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What explains early numeracy achievement: A comparison of South Africa and China

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Abstract

Mathematics is pivotal in the contemporary technology-driven world. However, poor mathematical performance continues to be a concern in many countries. Guided by Mathematics in a Cultural Context (MCC) framework, this article investigates the similarities, differences, and potential reasons behind early numeracy achievement in South Africa and China. Applying a qualitative research approach, selected teachers, parents, and government officials in the two countries were interviewed for their views on the cultural context and pedagogical practices that potentially impact mathematics teaching and learning. The findings confirmed the multifaceted and interconnected nature of mathematics teaching and learning. However, the findings raise questions about the efficacy of certain practices on mathematics learning and achievement, including the teaching approach, the value of different kinds of motivations, and methods to inspire motivation. This finding suggests the importance of practicing key mathematics concepts in building a solid foundation and confidence in mathematics.

Keywords: China, Early Numeracy, Mathematics Teaching and Learning, South Africa

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Mathematics skills and knowledge are pivotal in the contemporary knowledge economy. However, mathematics learning and achievement are often suboptimal and uneven across countries. This article compares mathematics learning in a seemingly improbable comparison: China and South Africa. The two countries do not participate in the same international benchmark test. South Africa participates in Trends in International Mathematics and Science Study (TIMSS), and its achievement remains low compared to benchmark figures despite improvements in recent years. China participates in the Program for International Student Assessment (PISA) and routinely outperforms others (often comes up top). We acknowledge that the difference in such mathematical performance comparison could be due to the potential (mis)alignment of the mathematics curriculum with test orientation. In this regard, PISA focuses more on mathematical applications in real-world situations, and the Chinese mathematics curriculum features approximately 60% abstract mathematics content and 40% applications (Cao & He, 2009). TIMSS measures more traditional mathematics content (Kadijevich et al., 2023; Margaret, 2010; OECD, 2016b). In South Africa, a choice between *Mathematics* (more abstract content theories and concepts) and *Mathematical literacy* (practical mathematics, focusing on daily life applications) was introduced in 2006 for students from Grade 10. Official statistics from the Department of Basic Education show that students enrolled in mathematics literacy far exceed those enrolled in mathematics, and the gap is widening (Figure 1).

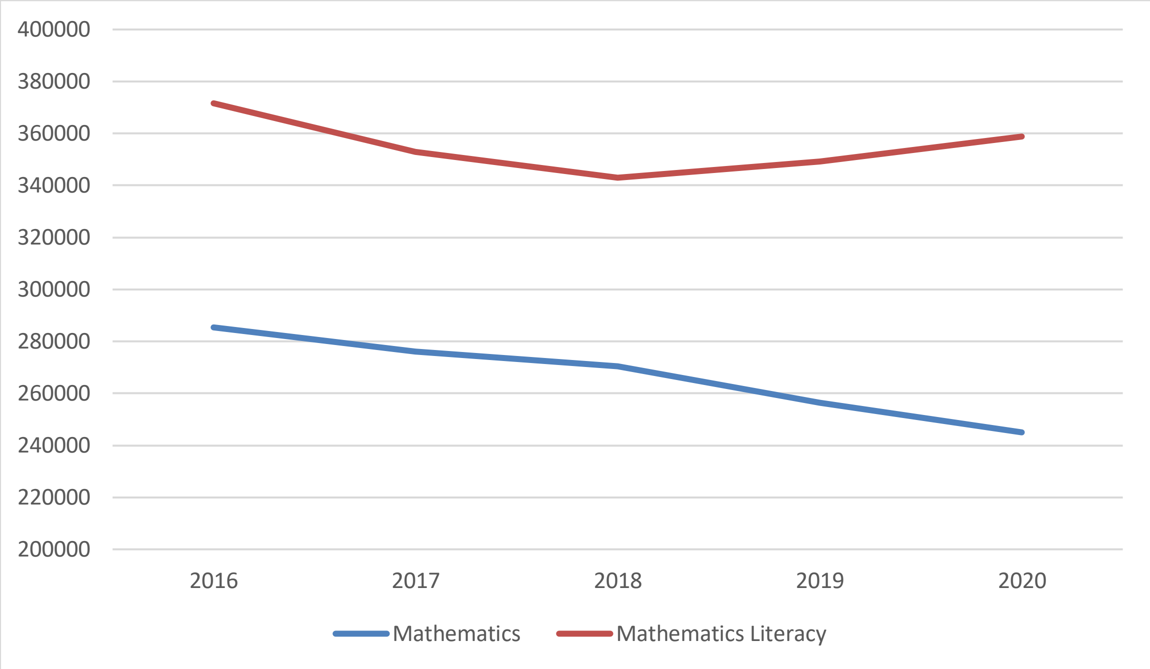

Figure 1. New student enrolled for Mathematics and Mathematical literacy (2016-2020)
Source: McKane (2020)

