In this checking process, we clarified that our review would include articles where the empirical base fell outside Grades R–3, but included findings or recommendations that were salient to these grades. For example, Planas and Setati-Phakeng's (2014) article has empirical excerpts of teaching taken from Grade 4 settings but discusses ways of seeing and using language as a

Journal	Citation details	Author/s	Country	Year	Article title	Article key words	Learners/ Teachers/ Tr Ed	Which grades	Empirical/ Theoretical	Sample size	Data source	Abstract

Figure 1. Information captured about each article.

Table 1. List of international journals yielding articles in our search

Name of journal	Abbreviation	Number of articles
ZDM International Journal of Mathematics	*ZDM*	8
Educational Studies in Mathematics	*ESM*	5
Mathematics Education Research Journal	*MERJ*	3
For the Learning of Mathematics	*FLM*	1
Research in Mathematics Education	*RME*	1
The Journal of Mathematical Behavior	*JMB*	1
International Journal of Science and Mathematics Education	*IJSME*	1
Journal of Research in Mathematics Education	*JRME*	1
Total		21

resource in the primary mathematics classroom that are directly relevant to Foundation Phase teaching. It was thus included. Our focus on Grades R–3 meant that early childhood education articles focused on the pre-Grade R years (0–5 years) were excluded.

After removing every entry in our initial spreadsheet that was not salient to our particular focus, we found 21 articles that met our search criteria in 8 of the top 20 international mathematics education journals and 102 articles in 8 locally accredited education journals. These journals are listed in Tables 1 and 2 respectively, in order from the journal with the greatest to the least number of publications.

A limitation of our focus on journal articles is that books and book chapters, conference proceedings and reports focused on EGM are excluded. The review of the Southern African Association of Mathematics, Science, and Technology Education (SAARMSTE) Conference Proceedings in Graven and Venkat (2003) covers some of our gaps. Our delimiting to EGM-related research published in accredited local and international education journals was pragmatic in terms of scope but also based on the rigorous processes of peer-review of these articles. Within our scope, we found a rich and expanding body of research ($n = 123$ articles), with the last decade including two South African special issues focused on EGM (in *SAJCE* and *PIE*). There have been prominent recent books and book chapters published with a focus on EGM in South Africa (Graven & Venkat, 2017; Venkat & Roberts, 2022; Spaull & Taylor, 2022). We note that while excluding this body of work is a limitation of this study, several of the key ideas, particularly those related to interventions, are covered in the published articles that feature within this review.

Once our spreadsheet was finalised, we collectively identified the EGM topic/s each article focused on and the total number of articles per topic. With some articles focused on more than one topic, these combined totals exceed the 123 articles in this review. Clear themes/clusters emerged by grouping topics that relate closely to each other. Our themes were:

Table 2. List of local/regional journals yielding articles in our search

Name of journal	Abbreviation	Number of articles
South African Journal of Childhood Education	*SAJCE*	46
African Journal of Research in Mathematics, Science and Technology Education	*AJRMSTE*	15
Pythagoras	*PYTH*	11
Perspectives in Education	*PIE*	10
Journal of Education	*JOE*	7
South African Journal of Education	*SAJOE*	6
Education as Change	*EAC*	5
Africa Education Review	*AER*	2
Total		102

- teachers and teaching;
- learners and learning;
- language and multilingualism; and
- assessment .

These themes/clusters covered all but one article in our sample. See Table 3 for the themes/clusters that emerged across the 123 articles that formed the corpus of our review and the number of articles related to each. Table 3 also shows the number of articles related to each theme, with the largest number related to *Teachers and Teaching*.

Searching across the articles in each cluster/theme, we proceeded to look for sub-clusters, and any patterns or trends emerging within each cluster of articles, noting too how these related to the other clusters and to EGM overall. We go on now to answering our research questions.

Findings

Which Journals are the most Frequent Publishers of EGM articles (for 2003–*2022)?*

Of the 123 articles in our sample set, the four journals with the most articles are all local/regional. The journal with the most EGM publications is *SAJCE* (46). *SAJCE* is an early childhood education focused journal that emerged in 2011 in parallel with the launch of the South African Research Association for Early Childhood Education (SARAECE). Contributing to these numbers is also a *SAJCE* Special Issue that focused on EGM in 2012. Next, regional and South African journals that foreground mathematics, namely *AJRMSTE* (15) and *Pythagoras* (11), are the most frequent publishers of EGM articles from South Africa. *Pythagoras* is the mathematics education journal of the Association of Mathematics Education of South Africa while *AJRMSTE* is the mathematics science and technology focused journal of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE). The education journal *PIE* has the fourth highest number of articles (10) mostly owing to a special issue focused on primary mathematics education in 2013. There are smaller numbers of articles in other local education journals, namely: *JOE* (7), *SAJOE* (6); *EAC* (5) and *AER* (2). The numbers were lower across the top international mathematics journals with *ZDM* publishing the most (8) followed by *ESM* (5) and *MERJ* (3). Single articles on EGM were published in *JRME*, *FLM*, *RME*, *IJSME* and *JMB* over the review period.

