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of the

Association for Mathematics Education of South Africa (AMESA)

Reimagining Mathematics in a Digital Space

17 - 21 June 2024

Sol Plaatje University, Kimberley, Northern Cape.

Editors: Mogalatjane Matabane, Chikiwa Clemence & Jeffrey Thomas

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Foreword and acknowledgements

Welcome to the Northern Cape and to the 29th Annual National Congress of the Association for Mathematics Education of South Africa (AMESA). We are thrilled to host you at Sol Plaatje University, a symbol of transformation and progress as the first university established in post-apartheid South Africa.

The AMESA Congress theme for 2024, “Reimagining Mathematics in a Digital Age,” offers an exciting platform for teachers, teacher educators, researchers, postgraduate students, and education officials to explore and share innovative practices in mathematics education. Our collective goal is to embrace the opportunities that digital advancements bring to mathematics teaching and learning, fostering environments where both educators and students thrive in this evolving landscape.

Within the South African mathematics education context, integrating technology has become imperative to enhance learner engagement and achievement. The AMESA Congress 2024 is dedicated to ensuring that mathematics classrooms are dynamic spaces where digital tools are harnessed to make learning more interactive, engaging, and relevant to real-world applications. This year, we aim to explore how digital innovations can bridge gaps, build connections, and empower both teachers and learners to navigate the complexities of the digital age.

This year’s congress is enriched by the participation of two international speakers and four local speakers, including two young South African educators who are leading the way in technology integration. These speakers bring a wealth of knowledge and experience, offering diverse perspectives on reimagining mathematics education through digital means. Their presentations, along with panel discussions and workshops, will delve into the congress theme, providing invaluable insights and practical strategies for delegates.

The AMESA 2024 proceedings are presented in two volumes: Volume 1 includes plenary and long papers, while Volume 2 encompasses short papers, workshops, and 'How I Teach' papers. Each paper has undergone a rigorous peer review process, ensuring the highest standards of academic integrity and relevance. Authors have meticulously revised their papers in response to reviewers' comments, with final approval from the Academic Coordinating Team (ACT).

In conclusion, we extend our heartfelt gratitude to the Local Organising Committee, the National Organising Committee, Sol Plaatje University – our esteemed host, the AMESA Congress 2024 sponsors, plenary speakers, presenters, and delegates. Your contributions and participation are what make this congress a beacon of hope and innovation in the mathematics education community.

Mogalatjane Edward Matabane, Clement Chikiwa and Jeffrey Thomas

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HOW TO USE A ZOOM-IN APPROACH TO IMPROVE THE RESULT OF A LEARNER AT LEVEL 1 IN THE FET, SENIOR AND INTERMEDIATE PHASE.

SANDILE MDLALOSE

If a learner is performing at level 1, it is very important that a teacher or parent to have a knowledge on the types of learning barrier and who can assist you in identifying it. Thereafter, parents, and a teacher must understand that once a specialist has diagnosed the learning barrier, it is a crime not to accommodate a learner as SIAS and other policies of the Department of Education stipulate and guide.

CONTENT:

A Zoom-in approach is a method whereby a teacher looks at the results of a child in the previous grade, and deeply zoom in the which paper, questions, topic, step is a learner struggling which has led to a learner performing at level 1.

According to the Guideline for Inclusive Teaching and Learning 2010, there are six (6) types of learning barriers, namely:

- Disability which is diagnosed by health professionals (Doctors on physical appearance, and Psychologist intellectual ability)
- Language and communication (Audiologist on hearing, and speech therapist on speaking)
- Lack of parental recognition (Teachers)
- Socio and economic (Social Workers)
- Attitude (Lawyers)
- Inadequate opportunity (Education Specialist)

Once a teacher has a report in his or her disposal, must ensure that a learner is accommodated in his or her lesson preparation, teaching, and environment.

According to National Policy Pertaining to the conduct, Administration and Management of Senior National Certificate examinations 2014, Annexure C1 clearly state that they are eight (8) possible reasonable accommodations namely:

1. Additional time

Learning Disability	Possible additional time
Physical	5 to 10 minutes per hour per subject
Intellectual	20 minutes per hour per subject
Visual	20 minutes per hour per subject
Hearing	20 minutes per hour per subject

Other	20 minutes per hour per subject

2. Rest break
3. A reader
4. A Scribe
5. Personal assistant
6. An interpreter
7. Separate venue
8. Assistive devices and technology.

Disability	Possible assistive devices and technology
Partially sighted	Eye-glasses, talking calculator, colour paper, voice recorder and tactile objects
Blind	Walking stick, talking calculator, voice recorder, braille machine, and tactile objects
Hard of hearing	Hearing aids, video recorder, and subtitles
Communications	ACC Go talk
Physical	Wheelchair, step, and specialised device

The Teacher must also ensure that a learner with prescribed assistive device and technology, use it to the fullest.

Once the above process has taken place, a teacher must ensure that a learner has all the necessary information on time e.g. number of papers, topics distribution, marks and how much time to spent on a particular question. Also must be able to differentiate between knowledge, routine, complex and problem solving.

A teacher must ensure that a learner, especially on level 1 on daily basis knows that for every mark in the task, a learner is expected to take fifteen seconds. e.g. if a task is 4 marks, then you will be expected to take 5 minutes to complete.

If a learner has a concession, then must add 30% of the time. e.g. 30% of fifteen seconds is 5 seconds or 30% of 5 minutes is 2 minutes and so on….

A teacher must ensure that a learner, especially at level 1 always start with what his or he knows and can do without making a mistake than the one he or she wants to try, because in life one need to do things that build their confidence and spirit, not vice versus.

Most often, if a learner starts with something that he or she does not know, it will destroy his or her confidence and spirit and she or he will end up doing mistakes even on simplest things.

e.g.

1. What is a square of a trillion?
2. Find x,

$$\sum_{k=3}^{4}(k-2)^2 = 5x$$

In each and every paper (1 or 2) or topics, there are questions (1,2,3,4,5,6,7,8,9,10,11,12….) that are more than 30% achievable (Knowledge 20% and Routine 35%) and the remaining (Complex 30% and Problem Solving 15%), reserve them for later or sub-question (1.1, 1.2, 1.3 and so on)

e.g.

Question R may be more achievable compared to Question K.

1.1, 1.2, 1.3, 1,4…may be always achievable.

But

1.5. May be the opposite.

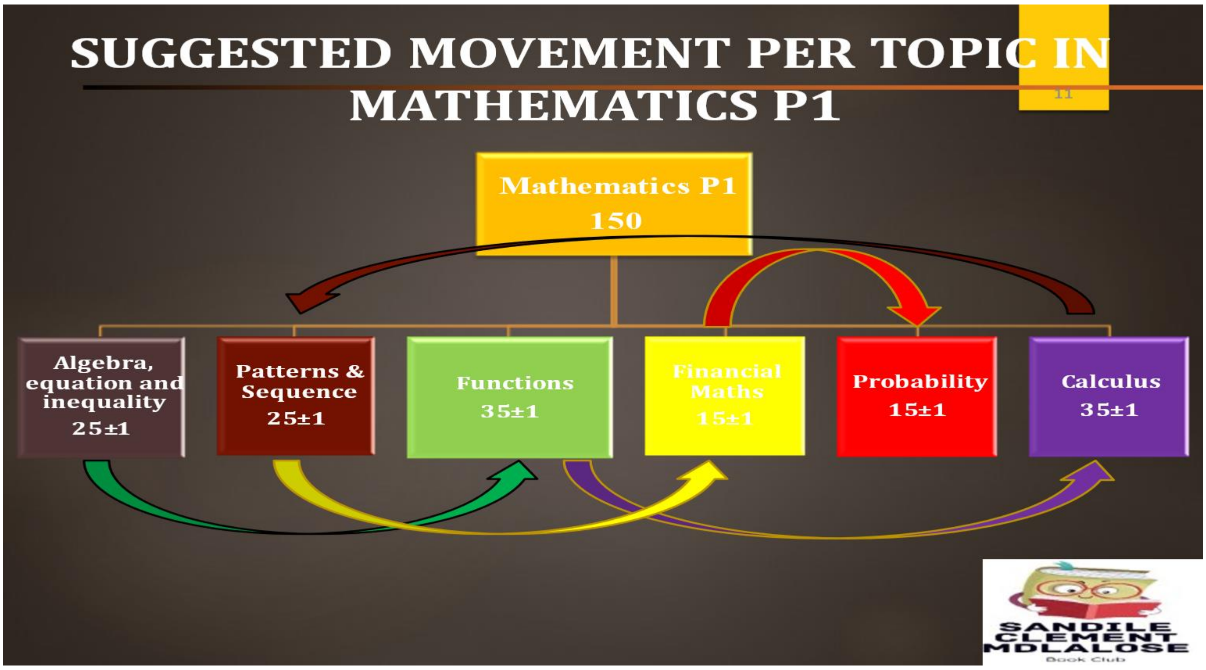
Or Vise versus………

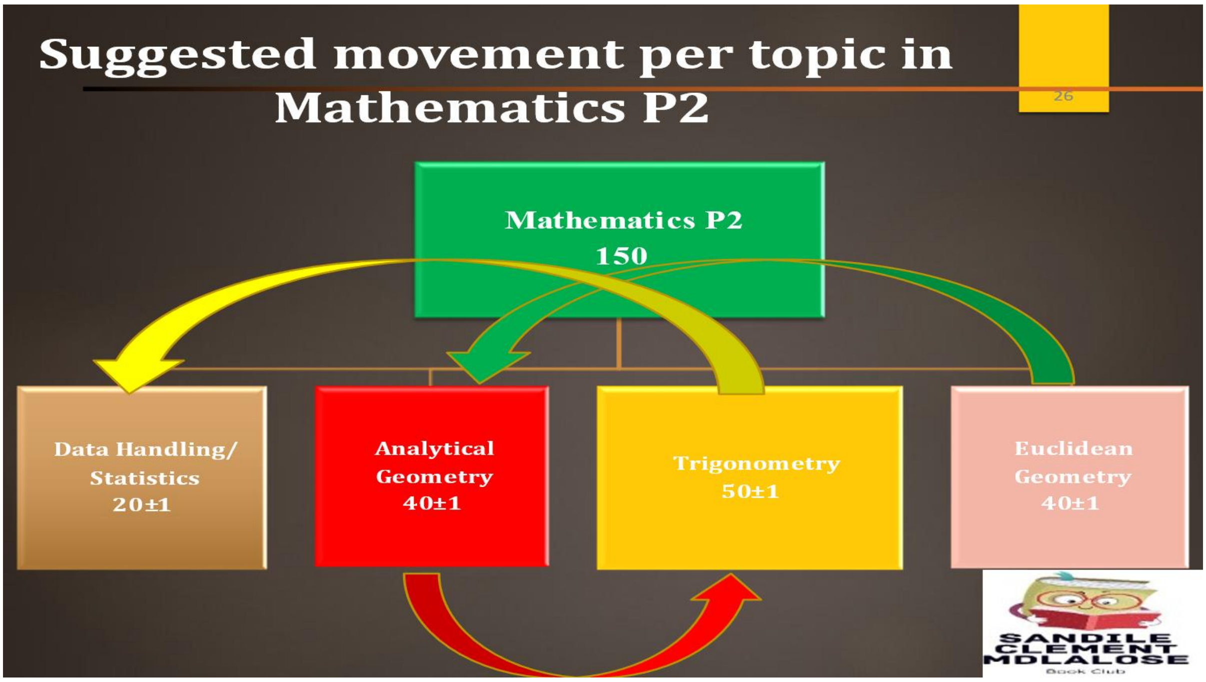
Question K (May not be achievable)

2.1, is not achievable.

