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Minimal Change in Achievement in High-Stakes Mathematics Examinations in Low Socio-Economic Status Environments in Post-Apartheid South Africa

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Abstract: Since various curriculum versions have been implemented in the post-apartheid era, achievement results in high-stakes mathematics examinations are still structured along socio-economic status lines. Continuing professional development (CPD) for mathematics teachers is widely viewed as a mechanism to address this issue. This study uses a specific CPD project to explore the question, "Are three decades-long enough to enhance achievement outcomes in high-stakes mathematics examinations for learners from low socio-economic status environments?" Bricolage is employed as the underlying research framework due to the multifaceted nature of CPD. In one of the residential institutes in 2018, a 7-item questionnaire, based on features of effective CPD and containing four ordinal response categories, was administered to 55 participating teachers (30 females and 25 males). To acknowledge the complex nature of CPD, themes were developed and primarily analysed using descriptive statistics. The analysis revealed that, although mathematics teachers respond favourably to practising previously taught material, there are factors that hinder the sustainability of such an approach. It is concluded that 30 years is not a sufficient timespan to expect significant change. It is recommended that drastic measures be taken regarding the continuing professional development of mathematics teachers to address disparities along class and racial lines.

Keywords: Post-apartheid mathematics, high stakes examinations, teacher professional development, productive practice.

1. Introduction

With the onset of democracy, one of the important tasks the elected democratic South African government had to undertake was to restructure 19 different, primarily racially based, education departments into a single department. This restructuring was accompanied by the development of a unified national curriculum designed to espouse the values, economic aspirations, and development goals that reflect the democratic ideals of the country. In the last 30 years, three different national curricula have been introduced, with the current one being the Curriculum, Assessment and Policy Standards (CAPS). The most severely criticised of these was the outcomes-based education curriculum (see, for example, Jansen, 1998). Hugo (2020, p. 115), in his review of Hoadley's (2018) book, proposes that with a particular kind of curriculum, "there is hope that we can use pedagogy to address historical legacies of inequality and discrimination." Hugo (2020, p. 120) claims that the preferred curriculum is "a curriculum that is clear and decisive, that provides trusted maps of, and ladders to, the academic terrain." He further contends that this type of curriculum is one that "connects the downtrodden and exploited with the full power of transcendence and possibility, but always caught in the in-between space, never to have the full power of a god, never able to address poverty with a single act, condemned to fight continually in the trenches for small victories" (Hugo, 2020, p. 120).

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This article focuses on the search for "small victories" in achievement in high-stakes school mathematics examinations, examining both the benefits and challenges of implementing a productive practice perspective by teachers who voluntarily participate in a continuous professional development initiative. It comprises several sections focusing on a specific project, the Local Evidence Improvement of Mathematics Teaching And Learning Initiative (LEDIMTALI—https://ledimtali.wixsite.com/ledimtali/), before discussing these sections in relation to Continuing Professional Development of high school mathematics under the democratic dispensation of the last 30 years. It concludes by arguing that it is unreasonable to expect massive changes in achievement in high-stakes, school-based, and nationally set examinations for learners from and in schools in low socio-economic status environments.

2. Research Approach and Underlying Perspective of The Initiative

Before delving into the underlying framework for the research, we provide a rationale for pursuing the specific research question. The research question, "Are three decades long enough for enhancing achievement outcomes in high-stakes mathematics examinations for learners from low socio-economic status environments?" is driven by the sub-topic, "Pedagogical responsiveness and inclusion in post-apartheid mathematics education" (Mbhiza & Jojo, 2024). The authors clearly indicate that achievement results in school mathematics remain a problematic issue. However, they refer to high-stakes examinations such as the end-year school-based assessments or the National Senior Certificate (NSC) examinations, which highlight the "gap" this research addresses.

The research framework underlying the study reported in this article is that of bricolage. The notion of bricolage has been used in research studies in mathematics education (Wedege, 2010; Mosia, 2016; Armstrong, 2017). Embedding research in bricolage represents a "multi-layered and multi-methodological approach to research" (Mosia, 2016, p. 144). In line with Gravemeijer's (1994, pp. 444 - 454) interpretation of bricolage, we use the construct as "purposeful and sensible tinkering of sorts…using whatever is available…with the analysis of the data staying close to the original meaning of the data."