The ratio of local to international publications being 102:21, we see that local journals contain the vast majority (83%) of EGM journal publications with international journals contributing only 17%. This points to the importance of local journals, especially early years specific journals (*SAJCE* makes up 37% of all journal articles) and subject foregrounded journals (*AJRMSTE* and *Pythagoras* jointly make up 21% of all articles). Of all the local accredited journals it is worth noting that the phase specific and subject specific journals contribute 71% of publications. Given the phase specificity of *SAJCE*, some articles in our review focus on both mathematics and literacy or working at the interface of these (for example, Bezuidenhout, 2020).

Are EGM Articles Increasing Over Time?

Our review of publications showed major growth in the number of publications in the second decade (107 in 2013–2022) compared with the decade before (only 16 in 2003–2012). This increase is highly visible in both local/regional publications (15–87) and the international publications (from 1 to 20 in the past decade). A major contributor to this increase over the second decade is clearly the emergence of

Table 3. Frequency of articles addressing key themes

Teachers and teaching	Learners and learning	Language and multilingualism	Assessment	Other
96	44	19	15	1

SAJCE in 2011. The 21 international publications also point to the increasing visibility of South African EGM research in the international field in the past decade. We similarly see an increase in the number of publications in the local and regional discipline focused journals (*AJRMSTE* and *Pythagoras*) over the past decade from the previous decade (from 4 to 22).

How Broad is the Publication Base Across Regions and Institutions?

A wide range of regions and institutional affiliations are represented across the articles published in local and regional journals, and this is especially the case for *SAJCE* that has the greatest range—unsurprising given this journal also has the greatest number of articles. This contrasts with the picture when looking at EGM articles published in the top international journals with only three South African institutions represented here, namely Rhodes, Wits, and one from the University of Johannesburg (Mostert & Roberts, 2022). Almost all the articles from Rhodes and Wits are linked to work associated with the two NRF South African Numeracy Chair projects (Wits: Venkat, 2013; Ekdahl et al., 2016; Abdulhamid & Venkat, 2018; Venkat & Askew, 2018; Askew, 2019; Askew & Venkat, 2020, Venkat & Askew, 2021; Venkat et al., 2021; Rhodes: Graven, 2014, 2016a; Heyd-Metzuyanim & Graven, 2016; Graven & Coles, 2017; Robertson & Graven, 2018, 2019a, b; Westaway & Graven, 2019; Westaway, 2019; Wits & Rhodes collaboration: Graven & Venkat, 2021). The single international journal article in the first decade (prior to the establishment of the Numeracy Chairs initiative in 2011) was also linked to Wits University and focused on language and mathematics teaching (Setati, 2005).

Our restriction to international mathematics education journals does mean that articles presented in international general education or early childhood education journals are not represented in this review. While this delimiting was practical for our mathematical focus on the early grades, we note that work by Nosisi Feza in journals such as the *Journal of Inclusive Education* (Feza, 2014) and *Early Childhood Education Journal* (Feza, 2016), and work related to Elizabeth Henning's Chair at University of Johannesburg (UJ) in other international journals in the field of early childhood education (e.g. Aunio et al., 2021) is omitted in this approach. Given that much of this excluded work is also in the second decade of our review period, this means that our data likely under-represents the extent of growth in EGM research articles in South Africa.

The substantial growth in the number of publications in South Africa, and the clustering of many of these articles over the last decade around three research Chairs focused on early grade mathematics (the two NRF Numeracy Chairs), or early childhood education more broadly (the UJ Chair), clearly points to the importance of establishing well-funded longitudinal research programmes to grow a particular field identified as needing attention.

Teachers and Teaching

The greatest number of articles in our EGM review relates to the Teachers and Teaching cluster/theme ($n = 96$). This coheres with the finding of the most prevalent topic across SAARMSTE long article conference proceedings (see Graven & Venkat, 2023). There is a sharp increase in the number of publications related to Teachers and Teaching in the second decade of our EGM review: 10 articles in the first decade (2003–2012) and 86 articles in the second decade (2013–2022). Topics that relate closely to teachers and their practices, like professional development, Grade R teaching, in-service teachers' pedagogic practices and initial teacher education (ITE) are included in this cluster.

The empirical focus underlying the articles in the Teachers and Teaching cluster could be grouped into these sections:

- pedagogic practices;
- teachers' knowledge;
- ITE; and
- teachers' identity.

While we report separately on these sections related to teachers and their pedagogic practices, we acknowledge that these are intertwined and sometimes difficult to tease apart. The research base indicates strongly that pedagogic practices and teachers' knowledge are intimately linked, and further, that motivation and affective issues that have been highlighted as concerns within teacher professionalism in South Africa (Graven, 2012) also feed into the ways in which practice plays out. The turn to ITE is—in many ways—an outcome of the nexus of these issues.

