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The development of the word sum-wheel to enhance Grade 3 teachers' mathematic word problem-solving instruction

Abstract:

This empirical paper reports on the development of a professional development initiative, namely the word sum-wheel, which teachers developed collaboratively. The study's objective was to determine how teachers' mathematics word problem-solving instruction could be enhanced through the development of the word-sum wheel using participatory action research as the research design. While using a qualitative research approach within the constructivist paradigm, the Continuous Process of Professional Development served as the study's theoretical framework. In this study, a continuous link to the reciprocal relationship between teaching and learning is maintained. Thirteen Grade 3 teachers were purposefully selected from government and private schools in the Gauteng Province. While the greater study comprised three stages – namely preparation, action, and reflection – the data generated for the purpose of this paper was collected as part of the action stage. Data generation included interactive discussions held during the six workshops, as well as teachers' reflective diaries and the researchers' journal. Data analysis was done through a hybrid approach of inductive and deductive analysis. Findings reveal that teachers' mathematics word problem-solving instruction was enhanced when they experienced a boost in their confidence levels. This was brought about through the playful and interactive implementation of the word sum-wheel. Similarly, the teachers' enhanced understanding of the role of reading comprehension and the mathematics register in teaching mathematics word problem-solving was highlighted. Instead of teaching mathematics word problem-solving in isolation, teachers have begun integrating it into their daily teaching programme.

Keywords: *collaboration; data generation; mathematics word problem-solving; participatory action research; professional development, teacher education*

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1. Introduction

Mathematical word problem-solving and mathematical knowledge have quickly become the core components of critical thinking and reasoning (Vessonen, *et al.*, 2024), yet there is a continuous need to support the teaching of mathematics word problem-solving (Gravemeijer, *et* *al.,* 2017; Vessonen *et al*., 2024). Owing to the complexity of mathematics word problem-solving, Vessonen *et al*. (2024) refer to the linguistic and mathematical tasks involved in mathematics word problem-solving, while Liljedahl, *et al.* (2016) describe problem-solving as the core of mathematics education. Some of the main objectives that remain globally are to improve learners' performance and attitude toward mathematics word problem-solving (Wakhatal,Balimuttajj & Mutarutiny, 2024). However, this is only possible if attention is given to teachers' training and development of knowledge in mathematics word problem-solving instruction skills (Cheva & Luneta, 2015). Teachers' professional development in teaching mathematics word problem-solving can only be supported once they start to understand the challenges posed by the different mathematics word problem-solving tasks. Only then can teachers' strategies and assessments be adapted accordingly (Vessonen *et al*., 2024).

Taylor (2021) asks uncomfortable questions about teacher knowledge and skills. In his work, Taylor (2021) asks whether teachers struggle to understand the subject matter related to the content or if it is a matter of teachers grappling with the pedagogy that impedes their ability to convey knowledge to learners. Taylor (2021) adds that studies conducted by Venkat and Spaull (2015) have proven that teachers battle as they do not have adequate subject knowledge. In response to this, Luneta (2014) adds to the challenge that learner performance cannot be addressed without attending to (1) teachers' knowledge of mathematics, (2) teachers' understanding of mathematics, and (3) equipping teachers with the ability to teach mathematics to learners in such a way that both learners and teachers gain from it (Luneta, 2014). Mathematics education, specifically mathematics word problem-solving instruction, is experiencing a crisis that needs intervention. The reality is that professional development opportunities dedicated to mathematics word problem-solving are limited.

This article shares encounters of the development of the word sum-wheel to enhance Grade 3 teachers' word problem-solving instruction. This was a collaborative initiative between the first author and Grade 3 teachers as co-researchers. The research question that the study aimed to answer was: *How can teachers' mathematics word problem instruction be enhanced through a professional development initiative?* Since teachers are the agents of change, our belief was that if teachers were provided with guidance to understand the finer nuances of what mathematics word problem-solving entails, they would be able to collaboratively construct knowledge with the aim of addressing the problem of weak mathematics word problem-solving instruction in their classrooms, and in such a way bring about change. By doing this, we became aware of the reciprocal relationship between teaching and learning. Thus, we wanted to see how teachers' word problem-solving instruction is enhanced, along with learners' performance in the same domain.

2. Literature review

Mathematics word problems occupy a critical role in mathematics education (Myers, *et al*., 2022), and learners' ability to solve mathematics word problems is vital to their overall success in life and learning (Swanson, *et al.*, 2013; Powell, *et al.*, 2022). Mathematics word problems serve as a "fundamental scientific discipline" that paves the way for "future thinking and reasoning abilities and forms the foundation of the advancement of modern technology", which plays a critical role in other scientific fields (Kumesan, *et al.*, 2023). Although word problems are not the most liked aspects of mathematics education, its value in life-long learning is vital (Sambo & Makgakga, 2024). Word problems are deemed challenging due to the inclusion of words in the mathematics task (Scheibling-Sève, *et al.,* 2020; Agusfianuddin, *et al*., 2024). Word problems are made more challenging to solve as they require the problem-solver to engage in multiple processes to develop a solution. The type of problem poses further challenges to the readability of the problem, and often, the word problems do not contain enough information (Powell *et al*., 2022). The beauty of mathematics word problems is that they provide learners with the ability to apply their knowledge and skills in what they are learning to the world around them (Kirkland & McNeil, 2021:1).