Most South African students learn Mathematical literacy at school, so their struggle with TIMSS should not come as a surprise. However, this potential (mis)alignment is unlikely to account for the entire performance gap, which this article explores. More specifically, this article explores similarities, differences, and potential reasons behind numeracy achievement in these two countries to distill aspects potentially underexplored in the existing literature. For example, mathematics education literature (particularly the one from South Africa, Adler et al., 2017; Morrison et al., 2023; Taylor, 2021; Venkat et al., 2009) tends to focus more on teaching and teacher education rather than adopting a more comprehensive lens including both within and outside the schools, e.g., culture (Bakker et al., 2021; Clarke, 2002; Gökçe & Guner, 2021; Jablonka et al., 2018; Julius et al., 2021). Both countries embody collective culture but are distinctively different in many other aspects; both have also undergone curriculum reform in recent decades (broadly towards converging on the global norm of constructivism, Gökçe & Guner, 2021. Also see Cross et al., 2002; Cui & Zhu, 2014). Against this backdrop, we ask whether the disparity in their mathematics achievement represent polarized practice in the two counties as well. As both countries face challenges related to educational inequality where socioeconomic factors (Gallo, 2020; Xue et al., 2020) potentially exacerbate disparities in educational access and outcomes across regions or population groups (Adler & Pillay, 2016; Reddy et al., 2020; Wang et al., 2017), we are also interested in examining both within countries differences and between countries differences.

An explicit comparison of the two countries doesn't exist in the literature (e.g., on Google Scholar or Scopus). Instead, available comparative studies on the topic typically compare west and east (e.g., Leung et al., 2006, more particularly between the U.S. and China) or adopt a broader cross-nation comparison amongst, e.g., participating countries in the TIMSS or PISA. Guided by broad research questions to search for similarities and differences and underlying reasons for mathematics performance, this article reports a study that explores a range of aspects related to early mathematics teaching and learning in the Foundation Phase (Grade R-3). Two reasons inform the focus on this foundation phase:

- There is limited focus on this phase in the literature. This is more acute in South African literature (Adler et al., 2017; Morrison et al., 2023; Venkat & Sapire, 2022) but is applicable to broader mathematics education literature as well (Gökçe & Guner, 2021); and
- The solid relationship between early numeracy and later mathematics achievements is established in research (Alex & Juan, 2017; Machaba, 2017; OECD, 2016a; Reddy et al., 2016). Many children who enter kindergarten with low numeracy skills are found to often remain behind their peers throughout their lives (Aunio et al., 2016).

The organization of this article is as follows: after explaining and reviewing the theoretical framework (Mathematics in a Cultural Context, MCC) and relevant literature, the method of qualitative inquiry was presented. This article then reports the main findings from the data. In addition to confirming the interrelated societal, school, and home aspects of mathematics learning predicted by the MCC, the findings highlight several controversial areas where the efficacy of certain mathematics teaching and learning practices that require further investigation.

Many scholars have examined various aspects to unpack why many students struggle with mathematics; many conclude that mathematics learning and achievement are influenced by many interrelated aspects (Bai & Daley, 2014; OECD, 2016a; Reddy et al., 2016; Rickard, 2017). However, most focus only on selected aspects, for example:

- The role of the society and cultural context (Rickard, 2015, 2017);
- The education system, curriculum, and reforms (Seah et al., 2016);
- Teachers' roles include their subject knowledge competency and pedagogy practice (Seah et al., 2016);
- Classroom teaching and learning practice (Hodge & Cobb, 2019);
- Students' motivation and attitude (Doabler et al., 2015);
- Parental involvement and homework (Feza et al., 2015; Naroth & Luneta, 2015).

Few studies holistically examine mathematics learning from a multifaceted point of view. This paper adopts MCC as its theoretical framework to view mathematics achievement from both cultural and pedagogical angles. MCC emphasizes the role of teachers, students, the community, and other interactive support systems in ensuring effective learning (Lipka et al., 2005; Rickard, 2015). It highlights three domains that contribute to mathematics learning and achievement: culture and context, pedagogy, and mathematics content knowledge, which overlap and influence each other. For example, pedagogy is shaped by culture and context; both pedagogy, culture, and context contribute to realized content knowledge (Rickard, 2015). Mathematics content knowledge here can be seen as a proxy for mathematics achievement, so the main thrust of the model is to highlight the interaction of culture and context as well as pedagogy on mathematics learning (see Figure 2).