Pedagogic practices

A substantial number of articles in this review relate to teachers' pedagogic practices in EGM ($n = 47$). A few common threads exist amongst the nine articles related to teachers' practices that were published in the first decade of our review (2003–2012). Setati (2005), Setati and Barwell (2006) and Nel (2012) all refer to aspects of language: the first two articles speak to the connection between language/multilingualism and mathematics teaching while the third focuses on teaching the meaning of mathematical symbols and vocabulary to first graders. Pietersen (2006), Gierdien (2009) and Venkat and Askew's (2012) work all touch on different aspects of teachers' use of resources. The articles by Venkat and Naidoo (2012), Hoadley (2012) and Venkat and Askew (2012) highlight important aspects of teachers' practices related to EGM from 2003 to 2012, namely, teachers' use of low-level strategies based on concrete counting-in-ones which inhibit learners' potential for developing more abstract understanding of number; the lack of coherence within teacher explanations and across teacher talk, use of artefacts and selection of tasks; teachers' lack of understanding of number and its progression and how children learn numbers. One 'stand-alone' article in this group speaks to collaborative co-teaching as the key to inclusion (Kruger & Yorke, 2010).

Venkat's (2013) overview of early number teaching in South Africa concluded that the persistent concrete counting approaches foregrounded in many classrooms resulted from focusing on the 'present' where the teacher approaches each example from first principles without drawing links to previous work. Venkat and Naidoo (2012) refer to this phenomenon as 'extreme localisation' (p. 21). From 2013 onwards, articles relating to pedagogic practices covered topics such as *teachers' experiences*, e.g. with implementing the 2012 Annual National Assessments (ANAs) (Graven & Venkat, 2014) and teaching Singapore Maths (Naroth & Luneta, 2015) as well as *different approaches to teaching primary mathematics*, namely, the conceptual fields approach (Long & Dunne, 2014), teaching through problem solving (Nieuwoudt, 2015), the structural approach to part–whole additive teaching (Ekdahl et al., 2016), the integrated learning approach (Kortjass, 2019), the dialogic approach in the context of teaching fractions (Shongwe, 2021) and responsive teaching which involves in-the-moment constructive responses to learner offers (Abdulhamid & Venkat, 2018; Abdulhamid, 2022). Three articles in the second decade of our review draw attention to teacher practices related to developing algebraic thinking in the Foundation Phase (FP)—du Plessis (2018), Afonso and McAuliffe (2019) and McAuliffe et al. (2020)—which is an important form of mathematical reasoning needed for learning mathematics in higher grades.

Teachers' mediational practices speak directly to pedagogical issues on the ground like teaching that negates connections and generalisability that militates against raising learner attainment in early grade mathematics (Venkat & Askew, 2018). The Mediating Primary Maths (MPM) framework—built on the notion that learning is mediated—outlines four mediational means, namely, tasks, artefacts, inscriptions and teacher talk. In our review, we found publications in local and international journals that elaborate on how some of these mediational means, viz. tasks and example spaces, artefacts and teacher talk/gestures, are used in primary mathematics classrooms.

Askew (2016, p. 2) notes that 'Tasks lie at the centre of teaching and learning mathematics', and therefore *tasks* are important for mediating early grade mathematics. Graven and Coles (2017) highlight a 'double gap' (between the planned, offered and lived object of learning) in teachers' use of tasks but reveal this to be an opportunity for productive learning in the professional development space. Similarly, teachers' limited *example spaces* (which directly affect the tasks used in lessons) in Morrison (2013) highlight the need to increase teachers' content knowledge from a pedagogic point of view. *Artefacts* are also key mediators of learning and surface in a range of articles in our review. The main

story about the use of artefacts is teachers' limited understanding of the mathematical structure underpinned in the design of artefacts (Venkat & Askew, 2012) and teachers' (inadequate) use of artefacts in ways that do not build conceptual understanding (Mntunjani et al., 2018).

Teachers' knowledge

Thirty-two articles in this cluster deal with teacher knowledge which comprises different kinds of knowledge that relate to mathematics content, mathematics learning and learners, mathematics teaching and various combinations of these aspects.

Three articles related to teachers' knowledge, published in the first decade of our review: Pietersen (2006), Ensor et al. (2009) and Venkat and Askew (2012), show shifts in our understanding of teachers' use of artefacts to enhance FP learners' numeracy skills. Pietersen's (2006) report on the evaluation of a number skills development programme concluded that 'the use of concrete educational materials should be central to teaching number skills in Grade 2' (p. 410). Since Pietersen's report, work done by Ensor et al. (2009) showed that the ubiquitous problem of counting-in-ones was perpetuated by teachers who encouraged learners to calculate using concrete counters up to Grade 3, where the number range extends to 1000. The article by Venkat and Askew (2012) points to shortcomings in Grade 2 teachers' understanding of the mathematical structure underpinning the design of certain artefacts. These articles point to shifts beyond a basic recommendation to include concrete artefacts towards the need to 'fade' the use of concrete artefacts over time, to support children's work with symbolic number formats within the number system.

