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Grade 4 Mathematics Teachers' Understanding of Including Investigations as Part of Summative Assessment

Rosina Nkadi Ngoako[1] and Joseph Jabulane Dhlamini[2]

[1,2]University of South Africa, Department of Mathematics Education

Abstract

A mathematics investigation task requires learners to explore and analyse a specific mathematical concept, fostering independent knowledge discovery and self-directed learning skills. This paper presents a study examining teachers' ability to integrate investigation tasks as a summative assessment method in South African Grade 4 mathematics classrooms. Employing a qualitative research approach, the study profiled teachers' knowledge and skills in implementing effective investigation-based assessment procedures. A pre- and post-intervention design was used to compare teachers' understanding of conducting investigations as part of summative assessments. A purposive sample of 16 Grade 4 mathematics teachers completed an open-ended questionnaire before and after the intervention program to document their knowledge of mathematics assessment. The findings indicated that, before the intervention, teachers demonstrated limited understanding of how to effectively implement assessment procedures aligned with investigation tasks while incorporating summative assessment elements. However, after the intervention, their ability to enact effective assessment strategies within investigation tasks showed noticeable improvement. The study highlights the need for enhanced teacher capacity-building initiatives to strengthen educators' knowledge and confidence, enabling them to effectively integrate state-approved curriculum concepts and establish a more comprehensive and effective assessment approach in Grade 4 mathematics classrooms.

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Correspondence

Rosina Nkadi Ngoako
engoakrn@unisa.ac.za

ORCID
0000-0003-3063-6643

Introduction

The South African Curriculum and Assessment Policy Statement (CAPS), is based on important principles that encourage active and critical learning approaches (Department of Basic Education, DBE, 2011). As a result, rote learning is discouraged and teachers are encouraged to incorporate active learning as a norm in their daily lessons (Sing & Maringe, 2020). The principle of active and critical learning aligns with the general aims of the South African curriculum outlined in the CAPS document. Generally, the curriculum aims to ensure that children acquire and apply knowledge and skills learned in class in ways that give meaning to their lives (Sitopu et al., 2024). Application of mathematical knowledge is evident when learners can use their prior knowledge to discover mathematical ideas by identifying or testing patterns, posing questions, and finding general trends (Pan & Carpenter, 2023). The processes of identifying patterns, posing questions, and finding general trends are some of the steps of the investigative process, and when doing these, learners would be involved in the investigative process.

Therefore, the authors opine that teachers are encouraged to teach meaningfully to make learners understand what is taught, and this can only be achieved when learners are actively involved during teaching.

The curriculum's objective can only be achieved if there is a way, a process, or a plan that is put in place that teachers can use during their teaching, and the objective of the teaching process is measurable at the end of the process. Jacob et al. (2020) state that problem-solving and problem-posing constitute a popular and familiar component of teachers' classroom pedagogy to engage learners in the teaching and learning process. Therefore, the DBE can achieve its objective by ensuring that teachers understand how to guide their learners when conducting investigative tasks.

Ways in which learners can be actively involved in lessons that foster creative thinking and develop problem-solving skills that can be applied in everyday life are by doing investigations (Mamun et al., 2022). In addition to tests, assignments, and projects given as part of summative assessment, at least one investigation be given in the intermediate phase (grades 4-6) (DBE, 2012). In addition to summative assessment, investigations as problem-based activities may be given to learners to achieve the learning goal (Ukobizaba et al., 2021). The authors in this paper believe that teachers should be familiar with the investigative approach and know how to set and conduct these tasks to enable them to guide learners through the investigative process and prepare them for assessment.

Since investigations foster critical and creative thinking and assist students in developing problem-solving abilities that will serve them well beyond their time in school, it is now clear that they are crucial to teaching and learning (Tekkumru-Kisa et al., 2020). Parry and Gordon (2021) state that South Africa is fraught with many challenges such as unemployment, energy and water crisis, and corruption, thus making it necessary for education to help in finding solutions to these problems. If learners can think critically and make meaningful decisions, then some of the societal challenges can be solved effectively. Hence, investigative tasks that foster critical thinking should be given to learners. However, to do this, teachers require a thorough knowledge of conducting investigative tasks.