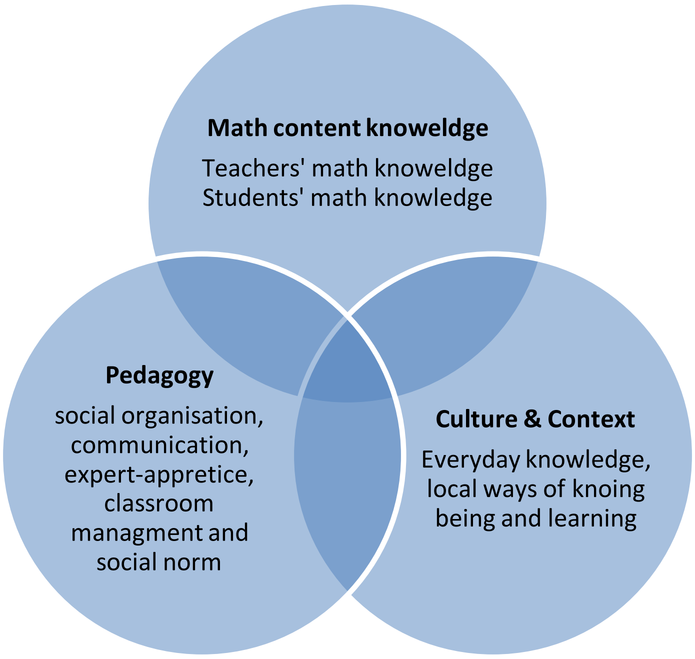

Figure 2. Theoretical Framework of MCC
(Source: Lipka and Rickard (2005))

In terms of culture and context, both China and South Africa boast collectivism; however, collective involvement in children's learning, e.g., parental involvement, is quite different. No matter what socioeconomic background one comes from, many Chinese parents try to invest in resources (e.g., learning materials) as much as possible (Domenech, 2018; OECD, 2016a). Many send their children to private tutorial classes after school and on weekends (OECD, 2016a; Wang et al., 2017). Even for those not less involved, many parents still expect the students to complete homework, even if it means working late into the evening (OECD, 2016a). In South Africa, parental involvement is much lower (Ndebele, 2018), particularly among illiterate parents who are not "confident or facing language barriers that prevent them from talking to educators about their child's progress" (Kralovec & Buel, 2001, p.9). Homework supervision is also generally much lower; some do not know what is expected of them regarding their children's education (Kralovec & Buel, 2001).

Both countries have a long history in mathematics, but their attitude towards learning mathematics is somewhat different. China adopted the positional number system as early as 1500 BC, where counting rods and positioning them on the checkerboard were used to represent numbers. Mathematical concepts are found in African cultural activities, such as beadwork and jewellery. However, one difference with the South African case is that the traditional mathematical principles tend to be not incorporated into teaching and learning (Mosimege, 2020). In both countries, mastering mathematics is seen as of great value in the new knowledge economy, is associated with a higher intellectual status, and is a gateway to a good career. Chinese students do not have a positive attitude towards learning mathematics or learn it for intrinsic reasons, like their counterparts in South Africa. Mathematics is also perceived as a difficult subject in both countries. However, studying mathematics is still the norm in China (Wang et al., 2017) due to filial piety (Lv et al., 2019), while in South Africa, many believe that mathematics is only for gifted students and accept their incompetency even before they have tried it or have opportunities to develop an interest in it (George & Adu, 2018). Another cultural difference between the two countries is China's strong competitive spirit (Bai & Daley, 2014) and emphasis on performance (Wang et al., 2017), and a much weaker obsession with high scores in South Africa (Domenech, 2018). In China, the pass mark is 60%; however, many students are not satisfied when they pass (Wang et al., 2017); in South Africa, students need much less to pass (50%-30%), and many are happy if they manage to pass (Ndlovu, 2017).

In the pedagogy domain, China has a continuous emphasis on high respect for teachers who are considered to be "the bearer of knowledge" (Wang et al., 2017, p.3). South Africa's attitudes towards teachers are more ambivalent. On the one hand, South Africa also used to be highly authoritarian (Von Holdt, 2013, although the authority was not necessarily assigned to teachers). Since the dawn of democracy, South Africa has deliberately sought a transition towards decentralization, inclusions, and shared decision-making. On the other hand, teachers are generally not seen as high-status or good career choices in most of its communities (particularly the black communities). In terms of teaching itself, Chinese classroom teaching and learning practices still tend to be traditional (Cai & Wang, 2010; Feng, 2006; OECD, 2016a; Wang et al., 2017): demonstrating a more teacher-centered approach involving adherence to a fixed plan, routine, and repetition (OECD, 2016a; Wang et al., 2017), although as Xu (2010, p. 133) claims "teachers' controlling in mathematics classroom does not necessarily put students in a passive position, and repetition does not necessarily equal to mechanical drilling". Teaching the *two basics* (teaching "only the essential, and ensure plenty of practice", Zhang et al., 2004, p. 195) through the whole-class discussion (also called the group teaching approach) —one teacher-centered approach—is widely practiced in China (OECD, 2016a). Unlike in China, South African classrooms, particularly after the demolition of Apartheid, are generally more student-centered (Machaba, 2017). Compared to the whole class teaching method where the Chinese teachers use 83.87% of the lesson time on content with the whole class, 15.27% of time on individual student activity, and only 1.448% of time on student discussion (Wang et al., 2017), teachers in South Africa, according to the prescription of the current curriculum, should use approximately 30% of the time for teaching, 10% for homework instruction and corrections, and the rest of the time for the students' activities. However, this is another area of ambivalence in South Africa. Although the official rhetoric often champions teachers being facilitators (Pereira & Sithole, 2020) who encourage collaborative activities and projects that allow students to explore, investigate, and apply the concepts on their own, classroom practice often sees "learner-centered practice remains at the level of rhetoric" (Venkat et al., 2009, p. 13) where teachers still tend to focus on maintaining classroom order and discouraging discussion.