Schools need to find ways in which learners can be guided to understand mathematics word problem-solving to "close existing achievement gaps" (Meyers *et al*., 2022:2). This shift is only possible if teachers understand and demonstrate the required knowledge in mathematics word problem teaching and learning (Scusa, 2008). Research on mathematics word problem-solving is not new. Meyers *et al.* (2022) report that researchers have conducted interventions since 1975 to find strategies to support mathematics word problem-solving. Kirkland and McNeil (2021) shed light on previous intervention strategies employed by teachers to assist learners with their sense-making. In most of the interventions, there are three aspects that always need to be addressed, namely (1) the introduction of "non-routine" tasks compared to traditional textbook word problems, (2) incorporating more teaching strategies, such as small group instruction and mathematical modelling, and (3) maintaining a positive classroom culture where word problem-solving is connected to the real world (Kirkland & McNeil, 2021). Although the work done by Wyndhamn and Saljo (1997) and Saljo, *et al.* (2009) are dated, it is worth noting that small group instruction strategies are used to teach mathematics word problem-solving to learners. More recently, Fuchs, *et al.* (2014) developed the RUN strategy: read the problem, underline the labels, and name the problem type. Freeman-Green, *et al.* (2015) have conceptualised the SOLVE strategy for solving mathematics word problems: study the problem, organise the facts, line up a plan, verify the plan with action, and evaluate the answer. Similarly, Flores, Hinton and Burton (2016) made use of hands-on tools and pictures to teach learners about word-problem solving. Intervention strategies are aimed at ensuring deeper engagement with the content of mathematics word problems and ensuring explicit reasoning (Jitendra, *et al*., 2023; Kiuhara, *et al*., 2024).

2.1 Reading comprehension strategies as part of mathematics word problem-solving instruction

Teachers[1] understand the importance of treating a mathematics word problem as a reading comprehension text (Fuchs, *et al*., 2018; Verschaffel *et al*., 2020; Swanepoel, 2022). Based on this realisation, teachers have noted learners perform better in mathematics word problem-solving: (1) when mathematics word problems are broken into short sentences; (2) where the mathematics register is revised; and (3) along with activating learners' prior knowledge about the context of the mathematics word problem. Moleko and Mosimege (2020) emphasise that learners need to be continually exposed to the mathematics register to assist with the linguistic aspect of reading a word problem with meaning.

Paying attention to the linguistic task of a mathematics word problem enhances teachers' mathematics word problem-solving instruction, making them less anxious. Teachers have been made aware of how to approach a mathematics word problem and understand how to break the word problem into smaller sections (Swanepoel, 2016).

1 Teachers referred to in this section are the co-researchers.

Teachers have found that learners' comprehension is better by making use of texts that learners are familiar with, basing mathematics word problems on learners' interests and integrating the theme of the week with mathematics word problem-solving. Consequently, learners spend less time trying to comprehend what has been read as they already understand the context of the word problem (Moleko & Mosimege, 2020). Teachers have also found that integrating reading comprehension exercises and the asking of leading questions throughout other learning areas, they can work informally on learners' mathematics word problem-solving skills (Boonen, *et al.,* 2016). Teachers' mathematics word problem-solving instruction is enhanced, as they can find time during the day, despite the packed curriculum, to expose learners to skills such as critical thinking, mathematics register instruction and reading comprehension (Swanepoel, 2022).

2.2 Continuous professional development initiatives

In reviewing the essential components of improved teaching and learning, which is the aim of continuous professional development initiatives, Morrison, *et al.* (2023) turned to the work of Hoadley (2017) and identified the 'triple cocktail' approach, which includes high-quality training for teachers, teaching and learning materials and instructional coaches. The development of professional development initiatives (PDIs) is only deemed successful if teachers are part of the PDI's inception, implementation and evaluation (Luneta, 2012). Accordingly, teachers have the "right to investigate and defend their instructional and intellectual principles" (Luneta, 2011) and select teaching methods that are the most suitable for the content taught, while keeping creativity and innovation in mind as necessary tools for supporting learners' understanding, ensuring that learners' performance is maintained (Macfarlane, 2024). A PDI where teachers are included in the design and implementation process is a lot more effective than one where teachers are mere recipients of the programme (Luneta, 2012).