For the research question, "Are three decades long enough for enhancing achievement outcomes in high-stakes mathematics examinations for learners from low socio-economic status environments?", the multi-layered themes include: the underlying perspective of the initiative, engagement with mathematics, teachers' reflections on the implementation of the CPD content, and learning from teachers. Primarily, the umbrella review on features for effective CPD by Cordingley et al. (2015) was utilised for theme generation in the research. The theme generation thus arises from tinkering with what is available from a bricolage perspective.

The analysis of the data is primarily conducted using descriptive statistics obtained from a 7-item questionnaire, which features 4 ordinal response categories—A lot, Quite a lot, A little bit, and Not at all—completed by 55 participating teachers (30 females and 25 males) in 2018. The questionnaire was developed through discussion and debate among the LEDIMTALI team members and administered by the LEDIMTALI facilitators at institutes in the two provinces in 2018. It is based on the content covered at the institutes since the inception of LEDIMTALI in 2011. Rasch analysis of this instrument indicated that the questionnaire was generally "productive of measurement" (Linacre, 2006, p. 214). Rasch measurement instruments are generally not piloted, as this procedure tests whether a unitary construct is at play. This approach was adopted because research reports focusing on the measurement of a construct of interest typically do not provide information on whether the instrument used measures the construct it claims to measure.

In an umbrella review on the features of effective CPD, Cordingley et al. (2015, p. 6) concluded that "Making the public knowledge base, theory and evidence on pedagogy, subject knowledge, and strategies accessible to participants" is an important element. This implies that any CPD initiative for mathematics teachers, whether implicitly or explicitly, has some framework underpinning it. The framework underpinning LEDIMTALI focuses on "theory… pedagogy… strategies accessible to participants." Subject knowledge will be addressed in a subsequent section.

The project started with classroom visitations to ascertain how teachers were enacting their tasks. The visitations rendered the general enactment of classroom teaching, which was traditional expository teaching of the CAPS-prescribed mathematical topic, following basically its rendition in the textbook in use. This implies that the teacher will explain the mathematical construct, mostly a mathematical procedure, with an accompanying example, also mostly from the textbook in use, as she/he goes along. A second example might or might not be done. After this exposition, learners are given two or three exercises on the lesson of the topic from the textbook in use to do. The teacher will monitor the learners' way of dealing with the exercises. Upon completion of the given exercises, the answers will be worked out on the white/chalkboard either by the teacher or learners called to do them. In most cases, learners "mark" and/or correct their work. After this action, the learners are given the rest of the pertinent exercises to do. Those that are not completed during the period are assigned as homework. The subsequent lesson starts with the homework problems being done on the white/chalkboard, followed by corrections and marking. Upon completion, the teacher presents the next lesson in the unit of work, following the same routine.

Observation of this general configuration of classroom teaching revealed that the consolidation of taught content was primarily achieved by completing most or all of the exercises in the textbook in use. Some textbooks include a section at the end of a topic unit that offers the opportunity to revisit the work completed in the unit.

During classroom visitations, opportunities arose to have informal discussions with learners and teachers regarding, among other things, achievement in mathematics examinations. In one instance, a learner (with others in the group nodding in agreement) stated, "When I did the work in class, I could do it. You can check my book, sir. But during the exams, I just went blank, sir." In a conversation with teachers, it was said, "When we did the work in class, they could do it. Check their books; I have marked them. When I mark their exam work, I wonder if I've ever taught them." This was understood as the articulation of the same issue by the two primary participants in classroom teaching: teachers and learners. This enunciation recalled what Denny (1977) describes as "The Great Mystery," vividly depicted in a journalistic manner based on interviews with teachers, where one teacher referred to the phenomenon as the "forgetting disease."

The "forgetting disease" triggered a recollection of Ebbinghaus's (1964) forgetting curve, which asserts that if something is learned, it is remembered if it is repeated frequently after the first encounter. It was decided that this revelation regarding frequent repetition after the first encounter should be part of the framework for LEDIMTALI. Frequent repetition suggests a focus on practice.