Both countries have undergone curriculum reforms. China's curriculum reforms have gone through many waves; despite, the overall characteristics and curriculum content have remained unchanged (Cui & Zhu, 2014). This also applies to the latest 1999's new Mathematics Curriculum Standards for Full-time Compulsory Education (MCSFCE). Despite its aspirations and aims to reduce students' workload so that they have more time to improve 21st-century skills such as critical thinking, MCSFCE still inherits many objectives from the traditional Chinese curriculum, such as favouring formal assessments, drills, and memorization (OECD, 2016a). The constructivist approach is increasingly acknowledged; however, highly influential scholars in China disagreed with this and still championed the advantages of the teacher-centered transmission models (Xie et al., 2018, p.2). In South Africa, all curricula were completely revamped after democracy (Gallo, 2020) and several curricula (although no specific mathematics curriculum), in quick succession, were introduced. Mathematics was introduced to all races in all schools. The Chinese mathematics curriculum is generally seen as fast-paced (Li & Huang, 2013), often involving a large amount of content covered in a short time (Li et al., 2019); while South African mathematics content is less heavily packed (Gordon & Wang, 2000) although schools and students still feel that it is too heavy (Khuzwayo & Mncube, 2017).

METHOD

Due to the limited literature exploring mathematics teaching and learning through a comprehensive range of aspects and this unique comparative lens, the empirical study reported in this article adopted a qualitative approach and is exploratory. Aligned with this objective and an aim to develop a theory to explain the underlying reasons for mathematics performance and achievement gap, a qualitative approach is adopted to allow the discovery of new or unanticipated aspects (Creswell & Poth, 2018).

Purposive sampling, one of the most common sampling strategies for qualitative studies, was applied. In South Africa, three types of schools that differ substantively in mathematics performance (Reddy et al., 2016, 2020) were selected. In China, public schools charge little; therefore, there is no clear distinction between fee-paying and no-fee schools. Although the mathematics performance differences between public and independent schools are also minor (OECD, 2016a), independent schools have greater access to resources and tend to adopt a different kind of curriculum, for example, one from America or Canada. Therefore, these two types of schools were distinguished by sampling. This sampling decision seeks to explore whether the performance gap could result from the type of school or resource.

Further guided by the literature (Hu et al., 2018; OECD, 2016a; Reddy et al., 2016), which indicates that school, home, and curriculum are at the center of early numeracy learning, mathematics teachers, parents whose children attended the selected schools, and government officials from both countries were chosen and invited to participate. Acknowledging that small samples are prone to produce bias and considering the interest of the study to explore the phenomenon from different *types* of participants and hear their views more fully, one participant in each category for each school was selected. After obtaining ethics clearance and permission from the Faculty Ethics Committee and the provincial Department of Education in South Africa, schools that fall within the selection criteria were approached where the principals recommended the participants.

Table 1. Teachers' demographic distribution

Participant code	Description	Gender	Grade and position	Highest qualification	Teaching experience
SA-PNT	South African public no-fee schoolteacher	Female	Grade R	B.Ed	19
SA-PFT	South African public fee-paying schoolteacher	Female	Grade 1	M.Ed	8
SA-IT	South African independent schoolteacher	Female	Grade 1 and HOD	B.Ed	18
CN-PT	Chinese public schoolteacher	Female	Grade 1	M.Ed	8
CN-IT	Chinese independent schoolteacher	Male	Grade 1	M.Ed	7

The teachers recommended parents. The Chinese schools were also identified through personal contacts and approached via principals. For government officials, they were both recommended by personal contacts. The government official in South Africa is a subject advisor working in district offices in the Provincial Department of Education who visits schools to facilitate curriculum implementation. In China, the government official is a mathematics researcher working in the Chinese Basic Education

Department at the metropolitan level. Mathematics researchers also observe teachers' lessons and provide feedback to teachers and school subject heads. This means that, in total, 12 participants were included in this study. Participant details (including codes used to refer to them in data analysis) are denoted in Table 1, Table 2, and Table 3.