Elements required for the development of a successful PDI have been identified by Archibald, *et al.,* (2011); Luneta (2012); Desimone and Garet (2015), and Darling-Hammond *et al.* (2017). They explain that the design of a PDI should be content-based and associated with specific curriculum content, as it supports teachers learning within the classroom context (Darling-Hammond *et al.*, 2017). The content of the activities within the PDI should focus on the subject matter and how learners learn that content (Desimone & Garet, 2015). Secondly, Darling-Hammond *et al.* (2017) emphasise the importance of collaboration in the development of a PDI. Lastly, Matherson and Windle (2017) affirm that "PD should be just as dynamic as the education its participants are expected to provide". In essence, Matherson and Windle (2017) explain that the development of the PDI should seek to answer whether the PDI in question provides opportunities that are interactive, engaging, and relevant for teachers and learners.

2.3 Professional development through participatory action research

Participatory action research (PAR) is a research design implemented to bring about change and empowerment within the community. The community members involved in research are referred to as co-researchers; they are involved in the process of knowledge-building and guiding change (Thomas, *et al.,* 2024). PAR seeks to employ both action and research into this research design to create a platform for change to take place (Benjamin-Thomas, *et al.,* 2018). There is a keen focus on the partnership between the researcher and the co-researchers, who are committed to working together to introduce change (Wallerstein, *et al.*, 2017; Brydon-Miller, *et al.,* 2020; Thomas *et al*., 2024).

Two of the main objectives of PAR include bringing about change and empowerment in the current day and age and seeks to work with community members as co-researchers in building knowledge and guiding change. De Oliveira (2022:288) explains that PAR focuses on empowering people at a deeper level through the process of creating and using their knowledge; it is through these actions that social change is brought about. The core of PAR is that it facilitates participants' telling their stories from actual events in which they account for experiences and share practices, memories, identities, and experiences (Chevalier, 2019; De Oliveira, 2022).

3. Theoretical framework

The Collaborative Process of Professional Development (CPoPD) is divided into three parts. Part 1 is Shulman's model of pedagogical reasoning and action (Shulman, 1987); part 2 is the Concerns Based Model of Teacher Development (CBMoTD) (Fuller, 1969); and part 3 is the interrelated relationship between teachers' knowledge, professional development and instruction of mathematics word problem-solving. All three sections of the CPoPD (cf. Figure 1) are required to strengthen the understanding to enhance Grade 3 teachers' mathematics word problem-solving through PDIs.

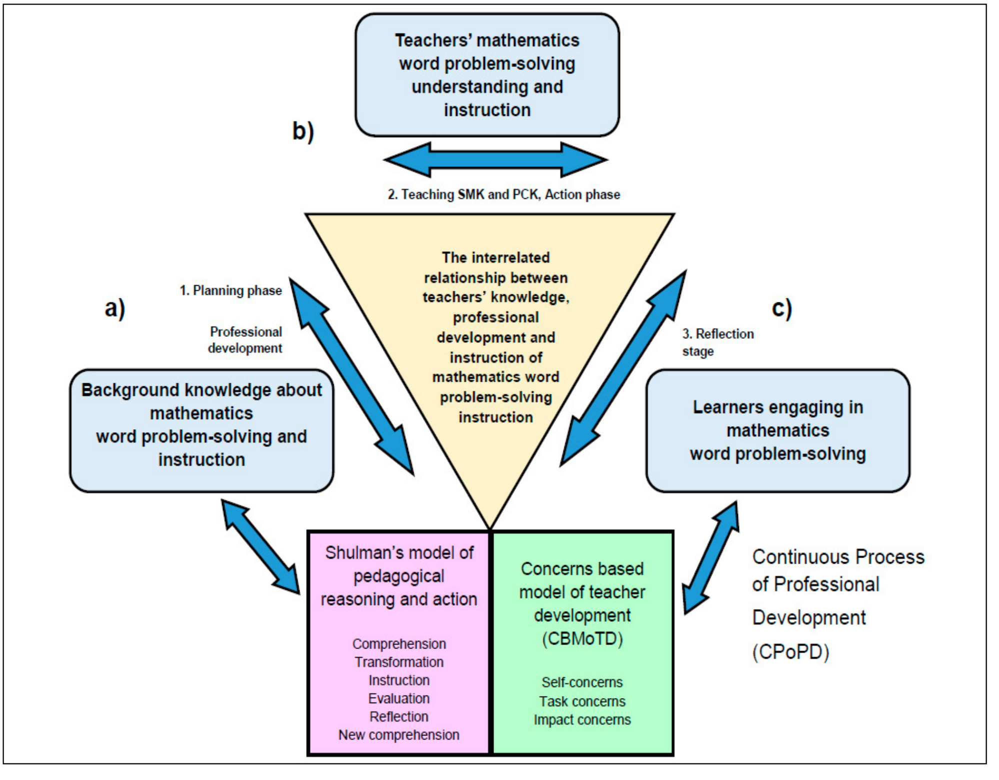

Figure 1: The Collaborative Process of Professional Development (CPoPD) as the theoretical framework (Swanepoel, 2022)

The top half of the CPoPD is represented by the interrelated relationship between teachers' knowledge, professional development and instruction of mathematics word problem-solving. The theoretical framework consists of three cyclical stages: planning, action, and reflection. The CPoPD was founded on two supporting pillars: Shulman's (1987) model of pedagogical reasoning and action and the CBMoTD (Fuller, 1969).