In most, if not all, textbooks used for teaching, exercises and activities are presented in a single section after the introduction, accompanied by examples of the mathematical concepts embedded in a topic. This type of practice is known as massed practice (Murray & Udermann, 2003) or blocked practice (Carey, 2013). In contrast, there is distributed practice (Murray & Udermann, 2003). Other terms such as spaced practice, spiral testing, continuous review, review-as-you-go, incremental rehearsal, interleaving, and shuffling share similarities with distributed practice. Based on Hattie's (2009) comprehensive analysis of factors contributing to achievement in school subjects, massed practice was compared with distributed practice, yielding an effect size of 0.71 in favour of distributed practice. It was decided to adopt the concept of distributed practice for LEDIMTALI.

More or less parallel to massed and distributed practice, the term "productive perspective" has emerged in the literature. It can be traced to Freudenthal's (1991, p. 114) view on drill, which he describes as a "way of training—including memorisation—where every little step adds something to the treasure of insight: training integrated with insightful learning." The term "training" in this quotation is associated with practice (Kindt, 2011). Insightful learning is linked to the processes of doing mathematics, which can be traced to Watson and Mason's (1998) processes for doing mathematics.

LEDIMTALI has a major objective: the enhancement of achievement in school mathematics examinations. Thus, examination preparation is a significant driver of LEDIMTALI. Examinations can generally be classified as high- and low-stakes. High-stakes examinations have direct consequences for those who take them, while low-stakes examinations are more related to systemic issues; in most cases, those who take them do not have access to their personal scores. The National Senior Certificate (NSC) examination is for non-compulsory schooling, and end-of-year school-based assessments are considered high-stakes examinations in South Africa. In terms of enhancing achievement in school mathematics examinations, the NSC examination serves as the foundation upon which activities are designed.

Finally, the exposition above primarily focuses on activities and exercises to enhance achievement. However, these activities must be implemented by teachers in their classrooms. It is well recognised that teaching is a highly habituated practice, and teachers do not, for good reasons, easily change their personal teaching styles. Wiliam (2016, p. 174) addresses the habitual nature of teaching by stating:

> …teachers have to make small, incremental changes to their practice. [T]hey have to improve their practice while keeping all their other routines functioning normally... [and they should] change only a small number—ideally one or two, and certainly no more than three—aspects of their teaching at any one time.

Bringing the above together has resulted in the framework for the CPD under discussion. This framework is called the productive practice perspective and is diagrammatically represented in Fig. 1 below. The term "spiral revision" was coined by teachers to address the forget problem, as indicated.

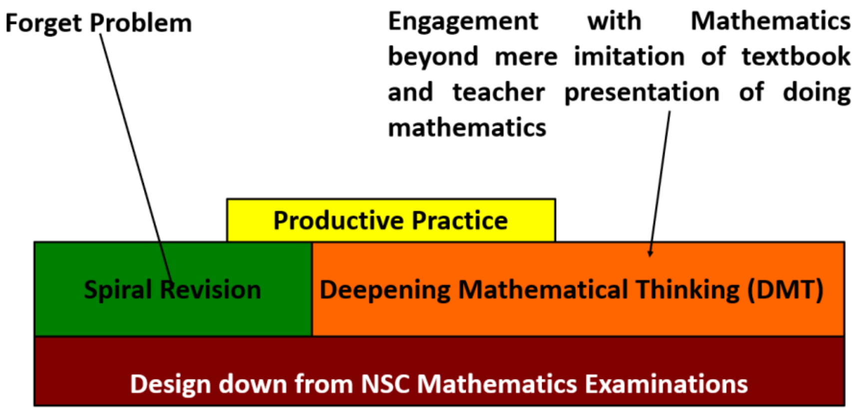

***Figure 1**: Productive Practice Perspective*

2.1. Ethical consideration

Ethical clearance was obtained from the Institute of Higher Learning, as well as the participants with the ethics registration number 11/9/33. The ethical protocol was followed where, prior to participation, the participants voluntarily consented to be part of the study. Participants were assured of their freedom to withdraw at any stage without any negative consequences, where data would be securely stored and only accessible to authorized researchers. Strict anonymity measures were implemented, with all identifying information removed or coded to ensure anonymity.