Table 2. Parents' demographic distribution

Participant code	Description	Gender	Highest qualification	Occupation
SA-PNP	South African public no-fee paying school parent	Female	Grade 12	Petrol attendant
SA-PFP	South African public fee-paying school parent	Female	B.Ed	Grade 2 Teacher
SA-IP	South African independent school parent	Female	Grade 12	Factory worker
CN-PP	Chinese public-school parent	Female	M.Ed	School principal
CN-IP	Chinese independent school parent	Female	BA	Business owner

Semi-structured interviews with a predetermined protocol but also allowed the conversation to guide the process (Maree, 2019) were the data collection method. The interview protocol was designed before data collection to keep the conversation focused. Additional, open-ended, and spontaneous responses were also allowed. Due to COVID-19 restrictions, data cost considerations for participants, and participant preference, about half of the interviews were conducted online. The analysis was completed by transcribing, coding, identifying, examining, and interpreting themes or patterns from the data (Creswell & Poth, 2018). Both deductive and inductive coding were used to develop themes. Deductive coding started with a codebook—important words or patterns from the literature that the researcher created before the analysis process (Maree, 2019). On the other hand, inductive coding allows codes to emerge from the data (Creswell & Poth, 2018).

Table 3. Government officials' demographic distribution

Participant code	Gender	Qualifications	Teaching experience before becoming official	Teaching grades	Government official experience
SA-MCA	Female	M. Ed	9 years	Grade R to 3	6
CN-MCA	Male	PhD. Ed	12 years	Grade 1 and 2	8

RESULTS AND DISCUSSION

The themes that emerged from the data in this study are discussed in detail below. They are organized along the themes identified in the literature review and suggested by the theoretical framework, that are related to culture, context and the pedagogical practice.

Culture and Context

Attitude and Motivation

Participants from both countries confirmed their observation of a prevailing negative attitude toward mathematics among students. They also concurred with the importance of developing an interest in mathematics, aligned with literature (Aizen et al., 2019; Ryan & Deci, 2020). However, they offered different approaches to stimulate student motivation and interest: some emphasized enjoyment as the foundation for motivation; some considered high expectation or confidence; and others used rewards. All parents confirmed their high expectations, but the South African parents did not directly communicate their expectations beforehand but only gave rewards when their children came home with good results. This contrasts with Chinese parents, who explicitly set goals and rewards for their children to visualize expectations beforehand. The two Chinese parents also pursued additional opportunities to expose their children to 'experiencing' the career they dream of to motivate their children. For teachers, rewards are only seen with Chinese teachers, while South African teachers focus more on intrinsic motivation, trying to make mathematics interesting through enjoyable activities. This shows the ambivalent impact of attitude and efficacy of practices to stimulate interest in mathematics.

Parental Involvement and Homework

Homework allows students to reinforce knowledge and skills already taught in schools, consolidating what students have learned and developing work ethics (DoE, 1998); it also allows parents to be involved in their children's learning. Therefore, students who spend more time on homework generally achieve better academic performance (OECD, 2016a; Reddy et al., 2016). In China, students are given substantial homework despite MCSFCE's aim to reduce academic workload (Zhao et al., 2015). In fact, some schools in China even resort to presenting homework as an extracurricular study activity to comply with the regulations (Wang et al., 2018). All participating parents assisted with homework. However, SA-PNP found the homework sometimes too difficult for her, so she asked others in the family to assist, while the other two parents complained about too much homework, which they struggled to do after work or after having fulfilled other family responsibilities. In China, on the other hand, both Chinese parents 'complained' about too little homework, reflecting their opposite expectations. To supplement this 'inadequate' homework, CN-IP "use[d] the textbook or internet to find more mathematics problems to solve with my child."

Another disjunction in the South Africa case is South African teachers' disagreement that parents were doing their best to help despite parents' claims. Not specifically complaining about the three participating parents, none of the participating South African teachers thought that parents took their children's homework seriously or provided full or appropriate assistance. This is consistent with the literature that also finds that parental supervision for homework in South Africa is generally low (Ndebele, 2018), especially for those from disadvantaged backgrounds (Kralovec & Buel, 2001). It is not that South African teachers didn't understand why parental involvement wasn't ideal or why homework completion was poor: it was precisely because "our parents and students go through a lot at home, it is hard to push them to do homework every day' (SA-PNT) that SA-PNT often resorted to not giving out homework or giving little. Parental involvement also sometimes took an opposite turn: some students "confess that their family members did it" (SA-PFT). SA-IT agreed: "Parents, instead of assisting students by explaining and giving examples and allowing the students to write their homework themselves, do the homework for them." Such observations or concerns were not voiced in China, although homework practice differed between public and independent schools: CN-PT gave homework daily while CN-IT only gave it on Fridays because he believed not giving too much homework to students in the lower grades made it easier for them to learn and cope.