When unpacking the CPoPD (Swanepoel, 2022), the planning stage reflects teachers' professional development, which is scaffolded by their background knowledge. The planning stage is also known as the pre-intervention stage of the research. The planning stage and the professional development of this stage are aligned with the constructivist paradigm selected for the research.

The action stage refers to teachers attending collaborative workshops, learning and teaching mathematics word problem-solving to learners, and imparting new knowledge to learners. This is also known as the intervention stage of the research. The reflection stage refers to the post-intervention stage of the research and allows teachers to reflect on their learning. This is done by looking at the relationship between teaching and learning, where teachers measure their teaching against learners' performance.

Each stage of the research is aligned with Shulman's model of pedagogical reasoning and action and follows a cyclical process. As the stages of research progress from the planning stage to the action stage to the reflection stage, according to the work of Shulman (1987), teachers ascertain what background knowledge about mathematics word problem-solving instruction they have (comprehension); after that, the planning stage commences. This allows for teachers' knowledge about mathematics word problem-solving instruction to be transformed through instruction and constant communication. This instruction takes on the form of teachers attending PDIs and learning from the community of practice. Teachers take the knowledge they have gained and teach it to learners in the class. As the stages of the research progress to the reflection stage, teachers reflect on their teaching abilities by looking at the learners' performance. Since a reciprocal relationship exists between teaching and learning, teachers' teaching is measured against learners' performance. Teachers reflect on their teaching and this results in new comprehension.

Lastly, the CBMoTD (Fuller, 1969) refers to the concerns teachers need to address while engaging in professional development. The teacher must be cognisant of the subject matter, interact with the content, and construct knowledge so that knowledge can be shared with learners when teaching. The teacher needs to be cognisant of the task and ensure that the procedures and the pedagogy of mathematics word problem-solving are understood to make it practical to learners. Lastly, the teacher needs to be cognisant of the impact they can make on effective teaching and be committed to learning as much as possible to ensure that effective teacher development takes place. The action stage involved developing a collaborative relationship between the researcher and the teachers. This stage was marked by the creation of the word sum-wheel, which was designed and implemented in classrooms to enhance mathematics word problem-solving instruction.

The CPoPD, with all its components, directly informs research as it encourages the teacher to participate in their own professional development from an asset-based approach. Ebersohn and Eloff (2006) explain that an asset-based approach is an internally focused strategy that concentrates on building knowledge and problem-solving capacities. When working from a mindset of building strengths, teachers are encouraged to focus on the knowledge and capacities they already have, and expand on that, by means of engaging in their background knowledge (planning), teaching and continuous reflection. This recognises teachers who embrace professional development, who are continually building knowledge by means of planning, research and harnessing their background knowledge to improve their understanding of a concept to enhance their teaching (Hernández, 2022). When they have a better understanding of a concept, they can apply their new knowledge in their teaching practice, allowing them to see a distinct difference in their teaching. Thereby, the CPoPD highlights the reciprocal relationship between teaching and learning. Since professional development is continuous, teachers' knowledge (subject matter knowledge and pedagogical content knowledge) continuously expands based on the content and context they teach. Professional development as an asset-based approach should encourage teachers to want to learn more from collaboration within the community of practice.

4. Research methods and design

This qualitative study used PAR as the research design and constructivism as the methodological paradigm. The researchers adopted PAR as the research design because they believed that this design would allow the participating teachers as co-researchers to construct knowledge and address challenges in mathematics word problem-solving instruction, allowing them to develop new knowledge and skills in this area. It was important for the researchers to create an opportunity for the participating teachers' voices to be heard. The researchers were interested in the knowledge teachers were constructing and how their understanding of mathematics word problem-solving instruction was enhanced. Essentially, viewing this research through the lens of the constructivist paradigm sheds light on the fluid and flexible nature of actively addressing challenges through PAR and constructing knowledge, which provides meaning and empowers participating teachers' knowledge in teaching mathematics word problem-solving.