Some teachers experience difficulties when dealing with investigative tasks (Yeo & Yeap, 2009). For instance, instead of designing their tasks, they request investigative tasks from their peers in other provinces, and in the process, recycle them without imposing necessary modifications. This study is largely framed on the view that if investigations promote critical and creative thinking, which can be used in problem-solving, how often are they done and how do teachers conduct them to prepare learners for summative assessment? It is against this background that the researchers wanted to investigate the knowledge of Grade 4 mathematics teachers in using investigations in summative assessments. The study is built on two main objectives:

1. To examine Grade 4 teachers' level of understanding of mathematical investigations, and
2. To find out how they construct mathematical investigations.

To achieve these objectives, the following research questions were asked:

1. What is the Grade 4 mathematics teachers' understanding of investigations as a summative tool for assessment?

2. How do Grade 4 mathematics teachers conduct investigations when constructing a task?

Summative Assessment in Learning

It is the type of assessment that assesses learners' knowledge at the end of a term, semester, or year after a topic or cluster of topics is completed (Gezer, 2021). Schools are required to provide feedback at the end of each term to stakeholders regarding learners' performances in the form of progress reports. It summarises learning outcomes achieved by learners in a longer period of learning (Chytry & Kubiatko, 2021). Regarding assessment, Mahlambi et al. (2022) argue that "to be an effective teacher requires a combination of pedagogical skills, and assessing learners" (p. 5). This agrees with Govender's (2019) argument that assessment and teaching are reciprocal processes. The CAPS document requires that investigations be given to learners in the intermediate phase (Grade 4 - 6) as quarterly summative tasks (DBE, 2011).

Conducting Investigations in Mathematics Classrooms

Ali et al. (2021) identified ways that teachers can guide learners into conducting problem-based activities or investigations, namely, 1) the ability to pose questions, 2) collecting data, 3) investigating and discovering answers, 4) solving problems, and 5) elaborating and evaluating findings. Hanna and Knipping (2020) argue that learners should be allowed to invent and test hypotheses through conducting investigations. Therefore, assigning open problem-based tasks encourages learners to make conjectures, test them, and generalise the findings. When these steps are successfully carried out, learners can communicate their findings to the teacher or their classmates.

Although the steps listed in the preceding paragraph are important in conducting investigations, they may not all be included in one task, especially in primary schools. The degree of difficulty of the task should be measured against learners' knowledge level.

The CAPS document states that investigations "may involve inductive reasoning, identifying or testing patterns or relationships, drawing conclusions, and establishing general trends" (DBE 2011, p300). When doing investigations, learners engage in multiple steps or different ways of looking at the problem, involving their cognitive thinking. For example, in numeric patterns, learners can investigate the pattern; 1; 3; 5; 7; …, employing different representations (a number line, number sentence, machine/flow diagram, and the table method) of the same pattern, ultimately leading to their creation of patterns.

Using a Number Line

In using the number line, learners can be given a number line to insert the missing numbers in Figure 1. The intervals can provide a clear picture to those struggling to identify the common difference between the terms.

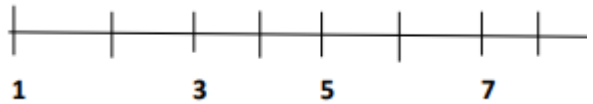


Figure 1: Using a number line to show numeric pattern

A number line is a basic technique to enhance number development and counting in lower grades; thus, learners can easily recognise the missing values.

Using a Flow Diagram

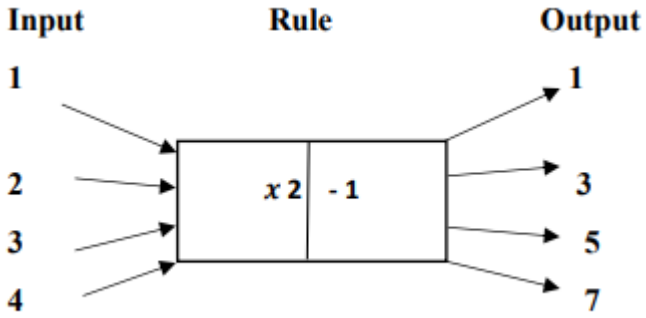


Figure 2: Flow diagram showing an alternative way of showing a numeric pattern

A flow diagram is a way of representing patterns, demonstrating how rules can be found by comparing the output and input values. Learners perform computations involving different operations, for example, the rule involving multiplication and subtraction in Figure 2. Some input and output values can be removed to allow learners to perform computations.