3. Presentation of Findings

3.1 Engagement with mathematics

Mathematics teachers in South Africa are sometimes harshly criticised for poor learner assessment results at different levels of schooling. Some South African researchers believe this state of affairs can be attributed to teachers and teaching. These researchers contend that many teachers 'lack' content knowledge (Venkat & Spaul, 2015; Bansilal, 2015). Their argument, therefore, is that to remedy this situation, teachers need to be presented with content courses to address their 'low levels' of school mathematics content knowledge. Consequently, a proliferation of CPD initiatives focusing on various aspects of school mathematics content knowledge has emerged. For example, the Wits Maths Connect Secondary (WMCS) mathematics teacher development initiative dedicates 75% of its time to the content of mathematics (Ntow & Adler, 2019). However, the pursuit of more advanced courses in mathematics does not necessarily translate into a deeper understanding of fundamental mathematics (Ma, 2010). Julie (2019) believes that South African mathematics teachers do not actually 'lack' content knowledge but may have gaps in their knowledge or may have succumbed to the forgetting curve. An important question, therefore, is what other avenues are available to address mathematics teachers' competency in terms of school mathematical content knowledge. The approach adopted by LEDIMTALI is to engage teachers in mathematical content activities to develop their '*mathematicalness*'.

'*Mathematicalness*' is a phrase coined by Mason and Davis (1991). The phrase refers to 'developing your mathematical being' (Mason & Davis, 1991, p. 97). They define *mathematicalness* as follows: Being mathematical with yourself, and thereby becoming aware of aspects of your *mathematicalness*, involves recognising the entirely natural thinking processes of specialising and generalising and learning to make overt connections between the inner world of images and aims and the outer world of behaviour and manifestation. Specialising refers to any act of simplification or testing of special cases to elucidate a presented mathematical problem, while generalising refers to the process of moving from the particular to the general.

Mason and Davis (1999) argue that this is important for mathematics teaching. They vividly illustrate their view as follows: The more overtly mathematical you are with, and in front of, your pupil, the more likely they are to become aware if only subconsciously, of how one engages in mathematical thinking. If you hide your *mathematicalness* and obscure your own mathematical thinking from pupils, they are unlikely to pick up from you how to appreciate or engage in mathematical thinking themselves (Mason & Davis, 1999, p. 61). An example of a *mathematicalness* activity is as follows:

How many times can paper be folded?

- Fold the paper in alternate directions until it cannot be folded any more.
- How many folds could you make? Compare your number of folds with other groups.
- Draw a table in which you indicate how number of folds is related to number of parts.
- Use algebra to show the relationship between number of folds and number of parts.
- Draw a table to indicate the relationship between number of folds and the size of the individual parts as compared to the original size of the paper.
- Use algebra to show the relationship between number of folds and size of parts.
- How does the thickness of the original paper compare to the thickness when the paper is folded? Write an equation that shows how the thickness changes after each fold.
- If a paper has a thickness of 0,05mm how thick will the paper be after 20 folds? How thick will it be after 100 folds?
- Discuss why it is so difficult to fold the paper more than 7 times.

In the activity, numbers 1, 2, 3, 5, 7 (first part), and 9 are examples where specialising is required. Numbers 4, 6, 7 (second part), and 8 are examples where generalising is required. The activity also requires some hypothesising, which develops the ability to do proof and proving. The activity is followed by an explanation of facts about paper folding, as below.

Some interesting facts regarding paper folding:

It was originally thought that paper could not be folded more than 7 times. Some mathematicians even produced a theorem that ostensibly proved that paper cannot be folded more than 7 times. Britney Gallivan (a high school student from California, USA) set out to prove that paper can be folded more than 7 times: in January 2000, Britney took a single piece of paper 1.2 km long and folded it 12 times (in a single direction).

For single-direction folding, the following formula applies:

$$L = \frac{\pi t}{6}(2^n + 4)(2^n - 1)$$

Where:

- $t =$ thickness of paper
- $L =$ length of paper in one direction
- $n =$ number of folds

As can be seen from the formula, a link to the topic, exponential expressions in CAPS, is established.

The '*mathematicalness*' approach is therefore premised on developing mathematical thinking, rather than simply presenting courses aimed at increasing mathematical content knowledge. '*Mathematicalness*', under the title "#mathematicalness", is a standard item on the programme of the quarterly residential institutes of LEDIMTALI. It is not assumed that teachers 'learn' mathematical content; rather, it is based on Gattegno's (1987, p. 220) notion that "Only awareness is educable."