4.1 Study population and sampling strategy

Purposive sampling was used to allow the researchers to purposefully select thirteen participants who teach Grade 3 learners in both government and private schools. It was essential to select participants purposefully to ensure that data was rich and that it provided enough depth. The only sampling criterion used was that the teachers should have been teaching Grade 3 for longer than two consecutive years. Once the researchers identified teachers who adhered to the sampling criteria, the teachers were invited to take part in the study. Each school's principal was first approached in writing to inform them of the study and enquire about the school's participation. The researchers ensured that all parties had information about what the study entailed. Both the principal of each school and the corresponding teacher were required to provide informed consent before data generation could start.

4.2 Data generation

The collaborative development of the word sum-wheel emanated from the intervention part of the study, which took place during the action stage. Interactive discussions were held during the six workshops. The content of each workshop was aligned with the theoretical framework and the key aspects teachers identified considering enhancing their mathematics word problem-solving instruction. Each workshop had three stages: preparation, action and reflection. Teachers had an opportunity to form partnerships with and learn from one another, allowing the formation of a community of practice (Altrichter, *et al*, 2002:126; Somerville, 2014). The data generation of the study took place from February to May 2021. Owing to COVID-19 restrictions at the time, data was generated through online interactions. There were six workshops, which meant that the researchers met each group six times during the data generation process.

Each of the six workshops had a different focus and rationale. The focus of the first workshop was to determine the teachers' understanding of mathematics word problem instruction. The second workshop started with an introduction to a variety of creative teaching methods suitable for teaching mathematics word problem-solving through play and creative thinking. In the third workshop, teachers explored the different roles involved in teaching and learning and were thus introduced to Shulman's model of pedagogical reasoning and action. The fourth workshop focused on teachers' PCK and SMK required for mathematics word problem-solving instruction. The fifth workshop was dedicated to clarifying and explaining the key concepts of *mathematics register* and *reading comprehension*. During the sixth workshop, the key concepts of *mathematics modelling* and *mathematics proficiencies* were explored.

Each workshop was recorded and transcribed to enable data analysis through thematic analysis. In addition, teachers were provided with a reflective diary for each workshop that contained information about its content and they wrote down their thoughts on each workshop. All the workshops were professional development programmes that teachers could adopt in their schools to enhance instruction and attention to word problems in general.

4.3 Data analysis

The data analysis entailed an in-depth process that included multiple cycles. A hybrid approach (Greco, *et al.,* 2001; Fereday & Muir-Cochrane, 2006) of thematic analysis (Braun & Clarke, 2006), which included deductive and inductive data analysis techniques (Bingham & Witkowsky, 2022), was used to make meaning of the data and generate findings accordingly. The first cycle of the data analysis process was deductive data analysis and included the transcriptions of the workshops and the teachers' reflective diaries (Locke, 2007; Nola & Sankey, 2007; Woiceshyn & Daellenbach, 2018:7). There were four pre-determined categories into which the data was classified: (1) The role of the teacher; (2) Critical instructional practices for mathematics word problem-solving; (3) Factors influencing mathematics word problem-solving instruction; and (4) Professional development practices. The second cycle of data analysis entailed inductive data analysis (Bingham & Witkowsky, 2022; Locke, 2007; Woiceshyn & Daellenbach, 2018). The first step in thematic analysis, was to familiarise ourselves with the data (Braun & Clarke, 2006). This entailed working through the transcriptions of the workshops and the teachers' reflective diaries by means of reading the data more than once to gain an in-depth understanding of the data. The second step was to generate initial codes (Braun & Clarke, 2006) by hand. Once we had an in-depth understanding of the data, we organised the data into meaningful sections and started to assign codes to the data.

Since coding was done by hand, we made use of a variety of highlighters and 'post-it' notes to the assign codes to the data. Care was taken not to take the data out of context; thus, coding was done inclusively (Braun & Clarke, 2006). After all the data had been coded, we started with step three, during which the codes were grouped to generate themes. We used tables and flow charts to guide our thinking and visualise our reasoning. Steps to review and refine generated themes were followed, as advocated by Braun and Clarke (2006:91). This was part of step four. The next step was to define and name the themes and start looking at where to place the themes under the respective pre-determined categories. It was important to identify the core of the theme and how the theme relates to the surrounding themes. It was important for us to have the theme speak for itself and not to be too complex. In line with the four pre-determined categories, the themes generated from the codes became sub-categories and were positioned under the respective pre-determined categories. The final step, step six, entailed the final write-up of the thematic analysis. Since many data generation instruments were used, each instrument was discussed considering the four pre-determined categories and the 20 subsequent sub-categories. Data saturation was reached in this data analysis cycle once the sub-categories and codes began to repeat each other. Considering this paper, attention is only paid to the last category, i.e. *Professional development initiatives* and the corresponding sub-category: *The development of the word sum-wheel*.

4.4 Ethical considerations

The study was conducted with approval from the University of Johannesburg (Ethical clearance number: Sem 2-2019-030). All ethical considerations were adhered to throughout the study. Informed consent was obtained from school principals and participating Grade 3 teachers.