There are 29 articles related to teachers' knowledge in the second decade of our review period (2013–2022) and five of these use Mathematics Knowledge for Teaching (MKfT) (Ball et al., 2008) to frame their studies. A few articles relate to pre-service teachers' (PSTs') knowledge and two relate to Grade R teachers' knowledge.

Ball et al.'s (2008) MKfT framework sets out different domains of teacher knowledge: *common content knowledge*, *specialised content knowledge*, *knowledge of content and students* (KCS), *knowledge of content and teaching* (KCT), *horizon content knowledge* and *knowledge of content and curriculum*. This was commonly drawn on in articles related to teacher knowledge. McAuliffe and Lubben (2013) use MKfT with Rowland et al.'s (2005) Knowledge Quartet to highlight the need to develop PSTs' knowledge of early algebra; Galant (2013) uses MKfT and Petrou and Goulding's (2011) knowledge model to question the connection between different kinds of teacher knowledge; Abdulhamid and Venkat (2014) demonstrate the possibility for ongoing development of MKfT that is informed by research; Sapire et al. (2016) use MKfT together with Hugo's (2015) distinction between cognitive and pedagogical loads to situate error analysis as an important part of teacher knowledge; and Chikiwa et al. (2019) show that all six knowledge domains in Ball et al.'s (2008) MKfT framework are drawn upon when teaching counting at Grade 2 level and highlight KCT as a vital part of this knowledge. The foregrounding of KCT in Chikiwa et al.'s (2019) study contrasts with a conclusion drawn in Galant's (2013) earlier empirical study of the knowledge Grade 3 teachers bring to bear in selecting and sequencing tasks. In Galant's study KCS predominated at the expense of KCT but in Chikiwa et al.'s study KCT stood out in teachers' knowledge. Henning's (2013) article about teacher knowledge argues that children's cognition in mathematics (or how children learn mathematical concepts) should form a major part of teachers' knowledge, rather than knowledge of specific mathematics content. Henning argues that knowledge of content and strategies is limited to a particular topic, but knowledge of children's cognition is far reaching and thus more valuable.

Perhaps owing to the relatively recent roll-out of Grade R across schools in South Africa, we found only seven articles from 2015 onwards related specifically to this Grade (learners aged 5–6 years). Four articles focus on developing Grade R teachers' practices in relation to professional development interventions (Wilmot & Schäfer, 2015; Barnard & Braund, 2016; Graven & Coles, 2017; Feza, 2018), and highlight the importance of professional development tailored for teachers of this Grade. Other authors highlight the potential of specific Grade R programmes like R-Maths (Hazell et al., 2019) and Meerkat Maths (Jansen van Vuuren et al., 2018; Ndabezitha, 2022) for supporting Grade R teachers in their work.

The intertwined relationship between teachers' knowledge and pedagogic practices is writ large in a few articles within our corpus: Venkat (2013), Galant (2013), Askew (2013), Morrison (2013), Moodley et al. (2016) and Hoadley (2017). Related to this are articles that propose typologies of mathematical content aimed at enhancing teachers' knowledge and practice, namely, Kuhne and Moodley (2013)—learning pathway for whole numbers; Roberts (2016) and Mostert (2019b)—typology for additive relation word problems; Herzog et al. (2017)—five sequential conceptual levels for place value; and du Plessis (2018)—typology for working structurally with patterns in the FP in ways that enhance early algebraic thinking.

Initial teacher education

Initial teacher education is focused on PSTs' preparation for their future careers in teaching, which includes developing knowledge of mathematics content and knowledge of teaching. There were no articles related to PSTs in the first decade of our review (2003–2012) and 10 articles within the second decade (2013—2022) related to PSTs knowledge of content and knowledge of teaching. There is a strong focus on PSTs limited knowledge of specific mathematical content, like early algebra (McAuliffe & Lubben, 2013), geometry (Luneta, 2014) and fractions (Ubah & Bansilal, 2014) while the work by Bowie et al. (2019) reports on the need to develop PSTs' deep knowledge of a range of primary mathematics concepts.

Beyond the need for PSTs' knowledge of content is their knowledge of how to teach specific content. Thus, the focus on developing both PSTs' use of manipulatives when teaching number operations (Ndlovu & Chiromo, 2019) and their use of questioning techniques when teaching through problem solving (Steyn & Adendorff, 2020). PSTs' limited knowledge of mathematics content and mathematics teaching has been connected to the negative attitude they display towards mathematics (Moodley et al., 2016). In line with the concern around developing PSTs' mathematics knowledge for teaching is work by Kortjass (2019) encouraging teacher-educators to improve their practice through self-study. Further, Msimango et al. (2020) call for greater subject-specific mentoring for PSTs by teacher-educators. These authors argue that the development of a set of subject-specific mentoring standards for teaching mathematics will help to further this cause.

Van Laren and Goba's (2013) article, published early in the second decade of our review, reports on the experiences of 16 FP PSTs who completed a few modules of their Post-Graduate Certificate in Education course in isiZulu to promote isiZulu as a medium of instruction for teaching and learning. This links to one of the later articles in our review that encourages PSTs to consider the interplay between language, children's home/learning environment and early number content (Bezuidenhout, 2020). The importance of acknowledging the relationship between language and mathematics is discussed separately in this review.