But

2.2, 2.3 and so may be achievable.





ADVANTAGES

If each learner is provided with the strategy, method, and approach early, it is results or outcome-based guarantee than to fully undergo a full-time teaching approach.

DISADVANTAGE

The strategy, method and approach is limited to results or outcome based than a learner obtaining generic and enrichment than the concepts as expected by NCS-CAPS principles.

IN CONCLUSION

It is very important that for every topic, a baseline is conducted. To inform planning and preparation, so that any possible barriers to learning is accommodated. Be mindful to be spot on and detailed about support plan and provide all necessary information as early as possible.

The key is:

"Don't panic, stick to the basics and you will never go wrong."

References

1. *Guideline for Inclusive Teaching and Learning 2010, South African Department of Basic Education, Pretoria*
2. *National Policy Pertaining to the conduct, Administration and Management of Senior National Certificate examinations 2014, Annexure C1, South African Department of Basic Education, Pretoria*

"PREPARE YE THE WAY": IDEAS FOR GETTING READY FOR ALGEBRA

NEIL EDDY

This How-I-Teach session aims to equip Intermediate Phase teachers with effective strategies to prepare their pupils for success in Grade 8 algebra, addressing the crucial transitional phase in mathematics education.

Marcus du Sautoy (2019: 155) in his book *The Creativity Code* claims:

> *"[A] mathematician, as G.H. Hardy first explained to me, is at heart a pattern searcher. Mathematics is the science of spotting and explaining patterns.*
>
> *It's this ability to spot a pattern that gives humans an edge in negotiating the natural world, because it allows us to plan into the future. Humans have become very adept at spotting these patterns, because those who missed the pattern didn't survive. When people I meet declare (as alas so often happens): "I don't have a brain for maths," I counter that in fact we all have evolved to have mathematical brains because our brains our good at spotting patterns."*

So how do we, as teachers, utilise this intuitive ability of young people of seeing patterns, to build a strong road of concrete thought leading to the generalisations needed to see the beauty of abstract algebra?

We will explore some ideas around visualisation to understand different ways of seeing a typical algebra question from grade 8 (such as the one below) through the strongly intuitive lens of a younger learner.

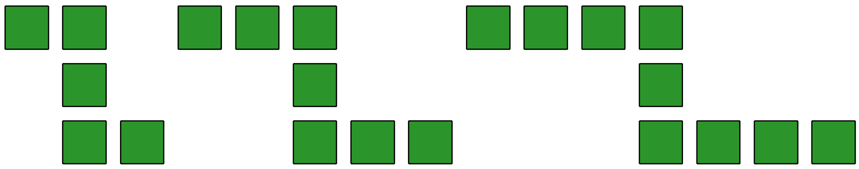
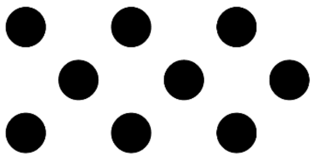


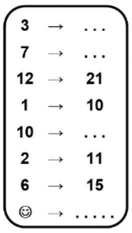
Figure 1 **Figure 2** **Figure 3**

Small squares are used to build a pattern of shapes as shown.

- How many squares would be used in the 10th figure?
- How many squares would be used in the 1 000th figure?
- How many squares would be used in the n^{th} figure?

We will build a path from sense-making of dot diagrams using multiple visualisations; through intuitively noticing the relationships between input and output numbers in tables; on to noticing geometric relationships between different types of objects in diagrams; finally to describing how we notice growth in consecutive diagrams in a pattern.





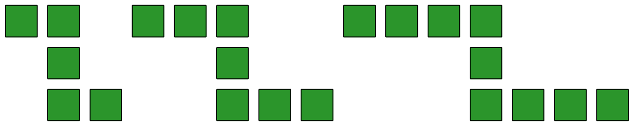


Figure 1 Figure 2 Figure 3

Participants will explore how visual representations, such as pattern blocks, geometric shapes, and graphs, can aid students in recognising and articulating algebraic relationships. Through guided exploration, teachers will learn how to scaffold students' transition from concrete patterns to abstract algebraic expressions, fostering a deeper understanding of variables, coefficients, and equations. By integrating visualisations into their instruction, teachers could empower students to perceive patterns as more than just sequences of numbers, enabling them to uncover underlying mathematical structures and make conjectures about algebraic rules and properties.

"One of the most interesting and perhaps most valuable methods of searching for generalisation is to find it in the growing pattern represented with visual or concrete materials," claims van de Walle (2013: 261)

Aligned to the work of Jo Boaler (2016) teachers will be encouraged to create inclusive learning environments where pupils are encouraged to express diverse perspectives and approaches to problem-solving. By validating multiple pathways to solutions, educators can nurture students' creativity, critical thinking, and collaborative skills, fostering a deeper appreciation for the richness of mathematical thinking. Examples will be given of the need to develop deep understanding of concepts as opposed to a shallow following of rules. Techniques developed during the session will hopefully allow even young children to describe the generalisation of patterns such as the sequence of diagrams below without having to resort to quadratic rules taught in grade 11.

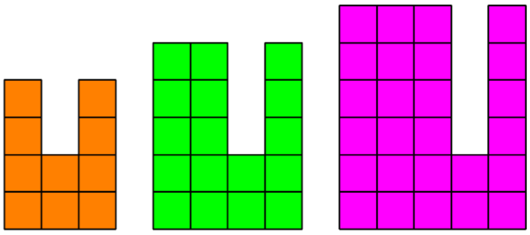


Figure 1 Figure 2 Figure 3

Noting the theme of the Congress we will consider the digital environment and tools that can be used for deepening conceptual understanding of the building blocks of algebra. In keeping with the theme, one of the paragraphs of this article has been written by an artificial intelligence. Are we able to notice which one, and what effects will such technology have on our understanding of teaching mathematics to young children?

By the end of the session it is hoped that teachers will have gained valuable insights into scaffolding algebraic thinking from the intermediate phase grades, using manipulatives, the power of visualisation, and learnings from current neuroscience to deepen pupils' conceptual understandings and, hence, lay a solid foundation for future success in algebra.

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Boaler, J. (2016). *Mathematical Mindsets*. Jossey-Bass.

Du Sautoy, M. (2019). *The Creativity Code, How AI is learning to write, paint and think*. 4th Estate.

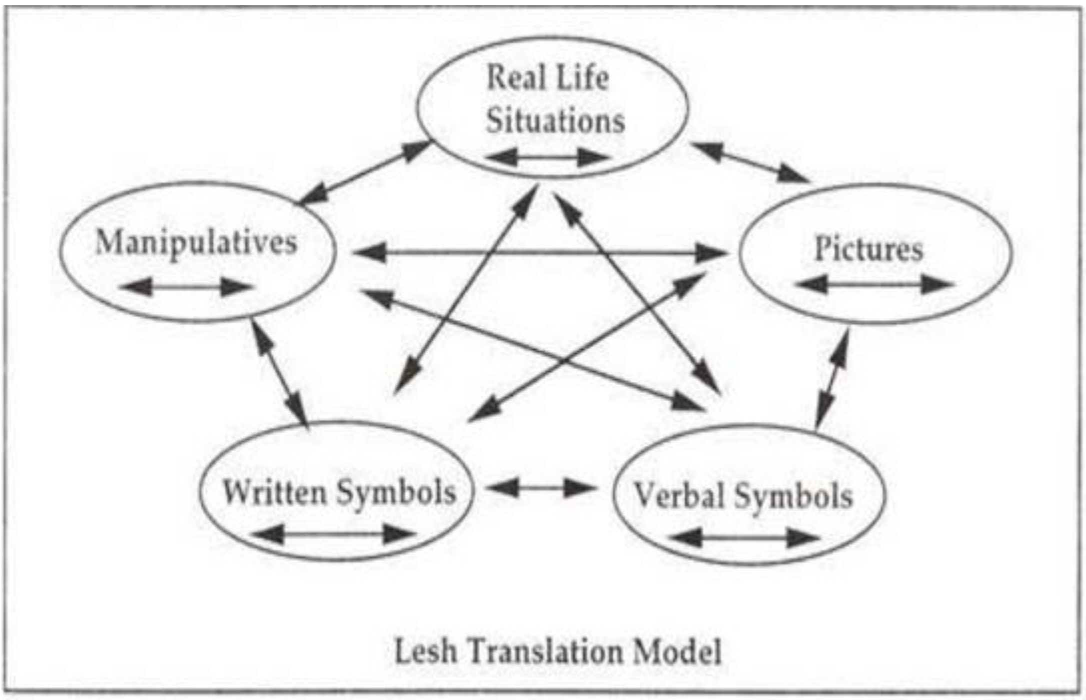
Van de Walle, J.A., Karp, K.S. and Bay-Williams, J.M. (2013). *Elementary and Middle School Mathematics*. Pearson.

RE-IMAGINING SQUARE ROOTS TEACHING-LEARNING IN A DIGITAL SPACE.

SIYA NYATHI

The first lesson that learners learnt at the junior phase, was to count to 10 using the counters as manipulative. Once done about counting both forward and backwards, learners were brilliant and could answer any question thrown at them. “What comes after three?” From counting the learners were taught four basic operations namely; Addition, Multiplication, Subtraction and Division. Learners used the counters to learn the four basic operations. For the lesson on Square Roots, we are going to implement the Lesh Translation Model, so as to include the learners in the teaching and learning process.

LESH TRANSLATION MODEL



Lesh Translation Model (Lesh et al., 2003)

Real Life World:

Thandi is organizing a beach clean-up party for the weekend. She invites four friends, and asks each of them to invite four people who have not been invited and so on. How many people are invited altogether?

Pictures:

What happens when you add up the first few odd numbers?

a. *1 + 3 = 4*
b. *1 + 3 + 5 = 9*
c. *1 + 3 + 5 + 7 = 16*
d. *1 + 3 + 5 + 7 + 9 = 25*

To the learners, this may seem like a random jumble of numbers, but there is a sequence namely; 4, 9, 16, 25. I see and I remember.

Manipulative:

The following are just the numbers of counters that the learner needs to make a perfect square design:

◦◦ ◦◦◦ ◦◦◦◦ ◦◦◦◦◦

◦◦ ◦◦◦ ◦◦◦◦ ◦◦◦◦◦

◦◦◦ ◦◦◦◦ ◦◦◦◦◦

◦◦◦◦ ◦◦◦◦◦

◦◦◦◦◦

So the square numbers stand out from the rest as having this particularly attractive property, which is why they get a special name, square roots. I do and I understand.

Spoken Symbol:

a. What is 1 plus 3? = *4*
b. What is 1 plus 3 plus 5? = *9*
c. What is 1 plus 3 plus 5 plus 7? = *16*
d. What is 1 plus 3 plus 5 plus 7 plus 9? = *25*

Written Symbol:

a. What is a number multiplied by itself = 4? *2 x 2 =4*
b. What is the number multiplied by itself = 9? *3 x 3 =9*
c. What is the number multiplied by itself =16? *4 x 4 =16*
d. What is the number multiplied by itself = 25? *5 x 5 =25*

e. What is the square root of 4? $2^2 = 4$
f. What is the square root of 9? $3^2 = 9$
g. What is the square root of 16? $4^2 = 16$
h. What is the square root of 25? $5^2 = 25$

In this lesson on square roots, we began with simple activities and moved down to more complex activities so as to include the senior phase learners in the teaching and learning situation. We began by a Real life situation, used manipulative to concretize the situation, used pictures to see what is happening, used the spoken symbols to read the situation and lastly the written symbols to mathematize the situation. If a learner can translate from one situation to the next situation, it means that the learner has understood the square root concept. My learners did very well in the square root assessment during the first term.