In a questionnaire completed by participating practising teachers, they ranked the extent to which LEDIMTALI addresses their knowledge about mathematics, including "*mathematicalness*", as illustrated in the pie chart below. This indicates that a significantly high percentage of participating teachers, regardless of the grade level they are teaching, valued the approach taken to address mathematical content knowledge.

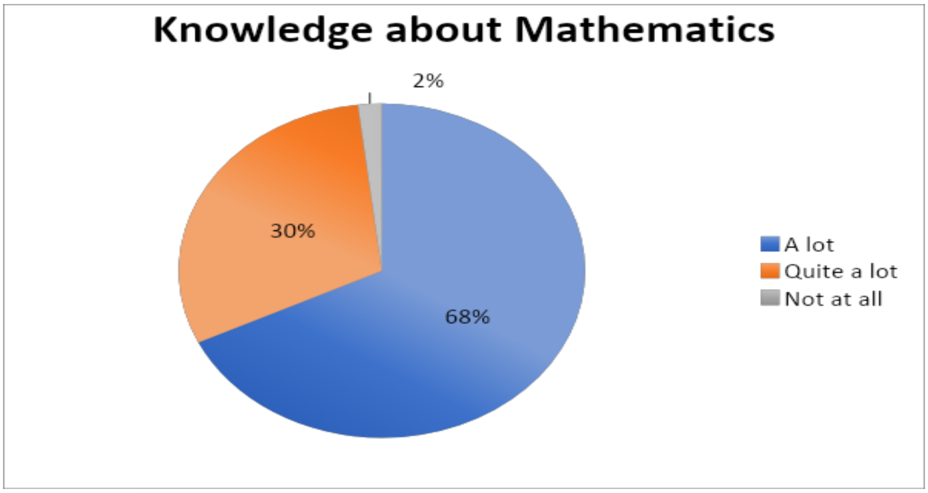

***Figure 2**: Teachers' ranking about Ledimtali addressing the knowledge about mathematics*

3.2 Teachers' reflections on implementation of the CPD content

Much has been written and researched about reflection. Rich and Tripp (2012) describe reflection "as an investigative, self-critical process wherein teachers contemplate the effect of their pedagogical decisions on their situated teaching practice, through retrospection, with the aim of improving those teaching practices" (p. 22). Reflective practice is valuable in professional fields where continuous learning and adaptation are essential, as it allows individuals to learn from their experiences and improve their execution of tasks over time. Moreover, reflection is a crucial aspect to consider when engaging teachers in enhancing their mathematics teaching (Biccard, 2018). Smith et al. (2022) highlight that, for the research reported here, teachers perceived critical reflection through personal inquiry as the most beneficial form of professional learning.

In LEDIMTALI, after being exposed to ways of implementing the productive practice perspective, teachers were encouraged to apply it in their classrooms. Following this, they were given opportunities to reflect on how they integrated the productive practice perspective into their own classroom practices. Various opportunities were created to allow teachers to showcase how they implemented productive practice in their specific contexts. One such opportunity involved identifying teachers who were confident and willing to demonstrate how they applied these ideas in their teaching during designated slots at institutes. Another opportunity for reflection was for teachers to write reflective essays on how they incorporate productive practice. Additionally, facilitators visited teachers in their classrooms to observe and assist them in effectively implementing productive practice.

The concern of the teacher educators in the project was that, as new teachers joined, it was unclear whether they understood what productive practice was. In response to this, teachers were invited to write a reflective essay about what they learned in a previous two-day workshop regarding their understanding of the productive practice perspective and how they applied it in their classrooms. From the video recording of some ideas that they shared, the following points emerged: "Re-teaching versus re-engaging. Re-engaging is deeper than re-teaching and can be used as part of spiral revision"; "You will always revisit old concepts throughout the year, and you must develop spiral revision ways to not teach but revise"; "PP should form part of every lesson"; "Use classification of solution procedures and focus on feedback, highlighting what learners do correctly instead of merely pointing out incorrect responses."