Using Number Sentences

2 x 1 – 1 = 3
2 x 2 – 1 = 5
2 x 3 – 1 = 7

Using number sentences helps learners draw on their prior knowledge of counting skills and multiplication tables. They can easily write number sentences by extracting information from the machine diagram as is.

Using a Table

Table 1

Using a Rule to Find Terms in a Numeric Pattern

Input	1	2	3	4	5
Rule	1 x 2 - 1	2 x 2 - 1	3 x 2 - 1	4 x 2 - 1	
Output	1	3	5	7	

When learners master flow diagrams and number sentences, they can be introduced to tables to represent numeric patterns differently and find rules, see Table 1 above. Teachers can then ask learners to refer to the examples of a machine diagram and number sentence to determine the rule. Mastering the rule leads to determining the next terms in the pattern, for example, a question like “if the input is 5, then what will be the fifth term in the table?” The same question can be asked with a bigger input such as 2-digit numbers.

Ukobizaba et al. (2021) highlight the need for assessment techniques to strengthen learners' mathematical problem-solving skills. Investigative tasks can be used in this regard because of their ability to engage learners in a mentally challenging and inquiring manner. Most researchers (Ali et al., 2021; Gleason & Zelkwoski, 2017; Mueller et al., 2014; Patricio & Canavarro, 2011), point to the importance and need for inquiry, problem-solving, and investigations in mathematics lessons. This suggests that investigations are valuable and learners need to be exposed to these activities regularly and in their earliest years of schooling. According to Marshman et al. (2022), teachers need to include investigations as part of teaching and learning authentically and realistically, having transparent goals that align with the general aims and principles as outlined in the CAPS document.

Research About the Inclusion of Investigations in Teaching and Learning

It is worth noting that formative assessment and teaching and learning reciprocate each other in preparing learners for summative assessments (Govender, 2019). As a result, the CAPS requires that in the content area of patterns, functions, and algebra, teachers encourage learners to investigate numeric and geometric patterns. The investigative approach engages learners in problem-posing, thus encouraging them to ask questions and provide solutions to the questions they have asked (Bicer, 2021). For learners to be able to do this, mathematics teachers need to have a clear understanding of how to use investigations and engage learners in these kinds of tasks (Gallagher et al., 2022). Constantly involving learners in the learning process through investigations can develop their self-regulation skills and independent learning (Ngoako & Mofolo-Mbokane, 2022).

Mueller et al. (2014) noted that, although investigations are important in teaching and learning, activities that promote problem-posing are not given to learners regularly. This is sometimes because investigations cause a feeling of discomfort in some teachers, especially those who are not familiar with the investigative approach, while other teachers see investigations as time-consuming (Bailey, 2007). Stoyanova et al. (2020) contend that investigative tasks can be very complex, and as a result, their development in the classroom represents a serious challenge for many mathematics teachers. According to Kem (2022), teachers need to scaffold and provide individualised support to learners. During investigations, scaffolding needs to be done carefully to prevent learners' over-reliance on the teacher (de Ruig et al., 2023). The results of the study conducted by Bailey (2007) with pre-service teachers on the use of investigations, revealed that learners became disappointed when mathematics was not scheduled in their timetable for a particular day, because of the interest investigation activities enthused them. For learners to reach a level of self-actualisation in learning through investigations, teachers require a professional support network from their peers and mentors (Marshman et al., 2022).

Theoretical Framework

For the theoretical framework, the researchers employed the use of aspects of teachers' professional knowledge described by Patricio and Canavarro (2011), namely, 1) knowledge of mathematics, 2) knowledge of learners and their learning process, 3) knowledge of the curriculum and 4) knowledge of the instructional process.