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1. Fitton, S. De Jager, C. & Blake, P. (1996). *Just Mathematics 10.* Cape Town: Maskew Miller Longman.

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TEACHING GEOMETRIC CONSTRUCTION USING TECHNOLOGICAL TOOLS TO PROMOTE PRESERVICE TEACHERS' TECHNOLOGICAL PEDAGOGICAL MATHEMATICAL KNOWLEDGE (TPMK).

SIBONGILE ZULU

INTRODUCTION

Geometric constructions is one of the topics in the Senior Phase (Grades 7 to 9) curriculum in South African schools. They provide a concrete opportunity for learners and teachers to engage with, and experience, geometric figures and their properties. This topic prepares learners for the Further Education and Training phase where they are introduced to Analytical and Euclidean geometry. Both fields of geometry require a strong foundational knowledge of geometric figures and their properties. Attention to how Preservice Teachers (PTs) are trained to teach geometric constructions is, therefore, crucial if we are to improve learner understanding and performance in geometry, and mathematics as a subject in general.

The 4^{th} - 5^{th} industrial revolution exposes learners to a wide range of technological tools and platforms that could be used to enhance their learning. In this regard, the development of TPMK (Guerrero, 2010) and its associated skills for PTs is important.

CONTENT

This presentation is based on both my experience of teaching Grade 9 mathematics, and training PTs. In teaching Grade 9 Mathematics, I always experienced two challenges. The first being the availability of mathematical instruments for me and most of the learners, which sometimes required that one goes around to smaller groups of learners for demonstrations. This challenge may be faced by many teachers in under-resourced schools, located in poorer communities. The second challenge was the difficulty in using heavy and over-sized mathematical instruments teachers must use to demonstrate constructions.

In the case of teacher training, the challenge is in that the lecturer is not only teaching content, but also pedagogical knowledge. In this process, PTs must acquire all necessary skills and techniques for using mathematical instruments for constructions. In addition, they must acquire mathematical flexibility, which is a crucial aspect of mathematical proficiency (Cox, Burns, Hughes, Wade, & Brown, 2024), needed for teaching various methods of constructing geometric figures.

The above-mentioned challenges lead to several other challenges, including time management. The use of mathematical instruments without employing technological tools could easily be a hindrance in the actual construction and learning of content. Technological tools could, thus, be used to address all these challenges as demonstrated in Figure 1, allowing productive and impactful use of time.

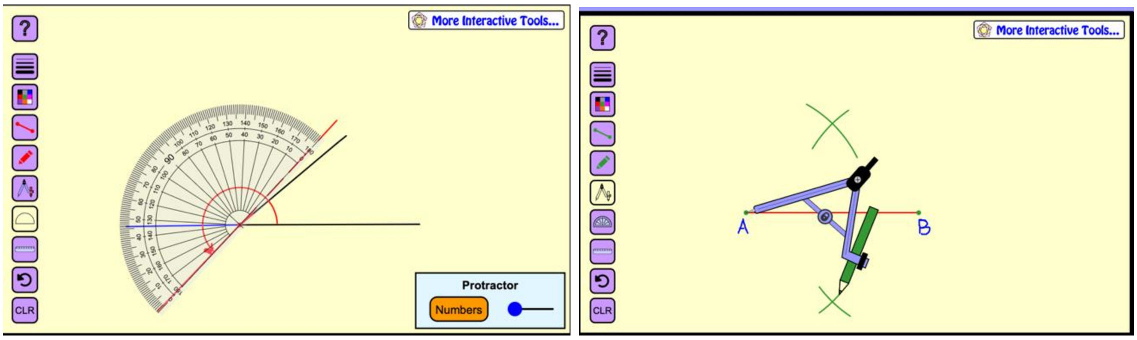

Figure 1: Measuring a reflex angle.

Figure 1 shows how Software packages also allow the opportunity for demonstration of how mathematical instruments are used such as in measuring reflex angles. In the case of teacher training, multiple methods/techniques could be projected on the screen whilst also projecting the demonstration as shown in Figure 2. Projections would be clear and visible to all, especially in cases where the class/lecture group is big, and PTs cannot enjoy more individualised attention. Several sources of content and techniques could also be projected on one screen. Without this, it would be expensive and time consuming to provide all these sources physically to each PT.

In my teacher training classes, I tend to focus on ensuring that the PTs explore as many methods of construction as possible. This is also done using various software packages (MathPad, GeoGebra, Triumph cloud, and more) to ensure that their technological knowledge improves. Below is an example of two different methods for a kite construction using MathPad.

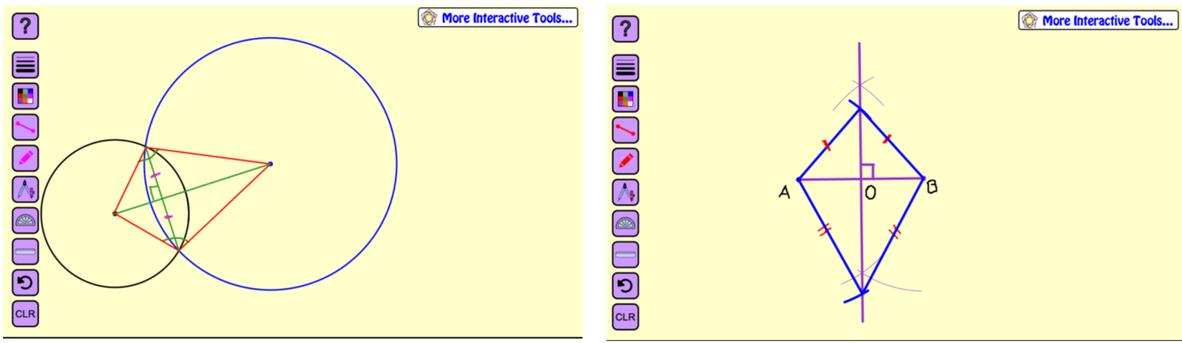

Figure 2: Kite construction

In the construction of the different figures, the PTs also get a chance to engage with the properties of different shapes or figures. This helps to close the content knowledge gap that exists from their secondary school learning, which diagnostic reports of the Department of Basic Education (DBE, 2020) decry.

CONCLUSION

In conclusion, as demonstrated above, technological tools could play a critical role in the improvement of the learning and the teaching of geometric constructions. They provide quick and efficient ways to demonstrate the use of mathematical instruments and allow flexibility in the use of resources and techniques. This, in turn, entails deeper engagement with geometric figures and their properties, which prepares learners for subsequent topics such as Euclidean and Analytical geometry.

PRESENTATION DETAILS

Duration

- Thirty minutes = 10 presenting + 10 minutes participant interaction with tools + 10 minutes question and answer.

Resources

- Participants are to bring the laptops to engage with the Software. This will give them the opportunity to engage different Software.
- Projector for the main presentation.

Presentation and Activity

- The presentation will be about demonstrating the use of the online geometric tools to construct parallel and perpendicular lines, construct angles, triangles, and quadrilaterals, and more.

1. Construct the following angles:

   a) an angle of 30° b) an angle of 45°

   c) an angle of 60° d) an angle of 90°

2. Construct the following triangle:

   ΔDEF – DE = 3cm, EF = 4cm and DF = 5cm.

   ΔGHJ – HJ = 4cm, $H\hat{J}G = 90°$*, and GJ = 3cm.*

   a) What do you notice about these two triangles?

   b) In what other ways could you construct these triangles so that they are the same?

3.

Construct a square with sides 3cm, a regular pentagon with sides 3cm and a regular hexagon with sides 3cm.

a) Measure the interior angles of the square, pentagon and hexagon.

b) What is the sum of the interior angles of the square, pentagon and hexagon?

c) What do you notice about this sum?

Number of Participants

- Preferably 50 participants.

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Title: Interactive Geometric Construction Tool URL: https://www.mathspad.co.uk/i2/construct.php

EXPLORING DECIMAL UNDERSTANDING THROUGH INTERACTIVE STRATEGIES: HANDS-ON ACTIVITIES, GAMIFICATION, AND DIGITAL TOOLS

MANAGE JULIET LEHUNGWANE

Introduction:

This proposal explores the effectiveness of using interactive learning techniques to teach decimals with the goal of improving learners' understanding and involvement. A greater knowledge of decimal principles is facilitated by hands-on exercises, as demonstrated by recent studies. This essay argues in favour of including practical tasks to supplement conventional teaching approaches by looking at recent research.

Content:

Teachers are becoming more aware of the benefits of interactive learning strategies in math classes. Research by Chen et al. (2021) and Smith et al. (2019) has shown that learners' comprehension of decimals is greatly enhanced by hands-on activities. By using manipulatives like interactive fraction bars and virtual base-10 blocks, learners can visualize and work with decimal numbers, which improves their conceptual knowledge.

Furthermore, Liu and Wu's research (2022) emphasizes the advantages of using gamification and digital simulations in decimal education. These cutting-edge techniques encourage learner engagement and motivation, accommodating a variety of learning preferences. Teachers can design immersive learning experiences that promote active engagement and conceptual reinforcement by gamifying decimal activities.

However, teachers must use caution when implementing interactive learning methodologies. According to recent studies, it is critical to align activities with learning objectives and provide sufficient scaffolding to support learners' progress (Jackson & Lee, 2023). Investment in digital resources and training for educators may be necessary to integrate interactive activities effectively, highlighting the need for institutional support and professional development programs.

To sum up, current research highlights the effectiveness of interactive learning techniques in improving learners' comprehension of decimals. Educators can develop dynamic learning environments that promote conceptual understanding and learner engagement by utilizing digital technologies and gamified approaches. Nevertheless, proper preparation and alignment with curriculum standards are crucial to ensure the successful incorporation of interactive activities into decimal instruction.

Teacher Tips:

- To successfully integrate learners' learning, start with basic manipulatives and gradually introduce more sophisticated tools.

- Encourage learners to take charge of their education by guiding research and making discoveries in interactive projects.
- Encourage thoughtful conversation and discourse to improve understanding and successfully dispel myths.

Some practical implementation tips and strategies for effectively integrating hands-on activities into the classroom:

1. **Lesson Planning Tips:**

- Match Activities to Learning Objectives: Ascertain that practical exercises directly relate to the lesson's or unit's learning objectives.
- Consider sequencing: As learners' comprehension grows, progressively introduce more sophisticated tools after beginning with simpler manipulatives to introduce concepts.
- Give Detailed Directions: Before starting the hands-on job, make sure that learners understand the activity's goal, its steps, and the expected results.
- Incorporate Situational Contexts: To increase relevance and interest, attach practical exercises to real-world situations or applications.
- Make a Flexible Plan: Be ready to modify exercises in response to students' needs and responses during the class.