5. Findings and discussion

The word sum-wheel is the product of participating teachers' collaboration through PAR and was underpinned by the CPoPD. The focus of developing the word sum-wheel was to equip other Grade 3 teachers with a model designed by practising Grade 3 teachers to serve as a tool for the teachers to understand what the process of mathematics word problem-solving entails. The word sum-wheel represents the six steps followed in mathematics word problem-solving instruction. 'Read and look for clues' is the first step. The importance of this step is linked to reading for meaning to find information related to *who and what* (Jackson, 2018) the problem is about, *number information* (Jackson, 2018) and *what the question* is asking (Jackson, 2018). The second step, 'Constantly communicate', creates an opportunity for the teacher and the learners to ask questions for clarity and to reflect on the answers. This step is very important for the teacher and the learners in the class and serves to ascertain understanding. The third step, 'Make time for play and creativity', serves as an opportunity for play to be implemented as a means of testing understanding or explaining a concept through play and/or informal teaching and learning activities. This is a time dedicated to learning about the word problem through play and incorporating concrete manipulatives or other forms of learning through physical movement. Step four, 'Work out operations and open number sentence', provides an opportunity to move away from concrete to semi-concrete and abstract thinking. This step's complexity can be adjusted to the grade or ability of the learners. This step can also be made complex for learners beyond Grade 3. The versatility of this step makes the word sum-wheel accessible to differentiation and multi-level teaching (Nel, *et al.*, 2013). Step five creates a space to 'Work out the answers'. The plural form of answer(s) has been used to emphasise the importance of the answer to the calculations and sentence answer. The last step, step six, allows for the problem-solver to 'Double-check' their answer.

The beauty of the word sum-wheel is that all the teachers were equally involved in the development of the model (Archibald *et al.,* 2011; Luneta, 2012). The teachers have started to implement the model in the class with relative success, which answers to one of the research objectives. The teachers involved in the study referred to the word problems by addressing the six steps of the sum-wheel. Their instructions in the classroom pointed learners to first read for clues, communicate and identify parts of the question, open up the question and operationalise it through play. Figure 2 represents the final version of the word sum-wheel. While keeping the reciprocal relationship between teaching and learning in mind, the researchers decided to discuss the study's findings considering the introduction of play in mathematics word problem-solving instruction and teachers' enhanced mathematics word problem-solving knowledge and skills. We are pleased that the study's overarching objective, which was to collaboratively develop a PDI to enhance Grade 3 teachers' instruction of mathematics word problem-solving, was achieved. This became evident in the way teachers were guided to teach mathematics word problem-solving in a fun, interactive and informal manner, as advocated by the word sum-wheel. Equally, we are delighted about the way learners perceived mathematics word problem-solving to be all about play and no longer about anxiety-stricken activities. Positive change did occur; the research question can be answered by linking to this realisation.