Knowledge of Mathematics in Investigation

Several researchers (Beswick & Goos, 2018; Ngoako 2018; Shulman 1986 & Venkat & Spaull, 2015) advocate the need for teachers to have subject content and pedagogic content knowledge to teach mathematics effectively in any grade. McCarthy and Oliphant (2013) regard teacher competency in mathematics as an issue that results in poor teaching and consequently leads to low development of knowledge, hindering the ability to address problems faced by the country. Knowledge of the subject not only enables teachers to teach the subject effectively but also assists them in setting standardised assessment tasks that cover all the cognitive levels required by the CAPS. Classroom assessment techniques such as the investigative approach which embeds assessment within the instructional process benefit learners to understand and teachers in understanding learners' misconceptions (Gezer et al., 2021). It is, therefore, important that teachers have adequate knowledge of mathematics.

Knowledge of Learners about the Investigation

When teachers know their learners, and what they bring into learning, they will be in a good position to assist and guide them through the learning process (Bene & Bergus, 2014). Furthermore, Govender (2019) contends that teachers of mathematics are likely to conduct formative assessments more intuitively if they have sound knowledge of their learners' mathematical cognition and conceptual development. Checking learners' prior knowledge of engaging in investigative tasks can assist teachers in planning their instructional activities (Hattan et al., 2024). For example, if learners are given a pattern, they can be asked to predict the next term, identify the common differences between the terms, and represent the pattern in different ways. Teachers need to know their learners' cultural backgrounds, intellectual abilities, and emotional well-being (Hill, 2020). These play a crucial role in determining the types of models and learning strategies to use, and what to include when planning instructional programs (Tularam, 2018). In addition, teachers need to know how their learners prefer to learn, that is, if they are auditory learners because consideration of learners' individual needs directs the teacher about how to teach a particular content (Foley, 2020).

Knowledge of the Curriculum Regarding the Investigation

One of the important things that teachers need to know is the curriculum they are supposed to teach (Dreher et al., 2018). In South Africa, the curriculum content is outlined in the CAPS document. Ngoepe (2021) argues that teachers need to know and understand the content outlined in CAPS, how it compares with that of the previous grade, and how it links with that of the next grade. This will help them realise knowledge gaps quickly as they teach and act decisively in addressing them (Aubrey, 2022). The CAPS requires the use of the investigative approach in the teaching and learning of numeric and geometric patterns, where it stipulates the concepts and skills to be learned as "investigate and extend geometric patterns looking for relationships or rules of patterns" (DBE, 2011, p. 80). Knowledge of the curriculum will also assist teachers in developing tasks that address the curriculum outcomes, thus covering the specific required criteria.

Knowledge of Instructional Processes About an Investigation

Knowledge of instructional processes can assist teachers in knowing what to include when planning for their lessons. For example, the kind of prior knowledge based on learners' cultural and intellectual background, deciding whether to use visual or auditory teaching aids and when and how to include types of assessments (Mohammad et al., 2022). One of the instructional processes that teachers need to be familiar with is the investigative approach. Ali et al. (2021) identified ways that teachers can guide learners into conducting problem-based activities or investigations, namely, 1) the ability to pose questions, 2) collecting data, 3) investigating and discovering answers, 4) solving problems, and 5) elaborating and evaluating findings. Knowledge of the investigative approach is not only essential for keeping learners engaged during lessons and developing their imagination and problem-solving skills, but it is also important to assist teachers develop tasks that are aligned with aspects of content and structure (Wu & Yang, 2022). For example, in the pattern shown in Figure 3, learners can investigate by posing problems such as what type of shapes make up the pattern. How many sides does each shape have? How is the number of sides increasing or decreasing?

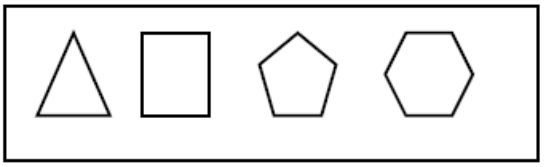


Figure 3: Pattern of 2-D shapes adapted from Grade 4 mathematics CAPS

Answering these questions will allow learners to extend the pattern by drawing the next shape or determining the number of sides for the next shape in the pattern. When teachers know instructional processes, it will be easier for them to use any approach or strategy during teaching and learning, including the investigative approach.

Research Methodology

Due to the interpretive nature of this study, the qualitative research approach was selected as the most suitable research methodology, because the data provided by the participants was textual, and needed to be analysed using interpretive methods (Taherdoost, 2022). The study used open-ended questionnaires as a method of data collection to detail participants' ways of conducting mathematical investigations. Researchers in this study used open-ended questionnaires because they were the appropriate method to enable participants to use their own words in describing their familiarities and acquaintances in conducting and constructing mathematical investigations (Muzari et al., 2022).