2. **Assessment Strategies:**

- Observational Assessment: During practical exercises, observe students' participation, methods of problem-solving, and interactions to determine their level of comprehension.
- Performance assignments: Create projects or assignments that are performance-based and call on students to apply ideas they have learned via practical application.
- Include reflection questions or self-assessment exercises so that students can analyse their own learning and pinpoint areas in which they still need to improve.
- Formative Assessment: During practical exercises, ask probing questions to formatively gauge students' comprehension and give prompt feedback.

3. **Differentiation Techniques:**

- Give Diverse Materials: To meet the needs and preferences of students with varying learning styles and skill levels, provide a variety of manipulatives and materials.
- Grouping Techniques: Use adaptable grouping techniques to pair students of different skill levels so that peer assistance and cooperation are possible.

- Extension Activities: Provide learners who show competency early with challenges or extension projects that will allow them to go deeper into the topics covered.

You may successfully use hands-on activities to improve learner-learning experiences and foster a deeper comprehension of mathematical ideas in the classroom by implementing these useful suggestions and strategies into your teaching practice. It is important to consistently evaluate the efficacy of these tactics and modify them as necessary to cater to the varied requirements of your students.

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PRESENTATION LAYOUT

Title: Engaging Strategies for Teaching Decimals in Grade 7.

Target Audience: Primary school mathematics educators

Presentation Duration: 60 minutes

Maximum number of attendees: 30 Participants

Time Breakdown:

Introduction: 5 minutes

Overview of Interactive Learning Strategies: 10 minutes

Review of Recent Research: 15 minutes

Practical Demonstration of Activities: 20 minutes

Discussion and Q&A: 10 minutes

Engagement Techniques:

To ensure active participation and engagement throughout the presentation, various interactive strategies will be employed:

1. **Think-Pair-Share:** Participants will be encouraged to reflect individually on their current practices regarding decimal instruction, discuss their insights with a partner, and then share their observations with the larger group.
2. **Polling and Surveys**: Interactive polls and surveys will be conducted to measure participants' familiarity with interactive learning strategies and their interest in integrating them into their teaching practice.
3. **Hands-On Activities**: Participants will engage in hands-on activities designed to reinforce decimal concepts, such as using virtual manipulatives or interactive simulations. They will have the opportunity to manipulate decimal values and explore mathematical concepts in a dynamic, experiential manner.
4. **Collaborative Problem-Solving:** Participants will work collaboratively in small groups to solve real-world decimal problems and share their solutions with the larger group. This collaborative problem-solving approach promotes teamwork and encourages peer learning.
5. **Reflection and Discussion:** Throughout the presentation, participants will be encouraged to reflect on their learning experiences and share their insights and questions during structured discussion segments. This fosters a supportive learning community where participants can exchange ideas and learn from each other.

Worksheets:

Worksheet 1: Decimal Manipulatives Exploration

Virtual Manipulatives - Fraction, Percent & Decimal Tiles • ABCya!

Worksheet 2: Gamified Decimal Exercises

Math Games, Math Worksheets and Practice Quizzes

Worksheet 3: Reflective Journal Prompts

Conclusion:

By actively involving participants in the presentation through interactive activities, collaborative problem-solving and reflective dialogue, this session aims to empower primary school mathematics educators to enhance their decimal instruction using innovative, experiential learning strategies. Together, we can cultivate a dynamic and engaging mathematics classroom environment that promotes deep conceptual understanding and learner success.

THE WORSHEETS/ACTIVITIES

Worksheet 1: Exploring Decimal Manipulatives

Objective: The purpose of this activity is to familiarise yourself with different decimal manipulatives and explore how they can be used to represent and understand decimal values.

Materials Needed:

- Decimal disks (in this case, we will be using the physical disks and show few virtually)

Worksheet 2: Gamified Decimal Exercises

Objective: The purpose of this activity is to engage in gamified decimal exercises to reinforce understanding and mastery of decimal concepts in a fun and interactive way.

Instructions:

1. **Introduction to Gamified Decimal Exercises:** Today, we will explore gamified activities designed to enhance your understanding of decimal concepts. These exercises will challenge you to apply your knowledge playfully and engagingly.

Worksheet 3: Reflective Journal Prompts

Objective: This reflective journal activity aims to encourage thoughtful consideration and self-assessment of your experiences with decimal instruction and interactive learning strategies discussed in the presentation.

Instructions: Take some time to reflect on the following prompts and record your responses in the space provided. Be honest and thoughtful in your reflections, as they will help you gain insights into your teaching practice and professional growth.

Conclusion: Take a moment to summarize your key takeaways from this reflective journal activity.

- What insights or realizations have you gained about your approach to teaching decimals and utilizing interactive learning strategies?
- How do you plan to apply your reflections and action plans to enhance your decimal instruction in the future?
- Remember to revisit your reflections occasionally to track your progress and make any necessary adjustments to your teaching practice.

HOW I TEACH LONG DIVISION IN A SIMPLIFIED MANNER (GRADE 4- 7)

MPHAKISENG TWALA

Introduction

The topic is relevant to Grade 4-7 educators because as per the annual teaching plan term 1. We start teaching long division in Grade 4 as a basic method to simplify the division of bigger numbers by smaller numbers, it plays a role in ensuring a learners become inquisitive when dealing with a divisor and divided as to find a quotient. Presentation aims to share and learn methodologies that helps learners to simplify the division in the level of their grade and also to eliminate the stereotypes that believes that long division is difficult in both Intermediate and Senior Phase. The presentation will also highlight the fun facts that learners needs to know prior they start engaging themselves in activities that involve long division. Throughout the lesson, examples of sums using box method will be used to clearly and concisely be applied using the algorithms or procedures of working out long division and assist students in understanding how can they simply workout the big numbers.

Content

The misconception that learners may have been to write the remainder on the bottom of the box and not include it in the final quotient (Answer). This presentation will also address the misconception in inverse sign (multiplication and division) which plays a vital role in understanding the relationship between multiples and groupings. This presentation aims to improve the learners' skills to multiply the two or more digits in a clue board up to the first 10 multiples of the divisor. The presentation then goes into the step-by-step procedure of long division, including the method for dividing multi-digit numbers, the role of remainders, and the significance of understanding the vocabulary used in the process of the calculation.

Conclusion

Answers will be discussed and there will be evidence shared on the effectiveness of the method.

Referenced

Rainbow workbooks. 14th Edition. 2024. Department of basic Education.

Bowie L., Cronje E, Heany F, Maritz P, Olivier G, Rossow B & Willers S. (2013) Platinum Mathematics learner's book 7 . (1st edition). Maskew Miller Longman

ENHANCING UNDERSTANDING OF ROUNDING OFF NUMBERS & ESTIMATION IN INTERMEDIATE PHASE MATHEMATICS

PALESA MAKALE

Introduction:

This presentation will cover a wide range of topics related to improving the methods used in teaching Grade 4 students about estimating and rounding off numbers. It is designed with teachers in the intermediate phase in mind. In this workshop, we will explore methods for dispelling popular myths and encouraging a deeper understanding of these foundational ideas in mathematics.

Presentation Overview:

1. **1. Duration and Capacity:** It is critical to determine logistical details before getting into the intricacies. There can be up to thirty people in attendance for the two-hour lecture. This clarity is crucial for organizers to ensure maximum participation as well as for potential participants to plan their schedules.
2. **Content Clarification**:
   - **Rounding Off Numbers:** A common misunderstanding among students is that rounding off is just guesswork. To help with this, we shall clarify what is meant by the "nearest" multiples of 10, 100, or 1000 in order to provide a more sophisticated comprehension (Harvey, 2019).
   - **Estimation Techniques:** To strengthen learners' estimation skills, we will examine a range of approaches, with a focus on real-world examples and applications to strengthen understanding (Van de Walle, Karp, & Bay-Williams, 2018).
3. **Specifics of Presentation**:
   - **Main Topics**:
     - Clarifying the concept of rounding off numbers.
     - Introducing effective estimation techniques.
   - **Objectives**: By the end of the session, participants will:
     - Gain a deeper understanding of rounding off numbers and estimation.
     - Acquire practical strategies to implement in the classroom.
   - **Engagement Activities**: Interactive activities and worksheets will be incorporated to actively engage participants, fostering a dynamic learning environment (Boaler, 2016).

4. **Abstract Inclusion**: There will be a brief abstract that summarizes the main points of the presentation, its goals, and the intended audience. This will act as a captivating preamble, drawing potential attendees and setting expectations in line.
5. **Reference List**:

Platinum Learner's Book: Grade 4 (Department of Basic Education, 2014)

Oxford Successful Learner's Book: Grade 4 (Oxford University Press, 2015)

Department of Basic Education Materials (Department of Basic Education, 2018)

Harvey, S. (2019). *Rounding and Estimation in Elementary Mathematics*. Mathematics Education Journal, 12(3), 45-60.

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2018). *Elementary and Middle School Mathematics: Teaching Developmentally* (10th ed.). Pearson.

Boaler, J. (2016). *Mathematical Mindsets: Unleashing Students' Potential through Creative Math, Inspiring Messages, and Innovative Teaching*. Jossey-Bass.

Conclusion:

In conclusion, this presentation endeavours to refine pedagogical approaches surrounding rounding off numbers and estimation in the intermediate phase. By addressing areas of clarification and enhancement, we aim to foster clarity, transparency, and scholarly rigour in the teaching of these fundamental mathematical concepts. We look forward to engaging with you in this enriching learning journey.

References:

Department of Basic Education. (2014). *Platinum Learner's Book: Grade 4*. Maskew Miller Longman.

Department of Basic Education. (2018). *National Curriculum Statement (NCS): Curriculum and Assessment Policy Statement (CAPS) Mathematics Grade 4-6*. Government Printer.

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Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2018). *Elementary and Middle School Mathematics: Teaching Developmentally* (10th ed.). Pearson.

Boaler, J. (2016). *Mathematical Mindsets: Unleashing Students' Potential through Creative Math, Inspiring Messages, and Innovative Teaching*. Jossey-Bass.

This presentation aims to support intermediate-phase educators in enhancing their teaching strategies for rounding off numbers and estimation, ensuring that learners develop a strong mathematical foundation.

SHORT PAPERS

USING CONCRETE-PICTORIAL-ABSTRACT APPROACH TO ENHANCE GRADE 11 LEARNERS' UNDERSTANDING ON NATURE OF ROOTS OF QUADRATIC EQUATIONS

PRENISURE RAMOROKA

Most learners struggle to understand nature of roots problems. As a result, they do not attempt solving them, especially those that involves practical problems. To address this problem, this study used Concrete-Pictorial-abstract approach to enhance Grade 11 learners' understanding on nature of roots of quadratic equations in a mathematics classroom. This is a Participatory action research (PAR) and uses a qualitative approach to enhance learners' understanding on nature of roots of quadratic equations. The study draws from Kilpatrick, Swafford,and Findell (2001) mathematical proficiency strands to develop strong mathematical representations to reason and communicate ideas. This study involved a whole Grade 11(aged 15-17) mathematics class who completed discriminant card sort, watched a video and completed response sheets in a period of three weeks. Data was collected in two ways, through interviews, and written tests. Inductive thematic analysis was used to analyse interview transcripts in the pictorial stage Direct content analysis approach was used to analyse learners' responses to the written test in the abstract stage. The findings of the study indicate that CPA improves learners' understanding in terms of mathematical proficiency strands. Learners' understanding has improved as learners were able to solve nature of roots in the abstract stage. The study also found that learners find it interesting and effective learning nature of roots through the discriminant card sort and watching visual aids. The name of the school and the participants were kept confidential and an ethical clearance has been obtained to collect the data for the study.