Besides homework, parents are also involved in their children's academic lives and impact performance in other important ways. This is the most likely explanation for the significant variation in numeracy knowledge when children enter formal schooling (Aunio et al., 2016). Early numeracy does not only begin formal schooling, but parents can also stimulate early numeracy skills by introducing numeracy activities at a young age. The Chinese teachers, Chinese parents, and SA-MCA all agreed that parents should be their children's first mathematics teachers. Corresponding to the widespread practice of extra tutorial classes in China (Guo et al, 2020), CN-MCA offered that school assessments are sometimes too complex or even beyond what was covered in class; therefore, these tutorials were sometimes used to train students on assessment or exams. Both CN-PP and CN-IP packed their children's schedules with private tutorials on weekdays after school and on weekends to help them grasp what they had failed to grasp in class (CN-PP) and for enrichment (CN-IP). The two Chinese parents also involved their children in working out the budget. They emphasized the need to select their children's struggles and specifically practiced those at home. In South Africa, SA-IP's child attended private tutoring after school offered by an independent institution near the school on weekdays, SA-PFP child attended free mathematics classes offered by the local community library once a week after school, while SA-PNP's children did not attend any extra classes apart from the schools' lessons, indicating the effect by their socio-economic standing and affordability (Merkley et al., 2023). Both SA-PFP and SA-PNP, however, taught their children's mathematics applications more informally, e.g., while shopping (where the children were asked to compare prices and count when they made payments) or using pocket money to help with counting skills, spending, and savings (SA-PNP).

Age to Start Numeracy

All participants agreed that early numeracy was essential and feasible, similar to the findings of Tippett and Milford (2017). However, all South African participants only considered early numeracy from Grade R when the students started attending school (usually age seven), while both Chinese parents introduced numeracy to their children (e.g., counting, number recognition activities, and songs) earlier: age four for CN-IP and age three for CN-PP.

Pedagogy

Mathematics Curriculum

A direct comparison of the two countries' curricula is beyond the boundary of this study as the study focuses on participants' understanding and perceptions, but within-country differences are detected. In the case of South Africa, although some independent schools in South Africa adopt a different curriculum— the United Kingdom National Curriculum— the independent school involved in this study also uses mainstream CAPS curriculum used in public schools. Both SA-IT and SA-PNT considered CAPS high standard and had a good balance between theory and practicality. SA-MCA added that the curriculum was well-structured, descriptive, and straightforward. Curriculum implementation remains a challenge, however. South African teacher participants highlighted the heavy content for the given timeframe, similar to Waller and Maxwell's (2017) finding. SA-MCA, on the other hand, proposed that the main challenges lay in some teachers not structuring, preparing or planning their lessons according to the curriculum. This indicates a different focus on the curriculum from the South African participants.

In China, the public-school curriculum is seen as heavier (CN-MCA) than that of the private school, whereas the BC curriculum followed was seen as emphasizing more relevance and applicability to real life and was seen as easier and lighter in terms of workload (CN-IP). From the parents' point of view, both Chinese parents were knowledgeable about the curriculum, while South African parents, except SA-IP, struggled with the concept of *curriculum* or examples of mathematics concepts, reflecting their different levels of knowledge about the mathematics curriculum.

Mathematics Teaching: Approach and Practices

Spending more time teaching and showing how to solve problems (often through repetition, e.g., multiple solutions to approach the same problem) was practiced by both Chinese teacher participants, similar to the findings of this practice among other Chinese teachers (Xu, 2010; Wang et al., 2017). Both teacher participants also reported paying conscious attention to making the content easier to grasp through the way they explained mathematics concepts to the students, for example, showing different strategies for students to choose a suitable one for themselves (also called variation teaching). Substantial teacher control (often with step-by-step instruction) with limited student exploration by themselves –one typical teacher-centered transmission approach (Xu, 2010)—is also reported. This is in line with the practice of other Chinese teachers (Wang et al., 2018).

This differs from the practice in South Africa, where the participating teachers stressed that students should figure out the solution independently instead of relying on the teacher to help them with strategies. The two public school South African teachers also claimed to use the learner-centered approach that focused on motivating students through "making mathematics learning fun" (SA-PNT) through activities such as counting blocks, beads, and group activities. However, SA-PFT also reported the challenge associated with adopting this approach. It often requires more class time and does not go well in classrooms with overcrowded classes and under-resourced schools, which is a feature for many public schools in South Africa. "Many times, I have to stop the fun games as they take more time and just do the teaching on the board so that I can try to keep up with the schedule." (SA-PFT).