Teachers' identity

Seven articles within our review deal directly with the sub-theme: *teachers' identity and beliefs*. The salient issues related to mathematics teachers' identity and beliefs have already been dealt with in Graven and Heyd-Metzuyanim's (2019) extensive review of this topic in *ZDM*, so we only highlight those issues touched on during the term of our review. Pausigere and Graven's articles published in 2013 and 2014(a and b) linked primary mathematics teachers' identity to the emphasis placed on the country's ANAs and how the influence of the national curriculum, e.g. C2005 and CAPS, changed teachers' identities. Pausigere and Graven (2014) refer to the potentials and limitations of developing teachers' identities through participation in an in-service teacher development model. The topic of teacher identity was extended to include PSTs' negative attitudes towards mathematics as learners and teachers (Moodley et al., 2016) and how these attitudes influence their identity in their future careers. In her article, Westaway (2019) speaks to the connection between mathematics teachers' identities and the apartheid education system as the reason for teachers' resistance to taking up progressive teacher roles while Westaway and Graven (2019) make similar connections between primary mathematics teachers' identities and the previous education system. Thus Graven's (2014)

clarion call for a discourse of agency and possibility (rather than deficit) concerning South African teachers seems more important than ever in the pursuit of equity and quality in mathematics education.

Learners and Learning

A substantial cluster of articles ($n = 44$) within our period of review included a focus on aspects related to learners and learning. This cluster includes articles studying teaching given evidence of shifts in learning, and articles looking at conditions affecting learning. The largest sub-group within this cluster consisted of articles focused on early number topics ($n = 21$), with this focus also appearing as a key point of interest in studies of curriculum, textbooks and workbooks (a further six articles). Early number emerged as problematic in studies of teaching and learning in the 2003–2012 decade. Ursula Hoadley's doctoral study (Hoadley, 2005) was focused on pedagogy, but offered illustrations of the counting in ones that has become a hallmark of the lack of progression in learning outcomes that was subsequently seen in ANA outcomes. This counting in ones was referenced in additive situations in Hoadley's (2007) article within this review, in multiplicative situations in Scholar's (2008) report, and linked to early grades' teaching that held learners in counting approaches across the FP (Ensor et al., 2009)—also in this review.

This outline of ongoing use of counting approaches as a key problem within early grades' mathematics learning formed part of a substantial move, in the second decade, towards intervention, rather than observation-oriented studies. This reflected a broader move in the research field into design research seeking to improve outcomes, rather than only studying the ground, with several medium and larger scale projects running in South Africa since 2011. Within this review, we saw only two articles in the first decade focused on intervention studies: Fraser et al.'s (2004) study working with a Grade 3 class to improve fraction understandings and Pietersen's (2006) evaluation study of a Grade 2 number skills development programme. In contrast, since 2013, 17 articles in this cluster included a focus on a range of features linked to intervention studies. Of interest, in relation to the flagging of early number as a key problem area in the earlier decade, 12 of these 17 articles directed their attention at aspects, or combinations of aspects, of early whole number learning—additive relations (Ekdahl et al., 2016, 2018), multiplicative relations (Askew et al., 2019; Venkat & Askew, 2021), basic fluencies, strategies and mental mathematics (Stott & Graven, 2013a; Graven & Venkat, 2021; Morrison et al., 2021), the four operations (Stott et al., 2019) and early number generally (Venkat et al., 2021), among these.

Venkat and Graven (2022) have noted that the intervention studies developed within the mathematics education field have tended to focus on the mathematical substance of particular topics, rather than dealing with the whole curriculum from a coverage vantage point as the larger-scale policy-oriented studies have tended to do. This topic-specific focus has offered illustrations and insights, for teachers as well as researchers, of what growth in early number proficiency consists of, and as such, these articles offer important resources for use in EGM teacher development.

The emphasis on early number does mean that other topics have received much less attention. Problems with understandings of equivalence, as an important early algebraic idea, were noted in a study undertaken with Grade 4 learners, confirmed a tendency to view the equals sign in operational terms, rather than in relational terms (McAuliffe et al., 2020). These authors pointed to the need for greater attention to equivalence in Foundation Phase texts and teacher development. Early algebraic structure is also in view in the attention to reasoning and strategic calculation using number relations in the mental starters assessment project (Graven & Venkat, 2021). Fractions were investigated in a small-scale study in the first decade (Fraser et al., 2004), and in Brown's (2019) study using learning data to propose more holistic ways of teaching fractions. While at one level, the emphasis of so much of the work on learning in early number can be seen as limiting learners' access to mathematics, the concerted attention to number—at least pre-Covid—has produced a credible body of research-informed intervention materials and assessments that are currently being used at larger scales: across provincial level interventions from the Wits Maths Connect-Primary project work, across maths clubs in several provinces from the Rhodes South African Numeracy Chair project, and in the extensive

attention to number structure and relations in the Bala Wande materials and resources, which have borrowed, in turn, from the materials developed within the Magic Classroom Collective project based in the University of Fort Hare (Porteus, 2022). Larger scale initiatives such as the Gauteng Primary Literacy and Mathematics Study (GPLMS), focused on the whole curriculum, have tended to offer more limited illustrations of what learning gains look like in mathematical detail (Fleisch & Schoer 2014). It is in this mathematically attuned detail that the studies in the learners and learning strand come to the fore.