Keywords: CPA approach, Nature of roots of quadratic equations

Introduction

How can learners effectively learn through the CPA approach to improve their understanding and performance on nature of roots of quadratic equations. The literature on nature of roots of quadratic equations is quite short and many of these available have focused on learning this concept procedurally. According to (Bansilal, Brijlall, & Mkhwanazi, 2014), a learner is said to display a conception in nature of roots if they are able to rearrange a given equation into standard form and use the determinant to describe the roots of the equation. An approach to learning mathematics which seems to be accordance with the expectations of this curriculum is the Concrete-Pictorial-Abstract (CPA) approach. Britannica (2020) explains the approach of CPA to learning mathematics that occurs in three phases: learning by physically manipulating concrete objects, learning by pictorial representation of manipulating concrete objects, and problem-solving using abstract notation. The stages are followed in a sequential manner because each stage guides the other. This is in line with Kolb(2015) learning styles where learners who learn best by touch(kinesthetics), learners who learn best when seeing(visual), and those who learn best through hearing(auditory) are all accommodated, for development of relational understanding to be made possible

Svehla (2018) reveals the importance of the use of concrete objects before visual ones and abstract activities to engage learners effectively in class. According to the author, the CPA approach can improve learners' mathematical problem-solving abilities. This study used the CPA to teach Spatial-Sense-Ability. This is consistent with the findings of (Salingay & Tan, 2018) who have argued that learners' performance has improved in those exposed to CPA approach than those expose to non-CPA approach. The results of (Putri, Rahayu, Muqodas,

& Wahyudy, 2020) research showed that learners' special sense increased for learners who received CPA approach than students who received conventional learning. According to (Kirchner & Lester, 2015), nature of roots should be learnt theoretically, conceptually, and practically. Moreover, it is important for teachers to acknowledge all three approaches to accommodate all learners differing learning styles.

An observable challenge in Grade 11 is that learners memorize the conditions of the discriminant without attaching meaning to their conclusions. As a result, they struggle in understanding the concept. This is seen when they fail to solve questions on nature of roots of quadratic equations in assessments. Many learners do not attempt nature of roots problems, especially those that involves practical problems, (Richards & Tau, 2018) says. They further observed that on average, learners dislike mathematics. According to (Skemp, 2014) learners turn to apply instrumental understanding rather than relational understanding and there are many challenges that come with learning instrumentally. This is simply because mathematical knowledge cannot be transferred by the teacher to the learners without their understanding (Jang & Kim, 2020). As a result, they lack relational understanding of the concept and usually describe the value of the discriminant instead of the roots. It is assumed, having this lack of knowledge result in many learners failing this concept and viewing it as being hard.

According to (Rakes & Ronau, 2019), correct answers do not indicate correct conceptual understanding. Learners should be given meaningful experience on each concept taught such that they develop a full understanding of the concept and develop a positive attitude towards the concept. Hence, I propose a need to use different representations to develop in learners innovative thinking. However, since most researches on the nature of roots have failed to integrate practical work that can stimulate relational understanding and requiring no background knowledge, there is a need to use CPA approach to fill this gap. This will enable learners to participate in a social context with others to facilitate the development of relational understanding. Therefore, this research the purpose of this study is to intends to use CPA approach to enhance Grade 11 learners' understanding on the nature of roots of quadratic equations

Methods

This is a Participatory action research (PAR) and uses a qualitative approach to enhance learners' understanding of nature of roots of quadratic equations through CPA learning approach. The study involved a whole Grade 11 mathematics classroom of 20 learners each aged 16-18 that consist of half males and half females. This group were selected because they are more disciplined and easier to work with. The learners were captured using videotape as they work on the tasks. The lessons took two (2) hours each day for three weeks. In this study, the discriminant card sort method was used as the concrete part of the CPA approach. The task's goal is to assist students in locating and interpreting a quadratic equation's discriminant. There were 40 cards utilized, which comprised graphs, word phrases, and quadratic equations. The task included three quick-fold pockets to hold the sorted cards, thirty basic cards (a mixture of graphs, word phrases, and equations), ten optional add-on cards with equations that are not already set equal to zero, three "answer cards" that specify which cards go in which pocket, and an optional "sorting mat" to provide an alternative format. Data was collected in all the stages, each using different methods. interviews and written work for stage 1,2 and 3 respectively. In the first stage, learners were expected to respond to response sheets based on how they sorted their cards and were later interviewed. The *Discriminant Card sort* method used is shown in figure 1 below.

Figure 1: Discriminant card sort method

In the next stage, a video on nature of root was projected and later on learners reponded to Semi-structured interviews. Open-ended questions were used to get an insight on whether learners found it effective learning nature of roots and whether they got a more idea of the concept. This allowed learners to express their attitude and thoughts on leaning through a video. A response test was administered to the learners in the last stage of the CPA approach to check whether their responses reflect the intended relational understanding. The learners' scripts were marked and showed their level of understanding according to the mathematical strands.

Results and Discussions

Analysis of interviews transcripts

Theme 1: Views on being taught through visual aid

Turn	**Speaker**	**Utterances**	**Comments**
1	**Researcher**	***Are you in favour of using visuals to teach mathematics? Why?***	

2	**Learner D**	***Yes, watching a video which is what I love was fun***	**The visual aid is at the level of interest of the learners**
3	**Researcher**	***Have you ever received math instruction through video before? If yes, how have you found it to work?***	
4	**Learner D**	***No, it engages us and we do not fall asleep***	**The use of video engaged the learners to an extend that they did not find it boring hence they did not fall asleep.**

Excerpt 1: Interview with learners

Turn	**Speaker**	**Utterances**	**Comments**
5	**Researcher**	***How did you find watching a video about the nature of roots?***	
6	**Learner B**	***It was very fun I enjoyed both the videos***	**Visual aids have the ability to draw learners' attention**

Excerpt 2: Interview with learners

From the tables above, watching a video seems to have engaged learners. Learners mentioned that learning through visual aid has helped them to understand where the discriminant originate from in the quadratic formula and reasons why it is used. Learner D enjoyed the video due to its ability to draw her attention and stayed focused. Learners enjoyed mostly the fact that they were watching a video, which is what they love.

Theme 2: Impact of visual aid on learning Nature of roots

Turn	**Speaker**	**Utterances**	**Comments**
7	**Researcher**	***Did you enjoy watching a video on nature of roots? Which section did you like the most?***	
8	**Learner A**	***The video was attention catchy, I liked the part of describing the roots , it was fun***	**Visual aid has the ability to drive learners'**

			attention to the concept
9	**Researcher**	***What about the nature of roots did you find challenging? Explain***	
10	**Learner A**	***Differentiating between a non-solution and a nonreal roots, I am confused***	**Learners were not aware of the relation between a non-solution and a non-real roots solution.**

Excerpt 3: Interview with learners

Turn	**Speaker**	**Utterances**	**Comments**
12	**Researcher**	***Do you believe the video improved your comprehension of the nature of roots?*** ***Explain.***	
13	**Learner G**	***Yes, it now makes sense from the previous activity on discriminant card sort, I am able to relate graphs, descriptions of value of discriminant and their value of roots.***	**Watching a video has improved learners' understanding on important ideas of the concept**

Excerpt 4: Interview with the learners

From the 5 interviewed learners, all of them expressed their excitement and relief of finally being able to understand the relation of the graphs, roots and discriminants. Many of them are appreciative that they could realize the difference between finding roots, describing their nature, and deciding on their nature which is something they had no idea before.

Analysis of written test scripts

20 scripts were collected and marked paying attention to the mathematical proficiency strands portrayed. The marks were recorded in a table below.

Category	**Explanation**
C1	**Correct answer with valid reason and show workings**
C2	**Correct answer with invalid reasons and show workings**

C3	**Correct answer without a reason**
C4	**Correct answer and reasons but did not use the discriminant**
C5	**Incorrect answer but valid reason and show working**
C6	**No answers provided**

Table 1: Categories for learners' responses to the test on nature of roots of quadratic equations

Question	**Categories**											
	C1	**%**	**C2**	**%**	**C3**	**%**	**C4**	**%**	**C5**	**%**	**C6**	**%**
1.a					**7**	**35**			**5**	**25**	**8**	**40**
1.b					**8**	**40**			**4**	**20**	**8**	**40**
2	**8**	**40**	**4**	**20**	**3**	**15**	**0**	**0**	**5**	**25**	**0**	**0**
3.a	**10**	**50**	**4**	**20**	**4**	**20**	**0**	**0**	**2**		**0**	**0**
3.b	**7**	**35**	**4**	**20**	**4**	**20**	**0**	**0**	**5**	**25**	**0**	**0**
4	**2**	**10**	**3**	**15**	**2**	**10**	**0**	**0**	**10**	**50**	**3**	**15**
5	**2**	**10**	**1**	**5**	**4**	**20**	**5**	**25**	**2**	**10**	**6**	**30**
6.a	**6**	**30**	**3**	**15**	**3**	**15**	**0**	**0**	**7**	**35**	**1**	**5**
6.b	**7**	**35**	**4**	**20**	**3**	**15**	**0**	**0**	**5**	**25**	**1**	**5**
7.a	**10**	**50**	**4**	**20**	**4**	**20**	**0**	**0**	**2**	**10**	**0**	**0**
7.b	**12**	**60**	**2**	**10**	**4**	**20**	**0**	**0**	**2**	**10**	**0**	**0**

Table 2: Number of learners in each category according to Table 1 for their responses

A summary of learners' Mathematical proficiency strands displayed to analyse learners' responses

Mathematical proficiency strands	**Description**	**Learners' responses categories**
Strand 1	**Conceptual Understanding**	**C1& C4**
Strand 2	**Procedural Fluency**	**C1,C2,C5**
Strand 3	**Strategic competence**	**C4**

Strand 4	**Adaptive reasoning**	**C1,C2, C4, C5**
Strand 5	**Productive disposition**	**C1**

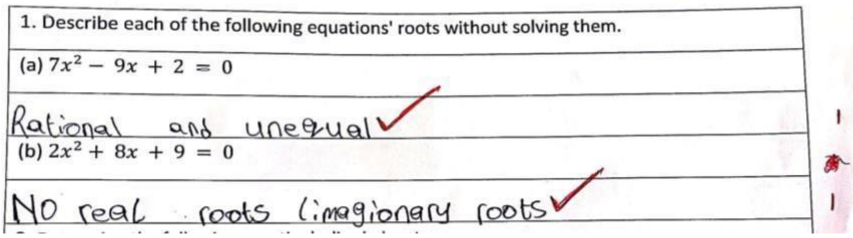
Table 3: Learners' responses categories classification into mathematical proficiency strands

In the given test, based on the mathematical proficiency strands portrayed, there was an improvement in learners understanding on nature of roots of quadratic equations. Most of the learners were now able to show all the mathematics stands and that was reflected in their responses in this way; most of the learners were able to show fluency in their writing, provided justification of their responses, and their workings were correct. Although at some questions they were not able to reach the correct answers due to mistakes they made, but their work showed that they were able to visualize the roots from the discriminant they got and relate the discriminant with the roots of the equations.

From table 2, the codings for question 1 a and b were intentionally left blank because learners were not required to show workings. As question 4 required learners to expand (t-2), most learners(10 in number) got the answer incorrect due to mistakes committed. This is C5 on the table. From the same question, few learners(2 in number) provided valid reasons and workings without mistakes while three(3) learners did not respond to the question. This could be that learners viewed the question as being different from others and complex to solve.