This is also one area of within-country differences for South Africa. SA-IT admitted preferring students working with the teacher or individually and explained her approach that allowed her to push the content faster and cover the heavy load required by the curriculum (similar to why many Chinese teachers also use this approach, Cao & He, 2009). Another similarity practice between SA-IT and the two Chinese teachers (& different from SA-IT and the other two SA teachers) is that the former all adopted a routine in their teaching: start their classes with teachers preparing, distilling, and generalizing problem-solving methods and simplifying them so that it is easy for the students to memorize (Cai & Wang, 2010). During class, the teachers present a problem, show students how to solve it differently, and then open the discussion to the entire class for a solution before the students practice individually. After individual practice, the teachers highlighted and summarized the main points or solutions. The same group (CN-PT, CN-IT, and SA-IT) also depended a lot on summary notes to help the students focus on the most critical concepts and remember them more easily (Cao & He, 2009). The two public school teachers in South Africa did not mention any form of routine or usage of summary notes.

Mathematics Learning: Practice and Feedback

All Chinese participants and several South African participants (SA-MCA & SA-IT) agreed with the importance and practice of mastering rules and processes to solve mathematics problems, often through drills. SA-IT claimed this to be one reason why she "give[s] my students a lot [of] practice questions in class to do and some for homework." However, the other two South African teachers did not place a similar emphasis on practice. Instead, these two public school teachers emphasize activities enabling students to work together to discover solutions to the problem. Among the parents, SA-IP and both Chinese parents also believed "practice makes perfect" and spent much time practicing mathematics with their children.

SA-MCA offered an additional observation: many South African teachers gave limited feedback, so students moved to new content without understanding the previous one. In addition, feedback in South Africa is often not given in time and rushed through (Kunene, 2016). Common feedback found in many South African students' workbooks includes ticks, crosses, and generic comments such as 'good job' (Kanjee, 2020), and "sometimes entirely absent" (Venkat & Sapire, 2022, p. 5). Ngwenya (2019, p.12) concluded that "despite the vital role of feedback in supporting learning, providing effective feedback is often still challenging for many teachers" (also related to an observation of SA teachers' inadequate drawing link to previous work, Morrison et al., 2023). Among the participants, SA-IT is the only SA teacher who reported giving feedback regularly, while both public-school teachers struggled with giving feedback as "giving feedback takes most of the teaching time because many students do not do homework. I, therefore, select one or two problems to do on the board quickly, and for the rest of them, I give them final answers" (SA-PFT). In China, giving individual feedback is also seen to increase teachers' workload (OECD, 2016a), but both teachers confirmed the practice of going around the class, providing individual feedback and guidance to the students when they are busy with their individual activities (Wang et al., 2017). They also reported providing feedback daily for homework given the previous day.

Other Teaching and Teaching Facilitating Practices

The teacher participants mentioned two additional aspects that facilitated the teaching practice in their classrooms: one related to the physical environment and the other related to technology use. Both Chinese teachers put up students' work-like projects together with content-related posters on the class's walls as they believed that by putting up good projects or activities in class, students who did well were encouraged to continue doing well. Those who did not would try harder to have their next project up on the wall. This practice is similar to that of South African schools. However, the intention differed: "When students see their work up, they get excited and share with their parents" (SA-PNT).

Teachers assisting each other seemed more common in China than in South Africa. Both Chinese teachers met weekly to discuss lesson plans and how to use resources in class amongst themselves, often spontaneously organized by teachers and sometimes facilitated by the Heads of department (HoD); while in South Africa, teachers only reported meetings when their HoD initiated so.

Technology use seemed to be more of a challenge in South African than in Chinese schools. Neither SA-PNT nor SA-PFT mentioned any form of technology they used in the classroom, while SA-IT only pointed to technology in relation to the COVID-19 lockdown. This confirms the findings of Pelser et al. (2015) on South African teachers' perceptions and needs regarding the use of technology and instruction. On the other hand, both CN-PT and CN-IT routinely used computer programs and animation as teaching resources. Related to COVID-19, both CN-IS and CN-PS switched to online classes within the first six months of the pandemic (similar to what Bakker et al. 2021 report), but all South African teachers haven't and were worried about what their students had missed due to the pandemic.

CONCLUSION

One key limitation of this study is its small sample size; therefore, the generalizability of the findings from this study is limited. Another limitation is related to the design of the study: as this is not an experimental study, the aspects pointed out by the participants as potential aspects that explain early numeracy achievement in the two countries or their impact on mathematics achievement should only be seen as conjecture, not conclusive. In this sense, the findings from this study should be accepted with caution, especially the more controversial ones, where further investigation will be encouraged.