Smith et al. (2022) indicate that a possible outcome of professional development is the emergence of new awareness, which can lead to a shift in assumptions. The points raised by the teachers demonstrate a shift in their understanding of the underlying productive practice perspective and how to engage with it. Teachers sometimes believe that when learners do not understand concepts, they need to re-teach the topic merely due to a lack of knowledge. However, the teachers confirmed that understanding the productive practice perspective does not entail re-teaching but rather re-engaging the learners. They recognised the importance of implementing the productive practice perspective consistently throughout the year to address the "forgetting" of concepts. Additionally, they noted that focusing on feedback to help learners understand where they can improve, as well as acknowledging what they do correctly instead of only emphasising mistakes, can lead to increased confidence in mathematics. It can, therefore, be argued that teachers involved in LEDIMTALI generally understand how to implement the productive practice perspective and what to avoid.

This CPD was endorsed by the provincial Department of Education (DoE), where a mathematics subject advisor regularly participated in the gatherings. The subject advisor reflected on the CPD activities and emphasised the importance of providing feedback to learners on their correct attempts to enhance their confidence. It was noted that teachers should be "drawing attention to small successes learners achieve" (Smith, 2019, p. 6), which can foster an 'I can' attitude and improve competency in mathematics. The subject advisor also added that "to increase the quality of passes and the number of learners doing mathematics from Grade 10 to 12, I should support Grade 10 and even GET (General Education Training) teachers differently" (p. 15). This advisor acknowledged the need to focus not only on revising previous topics covered by teachers in the exit level grades but also to emphasise continuous revision in lower grades.

It is evident that participating teachers implement the productive practice perspective in varying ways and with different frequencies. A questionnaire completed by the teachers revealed the following:

Table 1: *How teachers implemented productive practice*

Category	Records
Did not implement PP.	4%
Daily or regular revision.	11,5%
At the beginning of each lesson.	11,5%
After a topic was completed.	11,5%
Once a week.	11,5%
During extra time	15%
Not stated	34%

The difference in implementation dosage can be ascribed to the local contexts in which teachers work, the size of the classes, or some teachers' inability to know how to effectively implement the productive practice perspective. What is evident is that the majority of teachers do implement the productive practice perspective in their classrooms to varying degrees.

Teachers also identified the following categories of revision activities: recapping previous activities/topics covered, working through past examination papers, revisiting topics that learners struggle with, conducting surprise weekly tests/short tests, and having quick revision activities on previously covered work on a Friday or during administrative periods. These varying ways of implementing the productive practice perspective are not surprising, as individuals choose which methods suit their context or what they can accomplish within their available time. However, there are also teachers who do not implement what they have learned in CPD activities, as confirmed by Maass et al. (2019). Factors include, among others, teacher beliefs and personal background.

There is evidence that spiral revision addresses the challenge of "forgetting," as a teacher confirmed an increase in learners' algebra results (Links, 2019). Other teachers expressed various comments about deepening mathematical thinking and the context within which they teach (see Smith, 2019).

Teachers also voiced concerns about implementation. These included aspects such as how to incorporate the productive practice perspective within the time constraints of the curriculum, implementation in large classes (50+ learners), how to encourage learners to cooperate during productive practice perspective activities, which strategies are the most effective, and when teachers should know to stop implementing these strategies, among others. The posing of these questions may indicate that teachers want to implement the productive practice perspective but lack the know-how to do it effectively within their own context. When teachers ask these questions, it indicates that they are reflecting on their practice. Moreover, asking questions about how to best implement the aspects learned is a sign that teachers are serious about translating what they have learned into their particular classroom context. Luneta (2012) refers to the limitations of workshops where generic aspects are discussed, noting that when teachers return to their classrooms, they need to customise what they have learned in workshops to their own context. This is confirmed by Maass et al. (2019, p. 2), who argue that "the innovation is necessarily adapted to the local school and classroom context in the process of implementation." Assistance to customise new approaches may require support from colleagues, mentor teachers, or even through reflection within a small group.

Additionally, some schools' contexts are more challenging than others, and coping with large classes is very difficult, which directly affects the ability to encourage learners to cooperate in activities. The packed CAPS curriculum allows limited leeway to implement the productive practice perspective, and some teachers, especially novice teachers, need support and guidance on implementation issues.

However, through reflection and trying out different strategies, teachers may be able to answer their own questions and subsequently capacitate others by sharing their effective methods.