On question 1, it can be seen that few learners provided correct descriptions of roots without working on them while most learners left the answer blank. This could be that they did not know how they can assume the nature of the roots without having to work on them. Some could be that they required a lead as they did not know what they are expected to do.

Learners' responses to the test



1. Describe each of the following equations' roots without solving them.

(a) $7x^2 - 9x + 2 = 0$

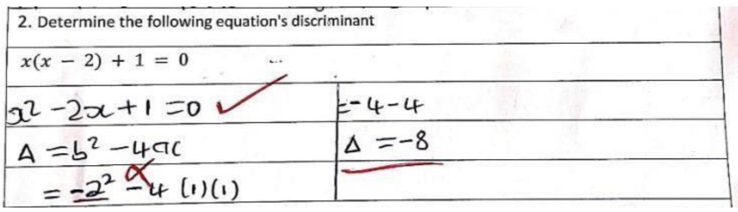
Rational and unequal

(b) $2x^2 + 8x + 9 = 0$

NO real roots (imagionary roots

Vignette 1: Learner 6's response to describing roots.

By looking at the response to question 1 letter a, it could be seen that the learner's response does not include whether the roots are real or not. This shows that the learner has a conceptual understanding that before roots can be rational, they have to be real because rational numbers are real numbers.



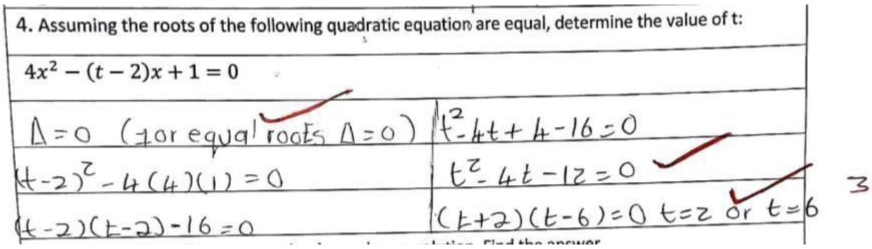
2. Determine the following equation's discriminant

$x(x-2) + 1 = 0$

$x^2 - 2x + 1 = 0$	$= -4 - 4$
$\Delta = b^2 - 4ac$	$\Delta = -8$
$= -2^2 - 4(1)(1)$	

Vignette 2: Learner 2's response to determining the discriminant

By looking at the response to question 2, it could be seen that this learner has a conceptual understanding that before using the discriminant the equation should be in quadratic form, hence the learner put the equation is standard form. Despite this conceptual understanding revealed, the learner committed a split on calculations. The learner wrote -2 outside the bracket and squared it. As a result, the learner got the solution incorrect.


4. Assuming the roots of the following quadratic equation are equal, determine the value of t:

$4x^2 - (t-2)x + 1 = 0$

$\Delta = 0$ (for equal roots $\Delta = 0$)	$t^2 - 4t + 4 - 16 = 0$
$(t-2)^2 - 4(4)(1) = 0$	$t^2 - 4t - 12 = 0$
$(t-2)(t-2) - 16 = 0$	$(t+2)(t-6) = 0$ $t = 2$ or $t = 6$

3

Vignette 3: Learner 6'response to determining an unknown variable

One of the learners' response to question 4, the learner had an idea that an equation with equal roots should have the discriminant that is equal to 0 hence the learner wrote Δ=0. This shows conceptual understanding that the 0 inside the equation results in one root. The learner also show procedural fluency Again in response to question 5 and 6, it was found that one learner cannot see the relation between an equation with one solution and the one with equal roots. Hence the learner used the quadratic equation on question 5 to see how many solutions he/she gets and set the discriminant to 0 on question 6.

In one of the learners' response to question 6 letter b, the learner had an idea that an equal roots equation should have the discriminant that is zero (0), Despite this conceptual understanding revealed, the learner committed a split on calculations. This shows that the effect of the CPA approach on learners' understanding was significant. From this finding, it also shows that there was a great increase in performance from the learners' in terms of conceptual understanding, procedural fluency, adaptive reasoning and strategic competence. Learners were able to respond with confidence to the test than in the first stage where they were using the discriminant card sort. The findings of the study also revealed that the CPA approach attract learners' attitude and motivate them to learn actively the nature of roots of quadratic equations due to its joyful learning tasks. As supported by (Paulpandi & Govindharaj, 2017), getting more answers correct can make learners to get a sense of achievement.

The analysis showed that the conceptual understanding of leaners has improved as learners were able to respond correctly to the test than in the initial stage where they were placing cards in wrong pockets. From this improvement, the effectiveness of CPA approach can be deduced. The analysis from Table 2 also showed that almost all the learners provided reasons for their discriminants. This reveals the mathematical proficiency strand of adaptive reasoning. According to the National Council of Educational research, when learners are able to reason their answers correctly, learning has taken place.

The analysis also showed that the strategic competence of learners has improved as learners were able to use the quadratic formula rather than only using the discriminant. For example, from the analysis on table 2, learners were confused on how the discriminant should look like as a result they went straight to using a different method. This improvement is essential as it guarantees good performance. Even though some learners were committing mistakes in their answers, they were showing more correct working on most of their answers and used the computations correctly in their workings.

From the improvement in conceptual understanding, adaptive reasoning, strategic competence and procedural fluency, it can be deduced that as a result of covering the four mathematical proficiency stands, productive disposition was also achieved. As outlined by (Awofala, 2017), if a learner can carry out procedures appropriately and provide reasons to the answers then the learner is said to have developed a good attitude towards the mathematics. This is because one cannot carry out a mathematics problem to the end without having hope of achievement. Thus, in this study learners' understanding on nature of roots of quadratic equations was improved.

Conclusion

Learners have shown excitement in engaging in the CPA approach. The mix of graphs, word phrases, and equations in the discriminant card sort task has helped the learners to get a variety of practice and engaged the learners. The CPA approach helps learners to became more proficient in the concept. Therefore, it is clear that their understanding has improved as they have shown all the mathematical proficiency strands. This study's main contribution is proposing an approach that enhance leaners' understanding of nature of roots of quadratic equations. In this approach, learners participate in a social context with others, and they get different experience as they will be learning in three stages which covers all the learning styles, through hands-on, watching and listening. As a result of this, they will learn effectively and develop relational understanding on the concept.

Some limitations are that the focus of this study was only on using CPA to enhance learners' understanding on nature of roots of quadratic equations. The participants were only twenty

(20) grade 11 learners from a school in Mphahlele circuit in Limpopo province that fall under quintile 1. The reliability of the result could have been improved if a larger sample was used and a better concrete model could have used if the school had enough resources. To ensure quality of the CPA approach, teachers can focus on the splits(mistakes) learners make in their writing and address them, use mathematical knowledge to teach mathematics such that learners are not left confused, and explain in detail the terms such as describe, determine, find and solve etc.

Reference

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LECTURERS' EXPERIENCES OF THE USE OF TECHNOLOGY IN MATHEMATICS TEACHING AT A TVET COLLEGE

HLENGIWE MHLUNGU & LOKESH RAMNATH MAHARAJH

This study explores the views of mathematics lecturers' use of technology in teaching circle geometry to level 4 at a selected TVET College. This qualitative study adopted an interpretive paradigm and involved five participants who were purposively sampled to gain meaning in a real situation. The data was generated through open-ended questionnaires and individual semi-structured interviews. The data generated was guided by a TPACK theoretical framework for this study. This paper reports on the views of lecturers on the use of technology to teach geometry at a TVET College, paying particular attention to their experiences and challenges. The findings reveal insufficient relevant technologies to teach circle geometry level 4 at the TVET College. Mathematics lecturers encountered many challenges concerning the lack of relevant technology for specifically teaching circle geometry. It also emerged from the study that TVET College has provided laptops for the lecturers. However, this is not the technology that is specifically for teaching and learning level 4 circle geometry. The findings of this paper may be beneficial to mathematics lecturers at TVET Colleges, the Department of Higher Education and Training and the Department of Basic Education.

Keywords: TVET College, circle geometry, GeoGebra, TPACK

Introduction

Teaching is the process of sharing knowledge, skills, and experiences with others in a way that helps them learn (Bergmark, 2023). It involves a variety of activities, such as planning, instruction, assessment, and feedback. Learning is the process of acquiring new knowledge, skills, and experiences. It can happen in many different ways, including through formal instruction, informal experiences, and self-study. Teaching and learning are two sides of the same coin. Without learning, there can be no effective teaching. The process of teaching and learning is dynamic and intricate. Numerous elements, including the learner, the teacher, the curriculum, and the learning environment, all have an impact on it. When the teacher and student work together to facilitate learning, teaching and learning are most successful (Silalahi, & Hutauruk, 2020). As a facilitator, the teacher should assist the student in drawing connections, posing queries, and resolving issues. The student should take an active role in their education and be accountable for their advancement.

For both auditory and visual learners, integrating technology into whole-class instruction can increase student engagement (Mulqueeny, Kostyuk, Baker, & Ocumpaugh, 2015). Simple technological integrations in the classroom, such as PowerPoints, games, online homework assignments, or online grading systems, can have a significant impact on students' development (Jaiswal, 2020). Some of the advantages of integrating technology into mathematics teaching are that it increases the cycle of proof, presents ideas through real-world scenarios, decreases the amount of time spent on laborious computations, and sharpens students' focus on key concepts and representing mathematics in ways that aid in conceptual understanding (Perienen, 2020). Technologies such as graphing calculators, the internet and computer mathematics software have the potential to improve teaching and learning in mathematics. The relationship between studied mathematics and the actual world is made more evident by the way that mathematical knowledge is presented to students with technology. Additionally, by streamlining computation and producing concrete representations of mathematics, technology helps teachers enhance both the content and the way that students learn. Technology is a major factor in improving education's teaching and learning process.

This research study explored mathematics lecturers' experiences of the use of technology in the teaching of circle geometry to level 4 at a selected Technical and Vocational Education and Training College in the Majuba District, KwaZulu-Natal, in South Africa. The paper responds to the following question: What are mathematics lecturers' experiences using technology to teach circle geometry to level 4 students at a selected TVET College?

Theoretical Framework

TPACK stands for Technological Pedagogical Content Knowledge. It is an applicable theory for this study because it is framed by the prominent gestures of the technological (lecturers' use of technology), the pedagogical (teaching using technology), and content knowledge (circle geometry content). These gestures are significant and specifically tackle the phenomenon of experiences of lecturers' use of technology in the teaching of geometry.

Related Literature

Mathematics has become a very important subject throughout South Africa (Jojo, 2019). Most high-paying jobs require mathematics as a compulsory subject to qualify for tertiary entry (Holzer & Baum, 2017). Parents have been known to encourage their children to do mathematics as a subject in high school (Harackiewicz, Rozek, Hulleman, & Hyde, 2012). Some parents force their children to opt for mathematics even if they do not have enough potential and interest in a subject (Lembrér, (2021). Vaidya and Kumar (2006) state that many fields and disciplines, such as computer science, engineering, natural sciences, medical science, economics, and accounting worldwide require mathematics to qualify. This suggests that mathematics is a subject that controls many careers. Regarding potential in doing mathematics, Mji and Makgato (2006) view that learners experience difficulty learning mathematics due to lack of motivation, resulting in low self-esteem and confidence in the subject.