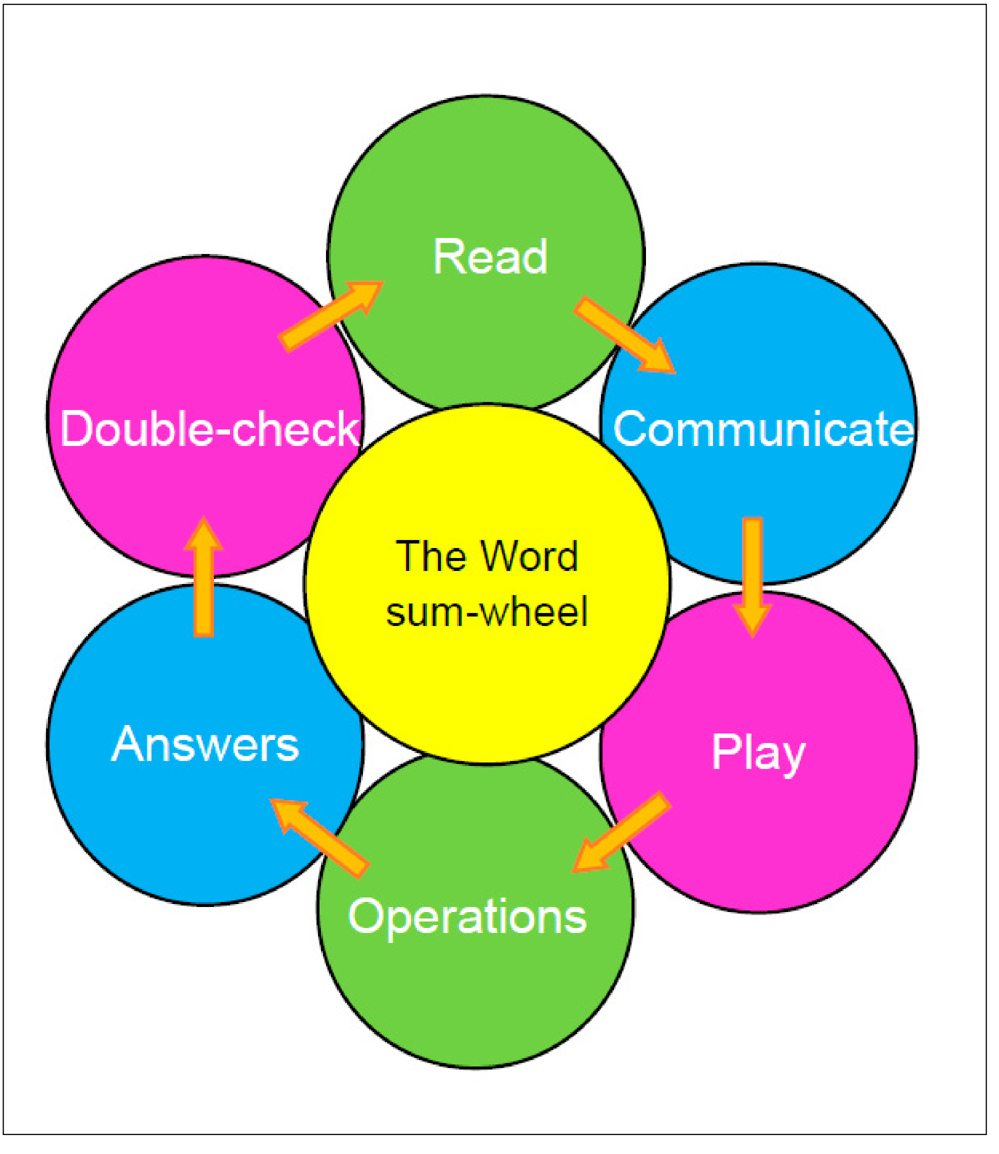

Figure 2: The word sum-wheel (Swanepoel, 2022)

5.1 The introduction of play in mathematics word problem-solving instruction

Implementing play in mathematics word problem-solving has significantly increased learner engagement and performance. By incorporating practical activities, manipulatives, and opportunities for peer and group engagement, learners are more excited to participate and actively involve themselves in solving problems (Taylor & Boyer, 2020). Teachers report that this approach makes it easier for learners to grasp mathematical concepts, and they enjoy teaching in an interactive manner that fosters both fun and learning (Parker, *et al.*, 2019; Naudé, 2021). This further takes hands with the study's objective, which is to enhance teachers' mathematics word problem-solving instruction, by providing teachers with strategies to teach mathematics word problem-solving in a way that learners understand and naturally appeals to them. The introduction of the word sum-wheel, and specifically 'play', links teachers to an array of strategies to assist teachers develop a better understanding of how play is introduced as an interactive teaching practice that enhanced both teaching and learning of mathematics word problem-solving.

Teachers also noted the value of incorporating movement and self-expression in the classroom, which allow them to understand learners better and adapt their instruction to meet diverse needs (Miller & Lindt, 2018; Samsudin, *et al.*, 2019). Peer and group engagement were found to be particularly effective, as they promote collaborative learning and give learners the chance to teach and learn from each other in non-traditional ways (Hanmer, 2010; Stach & Veldsman, 2021).

Additionally, integrating mathematics into other subjects, such as language and life orientation, and using concrete manipulatives help learners connect abstract mathematical concepts to real-world experiences (Ariba & Luneta, 2018; Larsen-Freeman, 2000). Teachers found that understanding and incorporating learners' interests into word problem-solving made the process more engaging and accessible, as familiar contexts allowed learners to focus on the mathematical aspects of problems (Double, *et al.*, 2020).

5.2 Teachers' enhanced mathematics word problem-solving knowledge and skills

Among the study's objectives were teachers' benefits in terms of their instructional and pedagogical development as they delved into the research. As such, throughout the research, we show evidence that highlighted the enhancement of teachers' mathematics word problem-solving knowledge and skills. Teachers' enhancement of mathematical word problem-solving knowledge and skills speak to the primary research question and highlight how the question was answered by referring to various accounts. Notably, co-researcher EC1 experienced a significant boost in confidence through the collaborative development of the word sum-wheel. This allowed her to teach and solve word problems with greater ease, improving learner performance. She attributed this success to understanding how to teach mathematics word problems and incorporating more kinaesthetic activities: "*Bringing in a more kinaesthetic way of teaching and getting them to move their bodies [has] actually made a huge difference. They seem a lot more enthusiastic about completing tasks*." Similarly, co-researcher AB2 found that following the prompt of the word sum-wheel, she can understand the process of word problem-solving more. This allowed her to enjoy the process herself, which made it easier for learners to engage, stating, "*I almost think I am also more motivated, so every now and then, we focus a lot more on understanding and try to be a little bit creative*."