Population and Sampling

The study focused on Grade 4 mathematics teachers who were purposively invited by the subject specialist in one of the districts in the Limpopo province of South Africa, to take part in the intervention program. The district was conveniently sampled because it was the geographical location of the main researcher. Limpopo province, with 10 districts, scored low in TIMMS 2019 results as compared to other provinces. Moreover, the province has many previously disadvantaged schools in rural areas. In

South Africa, most teachers do not prefer working in these areas and as a result, many rural schools lack qualified teachers especially in primary schools. At the time of conducting this study, there were approximately 20 primary schools in Capricorn district, and all the schools were representative of the sample. However, promotions and new allocations reduced the number to 16. Schools had one mathematics teacher in Grade 4, and available teacher was selected per school and altogether, sixteen teachers participated. Teachers voluntarily completed the open-ended questionnaire to provide researchers with an understanding of the level of their knowledge about conducting investigations before the intervention.

Intervention Program

After an initial analysis of teachers' responses to the questionnaire, the researchers chose the intervention program due to the iterative approach and emerging design being fundamental aspects of qualitative research (Moser & Kortjens, 2018). This implies that researchers did not wait to complete the analysis, instead, they focused on sections that required intervention. The aim of the intervention was to expose the investigative approach to teachers and equip them with pedagogic content knowledge particularly in doing investigations. The intervention occurred in two stages. The first stage was a two-day workshop in which the investigative approach was used to demonstrate the teaching of data handling. On the second day, numeric and geometric patterns were used to show how investigative tasks can be developed. The focus was on the skills to be tested in an investigative task and the types of questions to ask using the section on numeric and geometric patterns in the Grade 4 CAPS document.

The second stage was a one-day online workshop focusing on teaching patterns using the investigative approach.

Data Collection

Data was collected using a pre-and post-questionnaire, which was given to the 16 participants to complete before and after the intervention. The questionnaires consisted of open-ended questions about teachers' knowledge and use of mathematical investigations. The questionnaire was preferred because it contained open-ended questions which allowed participants to express themselves sufficiently, to ensure valid and reliable data (Meiklejohn et al. 2021). Apart from being a data collection instrument, a questionnaire is regarded as a structured interview schedule (Borgobello et al., 2019). According to Van Deventer and Steyn (2022), open-ended questions may be used in a questionnaire in which researchers seek narrative qualitative information and data may require content analysis. Moreover, a questionnaire is an effective way of collecting data that can be used on its own or in conjunction with other instruments (Van Deventer & Steyn, 2022).

Data Analysis

Data was analysed using content analysis. Data analysis comprised three steps; in the first step, the participants' responses were grouped according to the questions asked in the questionnaire using open coding. Kumar (2018) describes open coding as a qualitative data analysis method that involves segmenting data into distinct parts and assigning codes to label and categorize them using words, phrases, or sentences. Table

2 presents examples of coding using words. Teachers' responses were assigned codes depending on their responses to the three questions asked in the questionnaire.

In the second step, data was read, and participants' responses were compared with Ali et al.'s (2021) ways of using the investigative approach to determine the participants' level of understanding of investigations. Depending on whether the participants included some of Ali et al.'s (2021) ways of investigating in their responses, the researchers would determine whether participants understood using investigations.

Table 2

Codes Used to Analyse Data

Code	Description
Approach	How do you approach mathematical investigations?
Skills (Understandings)	What mathematical understandings are developed by the investigation?
Integration	What curriculum areas are integrated into an investigation?
Activities	List the activities that learners will be involved in.

The descriptions in Table 2 are questions asked in the questionnaire and served as predetermined themes, providing a framework for guiding the data analysis process.

Ethical Issues

Ethical clearance was granted by the University of South Africa, with reference 2022/11/09/1123408/08/AM. Consent letters were sent to participants and they voluntarily agreed to participate in the study.