Technology is the skilfulness, procedures, and techniques used to obtain objectives. Most people utilise technology to manufacture services or goods. TVET lecturers and students use different types of technology in everyday life, not for educational purposes but for socialising. Social networks are at high levels of usage. Technology is used in learning and teaching and for school administration and management purposes. The term technology may mean educational technology and digital technology. Educational technology is divided into traditional and modern technology (Sáez-López, Sevillano-García, Vazquez-Cano, & Development, 2019). Davies and Hughes (2014) state that technology helps during teaching and learning by arranging educational resources meaningfully.

As mentioned in the introduction, technology may have an important role in the teaching of mathematics generally, but circle geometry more specifically. A study done by Osakwe (2020) in South Africa set out to explore the integration of technology into teaching at a mathematics department at a South African university. This study took ten years (2003 -2013). The aim was to determine the attitudes and beliefs towards using technology for teaching mathematics by students and staff at the university. Findings indicate that the participants still use the chalkboard for teaching, not technology. One of the reasons mentioned by the participants for not using modern technology or why they prefer the use of chalkboards is that there is a lack of training regarding the use of technology in the teaching of mathematics. Billman, Harding and Engelbrecht (2018) found that teachers in their study preferred the chalkboard to technology in the teaching of mathematics. Ten years after their study began, Billman et al. (2018) found that the use of the chalkboard decreased. However, despite the remarkable increase in technology, half the teaching staff in their study still preferred the use of the chalkboard. Other studies that looked at teachers/lecturers' experiences of the use of technology in mathematics teaching include Trelease (2016) *(concluding that as techniques, practices, and educational research advance, new technology and their applications will also, and will be able to be used more successfully to education)*, and Ardıç (2021 *(who set to find out how mathematics teachers use technology as well as their thoughts and attitudes about it*).

The findings of many studies in the literature indicate that using technology in mathematics teaching replaced traditional methods and tools (Bray & Tangney, 2017; Egan et al., 2013; Ottenbreit-Leftwich et al., 2012; Thinyane, 2010) and that only a basic level of technology could be used in this process (Ardıç & İşleyen, 2017a; Avcı et al., 2019; Bray & Tangney, 2017; Psycharis et al., 2013).

Methodology

Sample of participants

I focused only on the mathematics lecturers who were teaching level 4 mathematics with the help of curriculum division administration at the TVET College. I excluded levels two and three because only level 4 has geometry in mathematics at TVET Colleges. Eight participants were eventually selected (from a possible 15 participants) to explore the lecturers' experiences of the use of technology in teaching circle geometry in level 4 at a TVET College. This enabled greater exploration, and I spent more time with the participants to understand the phenomenon (Ritchie et al., 2013). More time was spent with the participants to administer a questionnaire and interview processes. Geometry lecturers are directly involved in teaching and learning using technology. Using their experiences in technology teaching made it easier for them to be participants in this study.

Data generation

A questionnaire was used to explore the lecturers' experiences of the use of technology in teaching circle geometry in a TVET College. Gray and Outreach (2011) state that questionnaires are the tools that generate data, and participants are required to respond to the same set of questions as those pre-organised by the researcher. Questionnaires were also the most suitable instruments for this research because they provided information about their direct involvement with technology in teaching circle geometry at a TVET College. I also employed individual face-to-face interview sessions to generate data. Menjívar (2000) mentions that an in-depth interview is useful when a researcher needs people's experiences.

Data analysis

During the one-on-one semi-structured interview sessions, a voice recorder was utilised to facilitate the required and necessary information collection data analysis. When analysing data, thematic content analysis was utilised to identify, analyse, and report themes within the data (Pearse, 2019, p. 79). I transcribed interview data for each participant individually for the accuracy of the data analysis process. This assisted with the establishment of patterns and categorisation that came from data. Using patterns and categories ensured that only relevant data was obtainable to create a sense of the lecturers' experiences of the use of technology in teaching circle geometry at a TVET College.

Ethical considerations

I observed ethics strategies before, during, and after this qualitative study. Before conducting the study, I obtained a gatekeeper letter from the Department of Higher Education and Training and the College Rector to conduct this qualitative study at the TVET College located in the Majuba district. I also obtained consent letters from mathematics lecturers who teach level 4 (participants) at the TVET College. The participants were informed that they had the right to withdraw during the study. And that their anonymity, confidentiality, and rights would be protected.

RESULTS AND DISCUSSION

In Table 1 below, I summarise the participants' responses from one-on-one semi-structured interviews conducted to show their background based on educational technology use and experiences.

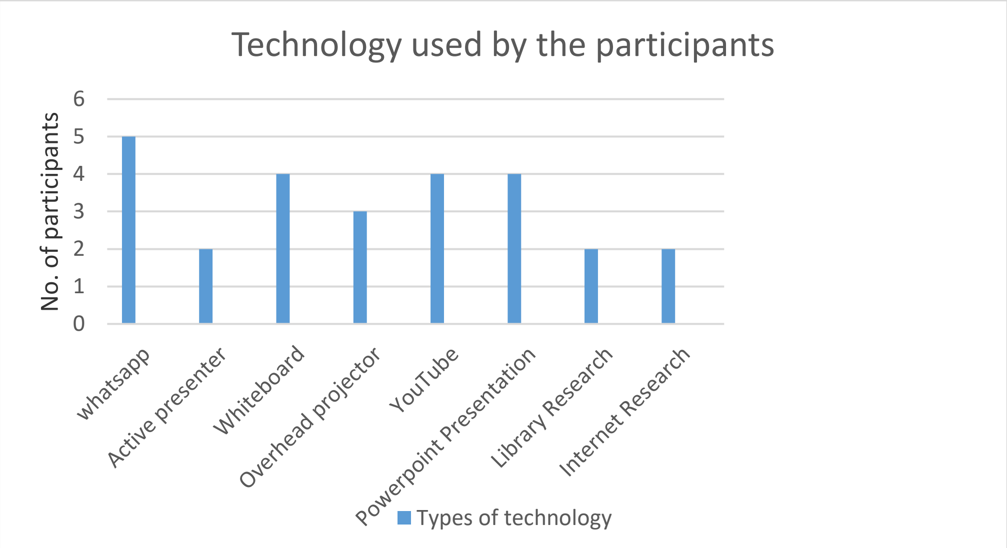

Figure 1: Types of technology that the participants used for this study

The purpose of the research was to determine lecturers' experiences of the use of technology in the teaching of circle geometry to level 4 students. Geometry is only done in level 4, the NCV program's exit level, where students meet geometry for the first time. It takes longer to teach them because geometry has unique content. During one-on-one interviews, the lecturers were asked if they were aware of the meaning of technology. They were asked: What does technology mean to you?

All the participants gave various meanings of technology. It is interesting to observe all the lecturers gave different opinions concerning the meaning of technology.

Participant C stated: "*Technology to me is advanced. It also means accessibility. Most of the time, when we think of technology, we think of, okay, well, students having a cell phone or the campus having internet. Still, we also need to understand that technology means that everyone is on the same level when it comes to having the same information at their fingertips. Hence, it's not just because one learner has data they benefit from; it's going to apply to everybody and everyone who has technology.*"

This lecturer mentioned that technology is accessible at the same level to everyone concerning data and the internet. It is surprising to see students fail to learn online. There are computers in the staffroom in one of the colleges, but they have been lying there without the internet for almost seven years. During the pandemic, the students were promised laptops in 2020 to learn online when they were not physically at the TVET College. This means that some of the students have no access to technology. Some parents could not afford to buy gadgets to resume online learning. The lecturers and the students have no Wi-Fi access, and even if they have gadgets, they cannot use them.

Participant D said: "*Okay, yeah, for me, technology will mean the tools, the resources I use, and the aids that will help the teacher deliver the lessons. But I also understand that technology is the way to make a process better. So really, it is teaching maths; it will be how to make the teaching and the delivery of lessons more effective and dynamic with the times and not just rely on the old-fashioned textbook and the whiteboard.*"

Each participant gave a different explanation. This shows that all the participants are aware of the meaning of technology.

If they were familiar with the concept of technological knowledge, they were asked: Are you familiar with the concept of technological knowledge?

Participant A uttered: "*Technological Knowledge, on the other hand, is talking about so I can say that a person who has been trained some many years ago…. may not have Technology Knowledge because then that technology was not there. So, technology knowledge now has to do with the knowledge of all these technologies in terms of how you can make use of them in the context of the subject under the circle geometry.*"

Participant D articulated: "*Technological Knowledge is what I will think, is the tools, resources that we use for…. teaching and learning, but according to the definition, realise it's also the actual technology of a particular subject like in physics if there's some even like in biology if there's some new technology like in like now like that thing for Covid- 19.*

Participant E stated: "*Technological Knowledge is knowing how to use technology in your teaching and learning—how technology interacts with technology. There are many facets of technology. It can be a cell phone or a computer. It can be many facets."*

It was very interesting when all the lecturers showed that they knew the concept of technological knowledge. They displayed various explanations of technological knowledge. One of the participants mentioned that a person does not have technological knowledge when a lecturer trained for teaching a few years ago. This means that those born before knowledge within the same education system know nothing about it. Those born after the technology was introduced became experts in technology. Because all the lecturers have laptops provided by the TVET College, they are familiar with some technology. This suggests that although they were born with technology, they do not know anything about it. For the sake of this study, technological knowledge is the knowledge of the use of technology in the teaching of circle geometry. Another lecturer (participant C) mentioned the technology resources used for teaching and learning and the need for technology use during the pandemic (COVID-19). These were the times that exposed the challenges of technology knowledge in lecturers. There was no time for training, but the lecturers were only shown through voice notes by the TVET College to use the LSM, named ACTIVE PRESENTER, to teach all the subjects in the college.

When the lecturers were asked about their technical knowledge, all the participants showed that they had the technological knowledge to teach geometry. They were asked: Do you have the technical skills required to teach a technology-based geometry lesson? If yes, which?

They all said yes and mentioned different technology names for teaching geometry.

Participant B: *Yes, GeoGebra and Blackboard*

Participant C: *Yes, I have a diploma in Instrumentation and computer-based training*

This shows that all the participants have received training and have the technical skills to teach circle geometry. On mentioning GeoGebra, the software was designed only for teaching calculus, algebra, and geometry (Vasquez, 2015). It is a very popular programme worldwide, and it can be downloaded from the GeoGebra website, known as http://www.geogebra.org (Ocal, 2017). Farrajallah (2016) states that GeoGebra is a unique programme based on global mathematics standards and supports the curriculum, which helps learners construct the geometry figures and institute Euclidean Geometry proofs through riders and proofs associated with appropriate reasons. This suggests that when TVET College level 4 students can learn circle geometry with GeoGebra, they will be exposed to constructive learning, making learning more meaningful to them and making it easier to pass mathematics with ease, making it easier to complete their NCV certificates.

All mathematics lecturers' knowledge goes as far as diagnosing a problem when using the mentioned technology because they were trained to do so. This may be because they are mathematics lecturers and not trained technicians, which could mean that they were trained on a specific programme, but they may forget it. Most participants mentioned that they could learn about any technology with ease should it be introduced to them.

When asked about updating the new technology question: Do you keep updated with various new technologies and pick new technologies incorporated in geometry lessons? Elaborate on your answer.

Most participants mentioned that they are up to date about new technologies, although they are not using them at college, and can learn the skill quickly since technology usage is currently the most important.