Similarly, the conditions of learning and learner experiences have also received more limited attention. A small cluster of work from the Rhodes Numeracy Chair (five articles) is linked to investigating and developing instruments for researching young learners' mathematical dispositions and identities (e.g. Graven et al., 2012; Graven, 2016a). A further small group, with a range of foci, have explored conditions around EGM learning—dealing with issues such as noise and classroom conditions, bullying and disruptive behaviour (e.g. Roberts & Venkat, 2016; Pillay, 2021).

Of interest in the learners and learning cluster is the significant presence of key research groups with specific areas of interest and expertise—EGM assessment development work at UJ, school-based number focused interventions and design research in the Wits Maths Connect-Primary project, and maths clubs and learner dispositional change in the Rhodes South African Numeracy Chair project. There are also emergent foci that are producing new emphases within learner/learning focused research—the literature on language and assessment in EGM are good examples of the field's expansion. The detail of these new foci is included in the sections below.

Language and Multilingualism in Early Grade Mathematics

Language and multilingualism can be considered a cross-cutting theme across our two-decade review of early grade mathematics as it surfaces across other themes, namely, Teachers and Teaching, Learners and Learning and Assessment. Nineteen articles were identified within this cluster.

A sharp increase in publications related to language and EGM is evident from the first decade of our review to the second. Three articles related to multilingualism and primary mathematics teaching and learning (Setati, 2005; Setati & Barwell, 2006; Nel, 2012) were published within the first decade (2003–2012) and 16 articles related to language and multilingualism in the EGM space were published within the second decade (2013–2022).

Setati (2005) highlights the complex relationship between language and mathematics in multilingual settings and Setati and Barwell (2006) explore the role of multilingualism in mathematics classrooms in two countries (South Africa and England) in the context of word problems. These authors share three sets of discursive practices common to both settings: the use of learners' main language, use of narrative and reading aloud. In her article, Nel (2012) argues that teaching first-graders how to crack the mathematics vocabulary code should be regarded as important, not trivial, because the terms and symbols used in mathematics lessons may seem like a foreign language to some learners.

A recurring theme in articles across the second decade is evidence of difficulties for children learning EGM in a second language. These difficulties include learners' underperformance in national assessments (Sibanda, 2017), African immigrant learners' struggles with learning word problems (Mahofa et al., 2018) and the negative effects of dialects and code-switching on isiXhosa-speaking learners (Mtstase & Combrink, 2018). Robertson and Graven's (2019a) article speaks to diminished meaning-making amongst Grade 4 English language learners showing that the challenges related to language and mathematics become exacerbated in the Intermediate Phase of schooling (Grades 4–6).

From 2019 onwards, an important sub-theme emerges within the EGM space, namely, leveraging the affordances and mitigating the constraints of learning in African languages in EGM teaching and learning (Mostert, 2019a, 2020). This sub-theme, which relates to teaching EGM, is important as demonstrated in Poo's (2021) work which shows the differences in teachers' practices regarding shifts between different modes of mathematical representations in English and Sepedi-medium classes. Thus, the mathematical detail of how to use language as a pedagogic resource (Planas & Setati-Phakeng, 2014) is seeing greater take-up as highlighted in the body of work by Mostert

(2019a, 2020) and Mostert and Roberts (2022), amongst others. One article discussed earlier (van Laren & Goba, 2013) shows that the importance of language and multilingualism in early grade mathematics is also being taken up at a South African university to promote mathematics teaching and learning in FP learners' home language, which in their case was isiZulu. Four articles focused on the translation of a standardised test into South African languages (Dampier & Mawila, 2012; Fritz-Stratmann et al., 2014; Bezuidenhout, 2018; Henning, et al., 2021) highlight the importance of language in mathematics assessment—which is discussed next.

Assessment

The move towards linked research and development in intervention studies in the EGM space has had other offshoots: 15 articles in this cluster included a focus, in one or other way, on assessment. Eleven of these are published in three South African journals (*PIE*, *SAJCE* and *SAJOE*), three are published in the Southern African journal *AJRMSTE*, and one is published in the international journal *MERJ* (Graven & Venkat, 2021).