The introduction of the word sum-wheel further inspired teachers to embrace word problem-solving. Co-researcher ED3 expressed newfound enthusiasm for teaching: "*There is like a zest for life for 2021!*" After its collaborative development, teachers implemented the word sum-wheel in their classrooms with positive results. Co-researcher AD1 noted, "*I took them to jump number lines outside… and the learners loved each moment of it.*" AB2 added that practical activities made learners more confident and eager to solve problems: "[*Learners] understand it more, so they make it their own*." EC1 emphasised the importance of considering learners' different learning styles: "*That was a huge one for me*."

The collaborative workshops played a key role in boosting teachers' confidence. Co-researcher AD3 found group discussions especially helpful, saying they addressed uncertainties she had about teaching methods. Co-researcher AD5 sought new methods for teaching mathematics word problems, while co-researcher AB1 acknowledged that effective instruction requires specialised guidance. After completing the PDI, co-researcher AD1 shared new insights: "*I now think about my approach to teaching mathematics word problems differently*." Co-researchers praised the word sum-wheel, with co-researcher EC1 noting, "*I am in the process of turning that into a giant wheel to stick on my board.*" Co-researcher ED2 concluded that teaching while having fun was the best way to engage learners, stating, "*I love having fun while learning*."

5.3 The role of collaboration in the development of the word sum-wheel

The community in which the research took place played a significant role in supporting the co-researchers with the collaborative development of the word sum-wheel. It is safe to say that without the community of practice, the word sum-wheel, as the PDI, would not have been developed. When reflecting on the core aspects of PAR in developing the word sum-wheel, co-researcher EB3 explained that she experienced the community and the weekly virtual meetings as one of the highlights of the process of developing the word sum-wheel. Co-researcher EB4 also noted that she enjoyed the collaborative nature of developing the word sum-wheel. She continued to explain that throughout the workshop, hearing other teachers' ideas was particularly beneficial, especially since they came from different schools. It was reassuring for her to learn that other teachers were facing similar challenges, and she appreciated the opportunity to hear effective strategies for addressing these issues. She found these discussions valuable and enjoyable, especially when colleagues offered practical suggestions for improving instruction.

Co-researcher EC1 emphasised that the highlight of the development of the word sum-wheel was the collaborative environment in which teachers shared their challenges and supported one another. She noted that it was helpful to engage with others facing similar situations and striving to find solutions rather than remaining stagnant in their teaching practices.

Co-researcher EB 2 appreciated the sense of camaraderie within the group. She expressed that hearing other co-researchers struggle with similar challenges in teaching mathematics word problem-solving was reassuring. She further noted that the group had bonded during the process, which made the discussions and shared experiences more meaningful.

6. Conclusion

The development of the word sum-wheel is unique in its nature, seeing that there are few PDIs aimed at enhancing teachers' mathematics word problem-solving instruction. The development of the word sum-wheel was based on teachers' concerns about mathematics word problem-solving instruction, which they specifically pointed out. The word sum-wheel set out to address the teachers' areas of concern through practical, hands-on activities, where mathematics word problem-solving instruction could be integrated into the weekly theme without necessarily having to wait for explicit time solely dedicated to teaching mathematics word problem-solving. Peer and group instruction, along with real-life experiences and integration of learning through play, were highlighted as alternative strategies to implement to enhance Grade 3 teachers' mathematics word problem-solving instruction, whilst supporting learner performance in mathematics word problem-solving.

The collaborative development of the word sum-wheel gave rise to a dynamic community of practice, where teachers were able to support each other and gain confidence in learning about mathematics word problem-solving instruction in a fun-filled manner, which gave meaning to learning through play. The development of the word sum-wheel was not without challenges or limitations. While we are proud of the word sum-wheel and believe in the value this PDI can instil in mathematics education, we have to disclose that it was really challenging to develop a PDI through virtual interaction with teachers due to the restrictions imposed by COVID-19. Furthermore, the development of the word sum-wheel was a PDI opposed to an organic process, seeing that time constraints meant that there was limited time to implement the word sum-wheel in classes. Owing to teachers' resistance to change, not all teachers bought into the implementation of the word sum-wheel with equal enthusiasm. We did not see a notable difference between the implementation of the word sum-wheel between private and government schools. We acknowledge that the findings cannot be generalised to all schools, since only quintile three and four schools participated in the research. In South Africa, the quintile system categorises schools into five groups based on socioeconomic status, determining funding and resource allocation, where quintile one schools are no-fee paying schools, and quintile five schools are very expensive schools situated in affluent socioeconomic environments. This is, however, a recommendation for future research to introduce a broader range of schools, ranging from quintile one to five, to the word sum-wheel and to allow teachers to adapt to the existing model based on their needs. This would be very valuable to allow schools to implement the word sum-wheel over a longer period, as to allow for an organic process of professional development.

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