3.3 Learning from teachers

Maass et al. (2019) assert that the implementation of "innovative teaching approaches" does not work when it is framed in terms of the transmission of knowledge from researchers or policymakers to teachers…" (p. 304). They provide a six-category interdependent framework comprising research, resources, professional development, context, cooperation, and communication for teaching improvement, albeit at scale. Although the professional development category of their framework includes that the initiation of improved teaching practices must be driven by teachers' needs, no mention is made of the contributions teachers can make to CPD (p. 312).

It is, however, contended that teachers can make contributions to CPD. Setati (2005) draws attention to tensions between 'working with' and 'working on' teachers. 'Working with' teachers can be instances where teachers share ideas that are innovative. As stated by a teacher in the United Kingdom, teachers have a huge amount of expertise, and sharing is a very effective way of learning (Ratcliffe, 2013). Such teacher contributions to CPD initiatives complement the feature of "expertise from outside the school" (see, for example, Cobb & Jackson, 2015; Cordingley et al., 2015) for effective CPD.

During informal conversations at an institute of the LEDIMTALI, it emerged that two teachers were using drill-and-practice software for multiple-choice questions (MCQs) in their teaching. One teacher was using Lumi (https://lumi.education/en/), and the other was using Quizizz (https://quizizz.com/?lng=en). None of the CPD provider team members was aware of and/or was using such software. In order to learn more about the use of the software and consider possibilities of adapting the MCQs for the type of activities favoured by LEDIMTALI, a special one-and-a-half-day institute with the two teachers, two other interested teachers, and the CPD providers was organised. The two teachers who were already using the software packages led the institute.

One of the activities designed at the institute was a 'words and symbols' one. The screenshot in Fig. 3, from Lumi, shows that learners are to match the columns labelled 'words' and 'symbols.' They are required to drop the six words/phrases or symbols on the far right into the open spaces present in either of the two columns, named 'words' and 'symbols.' A correct match in terms of words and symbols occurs within a row. This design affords the teachers' learners DMT opportunities with regard to algebraic concepts (words) and related procedures (symbols). Words such as terms, distributive law, additive and multiplicative inverses and their associated symbols are key to becoming algebraically competent (Matz, 1980).

Words and Symbols

In the table below the algebraic sentence is given in column A and the "word description" in column B. Complete the open parts in the rows.

WORDS	SYMBOLS
Solve the linear equation	$2m\,(3m-1)-(6m^2-4m)=6m+4$
	$6m^2-2m-6m^2+4m=6m+4$
	$-2m+4m=6m+4$
Simplify like terms (m)	
Add additive inverse	
	$-4m=4$
Multiplicative inverse	
Final answer	$m=-1$

- Simplify like terms
- $\frac{-4m}{-4}=\frac{4}{-4}$
- Simplify like terms (m^2)
- $2m-6m=4$
- Apply Distributive Law
- $2m=6m+4$

Figure 3: *Symbols related to solving a linear equation*

The screenshot in Fig. 4 illustrates the other teacher's design with Quizizz. It is a scramble/unscramble activity where the correct order for the procedure for the simplification of algebraic expressions must be determined.

2. Multiple Choice

Simplify the following 10y−3x−5z+4y+3x by choosing the correct order

1: 14y-5z+0

2: 10y+4y-5z-3x+3x

3: 10y-3x-5z+4y+3x

4: 14y-5z

- 3,2,1,4
- 1,3,4,2
- 2,4,1,3
- 2,3,4,1

***Figure 4**: Scramble/unscramble activity with Quizizz*

This design makes it possible for learners to deepen their mathematical thinking with respect to the simplification of algebraic expressions. It is interesting to note the time indicator in the top right-hand corner, which points to the design having a gamification aspect.

In conclusion, it was relayed how the two teachers have started using software packages such as *Lumi* and *Quizizz* to design questions that incorporate LEDIMTALI design principles aimed at deepening mathematical thinking. Setati (2005) reminds us to think ethically about the processes that we use and the products that we produce through the research on CPD work we do. Furthermore, she notes that it is also crucial that we share the research process, namely, reporting what CPD providers learn from teachers.

4. Discussion of Findings

The first comprehensive report on teacher development states that The President Education Initiative (PEI) identified the upgrading and reskilling of serving teachers in science, mathematics, and technology (Taylor & Vinjevold, 1999) as one of the critical areas that need to be addressed in the post-apartheid era. This seminal post-apartheid and well-researched publication provides an extensive array of CPD-based research. "The PEI researchers found that teachers do not develop their own materials because of time and conceptual knowledge constraints. It is important that the value of textbooks be re-established in the minds of teachers, teacher educators, and school managers. Without books to read and write in, schooling as cognitive development cannot happen" (Taylor & Vinjevold, 1999, p. 240).