Given that the move into EGM is an expansion that has occurred in the last decade, this cluster includes articles focused on developing progression models (e.g. Herzog et al., 2017 for place value) and assessments that can be used to understand the impact of interventions. International assessments have been used in some studies (e.g. the ThinkMath Scale assessment in Aunio et al.'s (2016) study and Bob Wright's assessments in the studies of the two Numeracy Chair teams). Elizabeth Henning and her collaborators at UJ have focused extensive attention in the last decade on developing standardised early number assessments for use in the early grades in South Africa, including versioning into different languages (e.g. Dampier & Mawila, 2012; Fritz-Stratmann et al., 2014; Bezuidenhout, 2018; Henning et al., 2021). In addition, there have been the timed fluency assessments that were developed by Stott and Graven (2013b) and the mental mathematics assessments developed by the Wits and Rhodes Numeracy Chair teams (Graven & Venkat, 2021), which are now part of national policy rollout. Thus, there has been significant expansion—in the wake of the demise of the ANAs in South Africa—in the range of assessments available for assessing early mathematical learning, with a particular focus on early number.

Five articles focus on the ANAs in South Africa (Weitz & Venkat, 2013; Graven et al., 2013; Graven & Venkat, 2014; Kanjee & Moloi, 2016; Sibanda, 2017). Weitz and Venkat (2013) question the usefulness of the ANAs by comparing learners' responses to two assessments: the ANA and Wright et al.'s (2006) diagnostic oral interview test. The learners in their study performed well on the ANA but had low performance on Wright et al.'s (2006) learning framework in number assessment. Their findings indicate that marking for correct answers regardless of the strategy used resulted in learners who use inefficient, low-level counting strategies scoring well on the ANA. Linked to this, Graven et al.'s (2013) article explores number sense and the development of efficient strategies for calculation, including examining the ANAs for evidence of the assessment of number sense. Their findings showed that while the CAPS curriculum includes mental computation for number sense the ANAs did not assess this. Sibanda (2017) similarly critiqued the ANAs with a focus on language complexity. Through analysing 106 Grade 4 learners' responses to ANA items, and conducting task-based interviews, Sibanda concluded that the language used was unnecessarily difficult for Grade 4 English language learners who had only recently transitioned from learning mathematics in isiXhosa in the FP. Graven and Venkat (2014) similarly critiqued the ANAs but from the perspective of primary teachers' experiences of the administration of the ANAs. They found that teachers expressed concerns for learners' experiences of taking these high-stakes assessments, for challenges in administering the tests and the lost teaching time.

In contrast, Kanjee and Moloi (2016) focused on how ANA results were reported, rather than on the assessment itself. They argued that the reporting structure 'overestimates the percentage of learners classified at the lowest performance levels and underestimates those in the next category' (p. 29). Their concern was that this limited the development and implementation of targeted interventions for improving learning.

Stott and Graven (2013a) and Herholt and Sapire (2014), while writing during the time of the ANAs, focused on different assessments. Stott and Graven (2013a) investigated the use of timed fluency activities, together with learners' reflections on those activities, as a research and developmental tool. This was done in an after-school mathematics club. Their conclusion was that these timed fluency activities allowed a 'quick way of tracking, evaluating, encouraging and valuing learner progress … with a mechanism for the learners to practise the fluency they were developing' (p. 79). Herholt and Sapire (2014) focused on tests of mathematical problem solving with Grade 1–4 learners and turned their attention to an analysis of the errors that learners were making. They discovered 'common procedural and conceptual errors' (p. 42) and argued that the analysis method outlined in their study could be adopted by teachers. Govender's (2020) study is the only study focused on formative assessments. It explores Grade 2 teachers' perceptions of formative assessment and found teachers struggled to enact formative assessment owing to limited understanding of it.

As noted earlier, Henning and her collaborators at UJ have worked to adapt the German MARKO-D assessment for number concept development of young learners (4–8 year olds) for South African use (Dampier & Mawila, 2012; Fritz-Stratmann et al., 2014; Bezuidenhout, 2018; Henning et al., 2021). These articles reflect on the translation and adaptation process. Dampier and Mawila (2012) focus on the translation of the test from German into English and then into isiZulu and Sesotho and reflect on the difficulty of accurately translating concepts referred to in test items. Similarly, Fritz-Stratmann et al. (2014) reflect on pilot studies conducted through the translation process that included 1600 South African children but focus their results presentation and discussion on the Sesotho version. Bezuidenhout (2018) presents the Afrikaans translation of the test and describes the process of considering the 'linguistic, functional, cultural and metric equivalence' (p. 1) of the test during the translation process, while Henning et al. (2021) relates a narrative of the development of the four South African language versions of the MARKO-D assessment through describing the cycles of research that were completed in its development. They also present the findings of the research done during the work to standardise and norm the assessment. This work is critical as there is a 'dearth of suitable assessment instruments for gauging young children's mathematical concept development' (p. 1).

Most recently, the work of Graven and Venkat (2021) reports on the development of diagnostic assessments for strategic calculation for Grade 3 learners. In this article, Graven and Venkat share the positive results of a pilot of the 'bridging through ten' strategy run in two provinces. They argue that if diagnostic assessments are paired with structured lesson starters, they could be useful for broader implementation. This project is a response to their aforementioned findings that highlight an absence of attention to number sense and efficient calculation strategies in EGM teaching and learning.