Findings

To determine teachers' knowledge of infusing investigations into summative assessments, participants were asked the following questions: "How do you approach mathematical investigations?", and "You are presented with a mathematical investigation task that focuses on sequences. Answer the following questions". What mathematical understandings are developed by the investigation? What curriculum areas are integrated into the investigation? List the activities that learners will be involved in.

Before Administering the Intervention Program

The questionnaire was administered before intervention to get insights of how teachers conduct investigations. Teachers' responses to the questions in the questionnaires are divided into before and after the intervention program. Table 3 is a summary including questions asked in the questionnaire, and teachers' responses.

Approaching / Doing Mathematical Investigations

The question "How do you approach mathematical investigations?" was asked to check if participants know instructional strategies relating to investigations. This question was asked to zoom in on the practicality of participants' knowledge in constructing an investigative task. When this question was asked, two participants did

not respond, and others displayed some lack of knowledge of doing investigations, for instance, one participant said they would tell learners about real-life activities. Others did not provide a clear description of what they would do in giving investigative tasks.

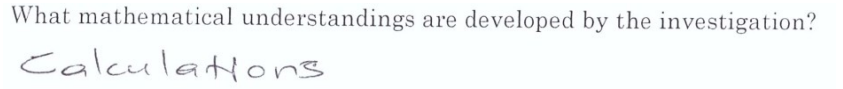
Table 3

Participants' Responses to the Questionnaire

Question asked	Response
How do you approach mathematical investigations?	*1. Tell them about real-life activities where investigations are used so they can relate.* *2. Ask learners oral questions about what is happening about their movement or within the area they live.* *3. By just giving them different questions* *4. Through ATP and CAPS, and also with the help of the HOD*
What mathematical understandings are developed by the investigation?	*1. Calculations* *2. Research and informed consent*
What curriculum areas are integrated into the investigation?	*1. Multiplication, drawing of graphs, and the relationship between dependent and independent variables* *2. Shapes and graphs* *3. Stocks, bands, and cash equivalent*
List the activities that learners will be involved in.	*1. Playing drama, singing, socialising, building relationships, and putting things in order* *2. Improve games, brain writing, real-time reactions, and chain notes*

Mathematical Understandings / Skills Investigations Developed in Learners

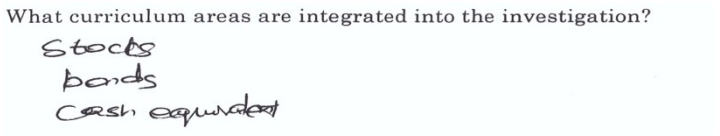
Participants' responses to this question were not clear and did not reflect an understanding of what skills investigations develop in learners. Most of the responses to this question were inappropriate, for example, in Episode 1.



Episode 1

Curriculum Areas Integrated into the Investigation of Sequences

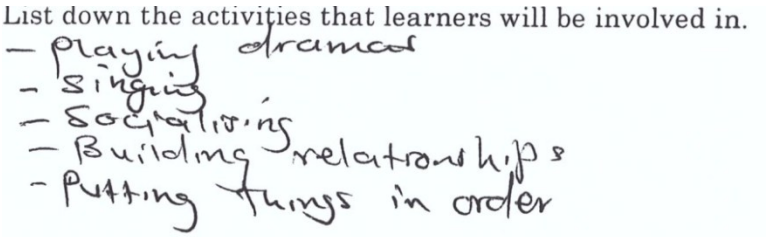
Most participants provided reasonable responses to the question of curriculum areas that are integrated into the investigation of sequences, however, others still did not display an understanding of curriculum areas integrated into the investigation that was given, and their responses were not related to mathematics or investigations, see Episode 2.



Episode 2

Listing of Learner Activities

Very few teachers were able to list the activities they would give to their learners in investigative tasks of sequences. Some of the responses given were either not activities or not related to the task of sequences, for example, in Episode 3.


List down the activities that learners will be involved in.
- Playing dramas
- Singing
- Socialising
- Building relationships
- Putting things in order

Episode 3

It was evident from Table 3 that some teachers demonstrated a lack of knowledge about conducting mathematical investigations and the questions to ask in an investigative task. Therefore, in answering the first research question of "What is the Grade 4 mathematics teachers' understanding of investigations as a summative tool for assessment?" it was concluded that participants did not have adequate knowledge of investigations and as a result, there was a need for intervention.