Volmink (2023), although not using evidence from actual projects as is the case with the PEI, also alludes to the lack of resources, including time as a resource and relevant teacher education as mitigating issues that need to be addressed to enhance achievement, identifying them as major challenges for implementation. He, however, highlights the framework, which includes examples of activities for learners at different grade levels, that the National Department of Education developed to assist teachers with the implementation of the intended curriculum, CAPS.

It can be assumed that Taylor and Vinjevold (1999) and Volmink (2023) are not only referring to school textbooks. Nevertheless, such textbooks play an important role in the lives of school learners and teachers. School mathematics textbooks are generally sparse in reading material. Apart from explanations of mathematical constructs that are provided, the content is mainly instructional. There is an expectation that teachers will expand this limited, primarily singular instructional type of reading. However, Wittmann (2021, p. 86) argues that "By no means can (such a task) be left to teachers, although teachers can certainly make important contributions…" In the project used as a backdrop for this article, attempts are made to engage learners through activities designed by project workers. For example, a word/symbol activity requires learners to read a sentence in words in one column and write the mathematical formulation in the adjacent column and vice versa.

Regarding the upskilling and upgrading imperative of the PEI and Volmink's research, there is an expectation that teachers involved in CPD interventions will implement most of the ideas and notions covered in the underlying courses. However, Wiliam (2016, p. 174) admonishes:

> ...teachers have to make small, incremental changes to their practice. [T]hey have to improve their practice while keeping all their other routines functioning normally. More importantly, they should continue to focus on the aspects they have chosen until these aspects of teaching become second nature.

We contend that based on our experiences offering CPD to develop teaching aimed at enhancing achievement in high-stakes examinations, the process will take much longer than what the typical short-sighted expectation suggests. For example, a comprehensive study conducted by the RAND Corporation (Berends et al., 2005) in the United States on closing the "achievement gap in mathematics" between Caucasian, Black, and Latino 17-year-olds supports this view. van der Berg and Gustafsson (2023), despite being more optimistic, arrive at a similar conclusion for South Africa when they state that "the association between race and educational performance is especially extremely strong" (p. 43). Studies of this nature demonstrate that CPD's focus on developing teaching in mathematics to enhance achievement in high-stakes examinations, from its current state to an improved state, is a long-term endeavour. Regarding the research question, Julie (2023) found, using a system dynamics modelling perspective, that according to a snowballed sample of 26 CPD providers in South Africa, it will take about 96 out of 160 teaching days for the implementation of ideas and notions to begin to slowly rise. This supports the need for extended time for CPD to meaningfully impact achievement in high-stakes examinations.

5. Conclusion

The central aim of this article was to reflect on whether, 30 years after the onset of democracy, it is reasonable to expect improvement in achievement in high-stakes school-based and NSC mathematics by learners from LSES and in schools in such environments through CPD for mathematics teachers in these schools. It was found that, given the extended time needed to achieve this goal, 30 years is too limited a timespan for the ideas distributed through CPD initiatives to work their way through school systems to achieve the envisaged goal. The use of data from a CPD project that was running for more than 10 years is a limitation. However, it is unlikely that a CPD project with a time span of 30 years will ever materialise.

It is recommended that CPD projects to enhance achievement in high-stakes mathematics should have a longer timespan than what is currently the case. Furthermore, longitudinal research should be conducted to get some picture of the CPD time cost to meaningfully impact the unsatisfactory mathematics achievement of learners in LSES environments. Our contention is that 30 years of democracy is just too limited a timespan to address the unsatisfactory achievement in school mathematics for the poorest of the poor in South Africa unless other agreed drastic measures are taken. Not embarking on such a journey might just lead to South Africa ending up with the same issue 30 years after 30 years of democracy.

6. Declarations

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drafting and preparation (B.P.N., C.J., F.G., S.M. & M.B.); review and editing (B.P.N., C.J., F.G., S.M. & M.B.); supervision (N/A); project administration (B.P.N.); funding acquisition (N/A). All authors have read and approved the published version of the article.

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