As noted above, the assessment thread includes attention to language issues, with the MARKO-D assessment developed by the UJ team versioned into several South African languages, and the mental mathematics assessments from the two Chair teams available, with DBE support, in all of the South African languages (https://www.education.gov.za/MSAP2022.aspx).

Insights and concluding remark

One aim of our review of the South African literature on EGM was to highlight the presences as well as absences within the field, as one way of informing the field going forward. Pertinent issues raised in this review are interesting in relation to its overlaps with the broader international field, but there are notable absences too such as the work on early algebraic learning/patterns, and other areas of maths (measurement and shape/space). While this follows from the finding of poor progression beyond one by one counting in South Africa, the early algebra/pattern, and measurement foci in particular, has been identified in the international literature as important for supporting number learning. On the upside, various aspects of number learning which include numeral identification, number bonds, representations, etc., do feature extensively. Given the evidence of post-Covid learning losses in early

mathematics (Van der Berg et al., 2022), we expect the attention to number learning to continue in the next decade. Grade R (and early childhood development more broadly) features only recently in terms of policy attention. Given this, it is understandable that articles on this topic feature only in the last phase of our review. We expect research in this area to grow in the next decade. Teacher educators within ITE has a relative absence owing to the recent focus on PSTs in the past decade. ICT and technology feature relatively extensively in the international EGM literature (e.g. TouchCounts: Sinclair & Heyd-Metzuyanim, 2014; Sinclair et al., 2016; Place Value Chart App: Larkin et al., 2019). It is reflective of the problems with resourcing on the ground in South Africa that technology features rarely in this review. There are a small number of recent publications noting the integration of low-level technology in support of mathematical learning (m-learning: Roberts, 2020; Roberts & Spencer-Smith, 2019 within the review; OLICO: Bowie et al., 2022; Jumpstart: Roberts & Moloi, 2021; SANCP online intervention: Vale & Graven, 2021 within the review), pointing to an emerging field that is likely to grow in the next decade.

Whilst the absences mentioned above shine a light on where the field might focus more attention going forward, the presences also have implications for work up ahead. We focus on this in our concluding paragraphs.

This review showcases the remarkable growth in the number of early grade mathematics publications in the last decade: 107 publications in 2013–2022, compared with the previous decade of 16 publications in 2003–2012. This substantial growth in publications can be attributed to a few key factors and the resultant offshoots thereof. The key factors that served as catalysts for this growth are: poor learning achievements in the ANAs that mirrored the poor attainment seen in international assessments Trends in Mathematics and Science Study; the nature of pedagogy in government primary schools (Hoadley, 2012) that serve most learners from previously disadvantaged groups (Spaull, 2013a); the establishment of three NRF Chairs focused on research and development in the early grades, and the emergence of a South African journal focused specifically on Early Childhood Education (i.e. *SAJCE*). The latter provided a key outlet for dissemination of findings emerging from the growth of research into EGM (as evidenced by it having 37% of articles in our review sample). Collectively, it is worth noting that phase-specific and subject-specific outlets comprise almost 60% of the overall sample, attesting to the importance of these more specialised outlets in supporting a focus on EGM.

Hoadley's (2012) overview shone a light on the nature of teaching and learning in South African schools that resulted in increased attention to the early grades from government and the private sector. This attention highlighted the need for increased professional development for FP in-service teachers, the need for quality teaching and learning materials, and the need for better trained pre-service teachers.

Poor ANA outcomes confirmed concerns raised about the quality of teaching and learning in EGM. Gaps in EGM learning were linked to the poor learning outcomes in higher grades (Spaull, 2013a), highlighting the need for early intervention which research shows to have a higher return (Spaull, 2013a). These showed the need for greater attention to the nature of assessments and how these results are interpreted and fed back into the system for improved teaching and learning. The issue of language and multilingualism is writ large across the challenges identified in pedagogic practices and assessment in early grades mathematics. Both assessment and language and multilingualism therefore emerged as substantive clusters of research in our review.

The cluster with the highest frequency of articles in our review period however is *Teachers and Teaching*. Some 79 of the 123 articles in our corpus focus on aspects related to teachers' pedagogical practices and teachers' knowledge. These articles collectively point to the urgent need for strengthening both pre- and in-service support for teaching EGM. Learners and Learning followed as the second most prevalent cluster with 44 articles.

Our data notes that the work of three research Chairs tasked with growing the field of early childhood learning, and in the case of two Chairs particularly mathematics learning, led to a dominance of publications emanating from their teams over the past decade (90% of the 21 international EGM articles emanate from these three teams). This points to the importance of establishing substantively funded long-term research and development focused programmes to stimulate the growth of an

identified priority area (such as EGM in this case). It also points to a need for such funding to spread to a wider range of regions and institutions, including establishing such opportunities in other Southern African countries if we are to broaden the base of contributions to this field and in the international terrain.

Acknowledgement

This work is supported by the South African Research Chairs Initiative of the National Research Foundation (grant nos. 74658 and 74703).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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