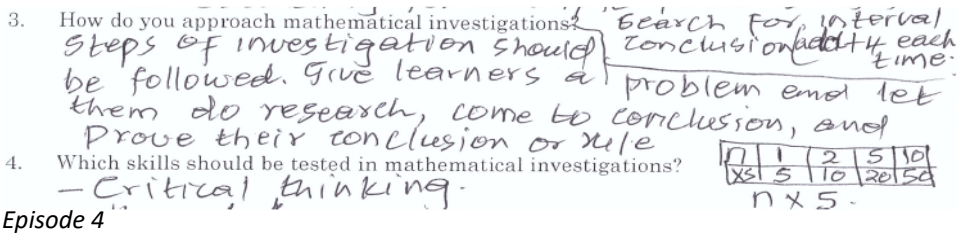
A two-stage intervention program, which lasted for two weeks, was conducted immediately after administering the pre-questionnaire, as explained in the methods section.

After Administering the Intervention Program

Questions asked in the pre-intervention stage were repeated after the intervention. Table 4 is a summary showing teachers' responses to the questionnaire after the intervention.

Approaching/doing mathematical investigations

Most participants displayed an understanding of the investigative approach when responding to the question of how they approach investigations. Some of the steps to be followed when doing investigative tasks, according to Ali et al. (2021), were included in their responses. For example, one participant responded by saying the "*steps of investigation should be followed. Give learners a problem and let them do research, conclude, and prove their conclusion or rule*", see Episode 4.


3. How do you approach mathematical investigations?
Steps of investigation should be followed. Give learners a problem and let them do research, come to conclusion, and prove their conclusion or rule
Search for, interval conclusion add 4 each time.

4. Which skills should be tested in mathematical investigations?
- Critical thinking.

n	1	2	5	10
xs	5	10	20	50

n x 5.

Episode 4

Table 4

Participants' Responses to the Questionnaire After the Intervention

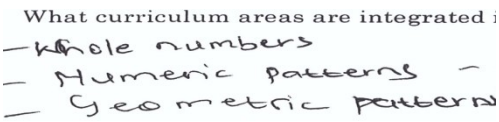
Questions asked	Participants' responses
How do you approach mathematical investigations?	1. *Steps of investigation should be followed. Give learners a problem and let them do research, come to conclusion, and prove their conclusion or rule.* 2. *Finding a pattern, or conjecture, and organizing the results*
What mathematical understandings are developed by the investigation?	1. *Critical thinking skills* 2. *Learners will be able to investigate and represent.*
What curriculum areas are integrated into the investigation?	1. *Whole numbers, numeric patterns, and geometric patterns* 2. *Space and shape*
List the activities that learners will be involved in	1. *Finding a rule* 2. *Complete and extend the pattern, draw a table, and describe in own words*
Comments	"*I will use the steps learned, look at the pattern, describe, number sentence and flow diagram"* and the other one said what they liked about the workshop was "*highlighting various ways of teaching patterns which can also be applied in other grades*".

Mathematical Understandings / Skills Developed by an Investigation

Although participants did not provide clear responses to this question, their answers reflected some idea of what learners would do and the skills they would gain when given an investigative task.

Curriculum Areas Developed by the Investigative Task

Regarding the curriculum areas that investigative tasks can be set from, participants were also able to give reasonable responses that demonstrated their understanding as compared to those given before the intervention, for example,



Episode 5

Table 5
Number of Responses per Question in the Questionnaire

Questions asked in the questionnaire	Competency level		
	No response	Inappropriate response	Appropriate response
How do you approach mathematical investigations?	2	11	5
What mathematical understandings are developed by an investigation?	5	7	4
What curriculum areas are integrated in the investigation?	0	5	11
List the activities that learners will be involved in.	9	2	5

Table 5 shows that teachers performed poorly in the question about listing the activities that learners would be involved in. From 16 participants, only five managed to respond appropriately, whereas nine did not respond. This implies that 11 participants did not understand the kind of activities to give learners in an investigation. The same applies to the questions of how to approach mathematical investigations and understanding developed by an investigation. Participants were able to respond to appropriately to the question of curriculum areas integrated in the investigation.