However, the findings of this small exploratory study are striking and, to some extent, surprising. As the main aim of this study is to compare similarities and differences from both culture and pedagogy related to numeracy practices in the two countries (both between & and within-country differences), this study uncovers quite a number of similarities, including prevailing negative attitude towards mathematics among students, an acknowledgment of the importance of developing interest in mathematics, high expectations from parents, informal parental involvement (e.g., using daily opportunities to practice mathematics), as well as the practice of showcasing student works. Between-country differences broadly refer to different approaches to stimulate student motivation and interest (e.g., directly communicating expectations beforehand or not), teachers' use of rewards, the amount of homework (and attitude towards it), parental involvement (especially related to extramural, although seems to be generally related to parents' socio-economic status), starting age for numeracy, practices of giving out homework, parental knowledge of mathematics, reasons for showcasing student works, teacher initiatives and collaboration and use of technology. Within country differences include curriculum heaviness and homework-giving practice (in China), perceived reason for suboptimal curriculum implementation (in SA, between officials and teachers), various aspects of the teaching practices, including the practices of giving feedback (particularly puzzling and intriguing with regards to the similarity between the SA teacher in independent schools to the Chinese teachers rather than with other SA public school teachers) and importance of practice (between SA public teachers on one hand & SA private teacher, government official & private parent on the other). One observation here is that the curriculum and practice in Chinese independent schools show signs of shifting away from traditional Chinese practice, although whether this is *more* successful in bringing out students' performance remains to be seen (current mathematics achievement seems to show them on par). Another potential implication from this, however, is whether a heavy curriculum is essential.

Although this study confirms the multifaceted and interconnected nature of mathematics teaching and learning (Bai & Daley, 2014; Mosimege, 2020; OECD, 2016a; Reddy et al., 2016) predicted by MCC, the findings from this study point to potential controversial that might contribute to or hamper mathematics learning and achievement, including the teaching approach, the value of the different kinds of motivations, and methods to inspire motivation that calls for further investigations. For example, despite the intuitive appeal of the learner-centered approach and South Africa's embracement, the teacher-centered or whole-classroom approach seems to work better (better results in Chinese and South African independent schools. Also, see the meta-analysis of the effect of group and variation teaching, which is found to be on par with those taught with constructivist models, Xie et al., 2018). One reason for this counterintuitive practice might be the better alignment between the teaching approach and curriculum load. More specifically, when the curriculum is heavy with rapid pace, the whole-classroom approach and a clear focus on important content (e.g., through summary notes) might work better in the short run in terms of efficiency. Along a similar line, although a student-centered approach and an emphasis on encouraging students to explore on their own or through groups may be more pedagogically sound, not only does it might take much longer to bear fruit, there might also lie "difficulties for teachers in trying to simultaneously 'deliver' the curriculum and yet deal with the demand for learner-centeredness" (Venkat et al., 2009, p. 14).

Owing to the accumulative nature of mathematics learning, one key to mathematics achievement seems to lie in a large amount of practice of key mathematics concepts that, in time, build a solid foundation and confidence. This aligns with the basics of Chinese mathematics teaching (Xu, 2010). Although making mathematics fun and enjoyable again sounds appealing, the longer time that such activities take might offset the benefit of inducing interest. This might suggest that making mathematics fun or enjoyable might not be essential to kick off students' interest in or confidence in mathematics (Dogan, 2012). Similarly, although intrinsic motivation is more ideal, extrinsic motivation through rewards or explicit expectations might work equally well. Again, fixed plans and rules might not seem ideal, but predictability and routine might help the students to establish a sense of familiarity and predictability (Wang et al., 2017) or just get used to completing homework. One effective way to build such confidence could be through a large number of practices, as well as timely feedback (both seem to be inadequate in SA's public schools), that kick off a virtuous reinforcement loop of engagement and achievement, which in turn provides further motivation for students to tackle mathematics learning challenges. The finding from this study suggests two means to achieve this: homework and starting numeracy early, both of which are key cross-country differences found in this study. Especially in the case of early numeracy, South Africa only started to pay greater attention to this phase of schooling after 2010 (Venkat & Sapire, 2022). Also see Adler et al. (2017), who examined mathematics education research in South Africa up to 2015. However, all these counterintuitive results require further investigation.

Chinese mathematics performance might have been better if some of the commonly accepted best practices had been adopted. However, it is also possible that some of the 'unconducive' aspects might not be critical, or at least not detrimental, to mathematics performance. Equally possible is that some aspects of where China does well, such as a large amount of practice, showing and practicing varied solution methods, parental involvement, timely feedback, or fast-paced curriculum, outweigh the disadvantages of those less-than-ideal practices. Or that other aspects of Chinese life, e.g. Chinese philosophy of life, its work ethics and culture, etc, may have had more major contributions to their education achievement too (Xu, 2010). Again, these issues would benefit from further investigations.

Declarations

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