Discussion of Findings

Teachers' knowledge of conducting investigations was evaluated through their responses to two questions namely, "How do you approach mathematical investigations" and "What mathematical understandings/skills are developed by an investigation".

Approaching an Investigative Task

When responding to the question "How do you approach mathematical investigations" in the questionnaire, teachers who mentioned the value of investigations, left the question unanswered. They only provided limited explanations related to mathematical concepts or topics. Teachers who mentioned using the ATP, CAPS, and consulting their Departmental heads were classified as not understanding how to conduct investigations. In answering research question 1: "What is the Grade 4 mathematics teachers' understanding of investigations", the researchers concluded that most Grade 4 teachers who participated in this study had limited understanding of how to conduct investigations. While McKenzie and Dalton (2020) suggest that teachers should know about instructional activities, the findings align with Stoyanova et al. (2020) who posit that the development of investigations is a complex task that poses a serious challenge for most teachers. In this study, knowledge of conducting investigations is crucial to enable teachers to teach learners how to conduct investigations, and lacking this knowledge will make it difficult for them to guide learners.

Teachers who said they give learners questions or questionnaires to answer were regarded as having moderate understanding as it was not clear what type of questions would be asked. Additionally, it was unclear how one teacher who mentioned telling learners about real-life problems was doing his/her investigations. For the sake of this paper, we regarded real-life problems as being like problem-solving, which is inherent in investigations. The majority of teachers who participated in the study demonstrated a lack of understanding of what investigations are as shown in Table 5.

Questions that assisted the researchers to answer the second research question were, "List the activities that learners will be involved in" and "What curriculum areas are integrated in an investigation".

Constructing Investigative Tasks

In answering research question 2: "How do Grade 4 mathematics teachers conduct investigations when constructing a task?" the researchers concluded that most teachers displayed some difficulties in constructing investigative tasks. This was demonstrated by their inability to list activities they would use to involve learners in investigative tasks. According to Olivares et al. (2021), problem-based tasks require learner collaboration and teacher guidance. The inability to select or construct investigative tasks is concerning as it reveals a lack of knowledge in teaching using mathematical investigations and constructing such tasks. Therefore, if some teachers required by the curriculum to give learners investigative tasks as part of summative assessment lack knowledge about the construction of such tasks, who will construct these tasks for summative assessment? In addition, if teachers do not have adequate knowledge of mathematical investigations, then who will guide learners in completing the tasks?

However, the results showed an improvement in teachers' understanding of mathematical investigations after the intervention program. Participants' comments in Table 4 indicated a positive change in their approach to teaching mathematical investigations.

The findings are consistent with Sancar et al. (2021) who link teacher professional development to learner outcomes; suggesting that professional development programs improve teacher quality, which in turn leads to improved learning outcomes.

Recommendations and Conclusion

The findings show that teachers who participated in this study lacked adequate understanding of constructing investigative tasks, however, the study also revealed that there was a considerable improvement in their knowledge after the intervention was conducted. This implies that there is a need for teacher development programs focused on constructing investigative tasks. There is still much that needs to be done to equip Grade 4 teachers in South Africa with the knowledge and skills they require to conduct investigative tasks for summative assessments as required by the CAPS.

The results from this study align with Sitopu et al.'s (2024) contention that the best way to improve achievement is to focus on primary schools where the foundation should be made. Because teachers cannot teach what they do not know, the authors in this paper believe that with effective professional development, they can do better (Sancar et al., 2021). Curriculum specialists can consider conducting workshops at least

twice a year to develop teachers in the area of investigations. This should be done before summative investigations are given to learners. Consequently, we recommend firstly, that Grade 4 teachers attend professional development workshops to help them understand investigations and how to conduct them for assessment. In addition, teachers need to participate in collaborative teamwork (Bashan & Holsblat, 2017) to help them set investigative tasks. Secondly, curriculum specialists should monitor the frequency at which investigations are incorporated into teaching because if something is done frequently, there is a tendency to master the process.

Limitations

This study focused mainly on teachers' responses to the questionnaire, and no documents were analysed to confirm what they said. Further studies may consider analysing the contents of investigative tasks that Grade 4 teachers give their learners to confirm and extend the findings. Additionally, the sample was limited to 16 participants. In order to generalise the findings, quantitative methods can be included in data collection.

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