Participant C said: "*Yes, one can self-learn through online courses, etc.*"

This shows that the mathematics lecturers are concerned. They can learn online using the new technologies should they be incorporated and used in geometry teaching. In that case, they may be the generation that wants to use technology to teach circle geometry. They showed a very positive attitude toward technical knowledge. One participant mentioned that it is useless since they are not using any technology to teach circle geometry, which suggests that lecturers have a high level of technical knowledge. However, the study is based on how the lecturers can use technology to teach circle geometry in the NCV programme to benefit teaching and learning.

Similarly, in the TVET context, the lecturers find some challenges preventing them from using circle geometry technology. For instance, when looking at some classrooms, technology was installed but was removed, although, in some lecturers' classrooms, it can be observed that technology is still installed.

Figure 1 shows the classroom belonging to Participant D, with the data projector mounted on the ceiling and no interactive board used, but a whiteboard is available. A laptop provided by the college is used and can be connected to the data projector to show what is on the laptop, like in previous question papers.

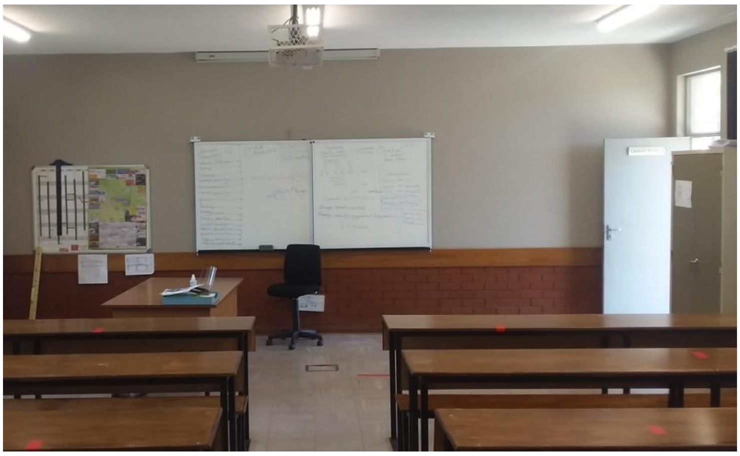

Figure 2 indicates participant C's classroom inside with the technological tools fitted. According to the participant, there is a data projector, interactive board, internet port with no

internet for almost seven years, a laptop provided by the college, and the learnerscape software that terminated its use and no license renewed.

Conclusion

Using technology in circle geometry requires pedagogical knowledge, content knowledge, and technical knowledge. The mathematics lecturers showed that they were trained in different institutions to use technology to teach circle geometry during their studies. All the lecturers have pedagogical knowledge and content knowledge of mathematics and circle geometry because they all have majored in mathematics subjects. However, the study conducted by Tachie (2020) revealed that teachers from ten schools in the Free State lacked mathematics content knowledge (CK) and pedagogical content knowledge (PCK) to teach geometry in the classrooms.

This study also revealed that the mathematics lecturers only have the technical skills needed for a technology-based geometry lesson. This suggests that mathematics lecturers have gone for training and have the technical skills to teach circle geometry. However, those skills are not utilised because there is no relevant technology to teach circle geometry. The DHET and the curriculum department of the TVET College need to liaise and provide the relevant technology to be used to teach circle geometry level 4 in a TVET College.

Most lecturers mentioned that they adapt teaching styles to different learners depending on their interests and technology skills. The problem they experience is the lack of data on using technology, which shows that lecturers would like to go the extra mile in using technology to teach circle geometry. At the same time, one participant said that teaching circle geometry enables learners to visualise the problem because they learn and understand better when they see an object they tend to remember. The DHET and a TVET College must provide network access to TVET Colleges.

Lecturers can use technology for assessment, but available resources limit them for this study. Lack or insufficient resources limit the teaching and learning of circle geometry at this particular TVET College. Professional development is recommended for mathematics lecturers to be conducted by the DHET and TVET College for the mathematics lecturers concerning the use of technology to assess circle geometry.

There is no opportunity for lecturers to use technology for individual assessments of students. This suggests insufficient time to cover all this work in level 4 during the teaching and learning of circle geometry.

Most of the lecturers showed that they are trying to use technology for classroom organisation, but it is not relevant for circle geometry. When one of the participants stated that no technology is used, there is inequality amongst the TVET lecturers in using technology in circle geometry teaching NCV level 4 students. Relevant technology for circle geometry is recommended to be supplied to mathematics lecturers.

Mathematics lecturers showed that most lecturers could combine mathematics, geometry technologies, and teaching strategies when teaching. This illustrates that the lecturers are well-equipped with the necessary skills to teach circle geometry and mathematics. However, there is a lack of technology to be used during teaching and learning as the participants were asking for software to be bought by the TVET College to make learning more practical. A technology relevant to circle geometry is recommended to be supplied to the DHET and the TVET College mathematics lecturers.

Further Research

Different opinions were raised by different lecturers concerning the use of technology for geometry teaching in the TVET College. However, these TVET lecturers are not different from those in other countries and various institutions. Difficulties are experienced in schools, TVET colleges, and higher institutions in various countries. For instance, Noori's (2021) study showed that technology use in mathematics classrooms has displayed many difficulties in various countries because they have different learning contexts as required by the 21st century. Also, mathematics lecturers in Ethiopia can use technology; however, there are barriers in the institutions that prevent them from using it in the classroom (Machaba & Bedada, 2022).

Limitations of the study

This study is limited to mathematics lecturers in the TVET College lecturing NCV level 4 students. There might be a great possibility of including other mathematics lecturers in TVET Colleges in another province using technology to teach circle geometry. Future studies should also include private and government colleges and lecturers from other learning areas from different provinces within South Africa.

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ASSESSMENT FOR EARLY DIAGNOSTICS WITH COMPUTERADAPTIVE TECHNOLOGY

TATIANA SANGO & MUDAVANHU

Over the years computer-adaptive testing (CAT) has proved to have many advantages over traditional tests. For example, CAT may reduce testing time (Weiss & Kingsbury, 1984) and promote a better examination experience, resulting in increased student motivation. CAT takes into account the individual differences of students, offers the advantage of precise student profiling, and provides detailed insights into their strengths and weaknesses. The core purpose of this innovative assessment instrument is to serve as a diagnostic tool that identifies areas where students may require targeted support and improvement. The central idea is to understand what students know (as opposed to what they do not know) and to build on their expanding knowledge profiles.

INTRODUCTION

In South Africa, universities are expected to meet the National Development Plan (NDP) enrolment target of 1.62 million by 2030 (Khuluvhe et al., 2021). The participation rates of students from diverse backgrounds have increased significantly and, with widening participation, many students enrolling in higher education institutions might find themselves underprepared to meet the academic demands of their intended degrees. The higher education sector in South Africa is grappling with the challenge of addressing the unpreparedness of incoming students and the alarmingly high dropout rates during the first year of study. To effectively tackle this issue and to make meaningful improvements, universities are working to enhance curricula and academic programmes. However, this might still not be sufficient to address the academic needs of incoming students, especially considering the consistent trends in Mathematics performance over the years, as illustrated by the National Benchmark Test (NBT) scores in Figure 1 below (NBT, 2023). In 2022 and 2023, half of the candidates who took the NBT Mathematics test scored below 37%, placing them in the Basic benchmark performance level.

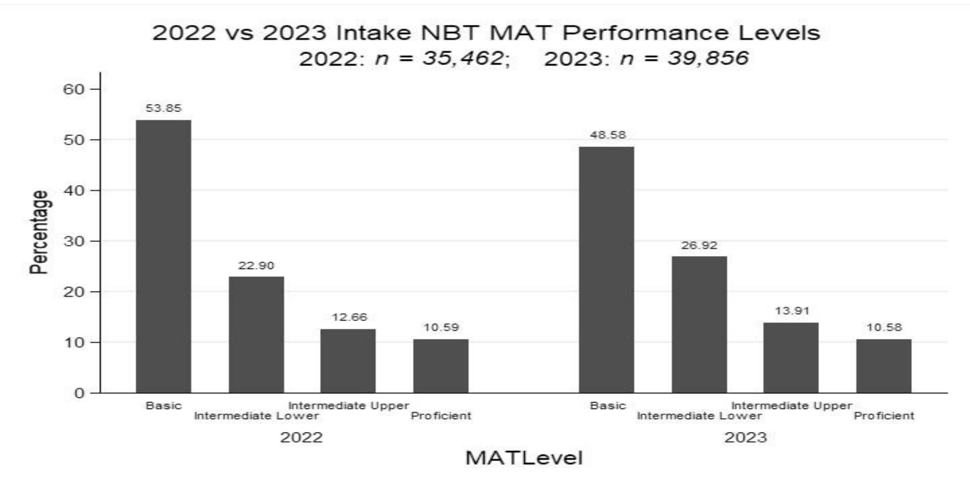

Figure 1: NBT Mathematics performance: 2022 and 2023 intakes

Hence, it appears logical to start early and to address the needs of *future* students before they encounter the university application process and take the NBTs. The NBTs serve as valuable assessments of students' readiness to handle the typical demands of higher education in the Academic Literacy, Quantitative Literacy, and Mathematics domains (Bohlmann & Braun, 2006). Moreover, the NBT Mathematics (MAT) is optional, often catching prospective students by surprise, particularly those who aspire to enter fields like medicine, when they sit for the NBTs in Grade 12. This timing frequently leaves little opportunity to address any gaps in mathematical knowledge.

The implementation of computer-adaptive testing (CAT) technology in assessment for early academic profiling and preparedness for higher education may enable the early identification of students' academic strengths and weaknesses, providing valuable insights into the development of critical skills and allowing for targeted interventions and support as needed. While CAT was introduced decades ago and has been widely used in the Western world, its implementation in the South African education system has been limited. The significance of CAT lies in its ability to measure the extent and breadth of knowledge, addressing student motivation and testwriting anxiety observed during online sessions. CAT not only reduces test time but also enhances the precision of measuring students' performance levels. While CAT has demonstrated success globally, its limited implementation in the South African education system underscores the need for its introduction. The rationale for introducing CAT in this context is to provide early diagnostics and accommodate diverse student profiles, thereby addressing the unique needs of the South African educational landscape.

This paper provides some insights into what CAT is, its significance, and the role that CAT can play as a precise assessment tool for enhancing students' potential for success in higher education. Through a pilot study involving Grade 11 Mathematics learners, we discuss the initial implementation of CAT, and share our analyses related to the test design, item administration patterns, and preliminary findings and observations. The Grade 11 Mathematics assessment instrument was designed with a specific focus on understanding how CAT leverages adaptive technology to customise the difficulty of test items based on each student's demonstrated proficiency level. This approach ensures that the assessment provides accurate and actionable insights into students' mathematical abilities.

LITERATURE REVIEW

The literature suggests that it is important to conduct early diagnostic assessments of academic preparedness in literacies that are not explicitly taught in the school curriculum, in order to support first-year university students. Palmer (2018) highlights the benefits of embedded diagnostic assessment, including individualised feedback and insights into expectations and requirements. Students need to understand their academic strengths and weaknesses and engage in the learning process.

It is believed that CAT can assist with better student profiling by assessing the student's ability level more accurately and efficiently (Goto, 2023). This is because CAT uses a dynamic test format that adapts to the student's ability level in real time, presenting questions that are tailored to the student's level of proficiency. This information can be used to develop personalised learning plans that target areas where the student needs to improve. In addition, CAT can help to identify gifted students who may be overlooked in traditional testing methods, as well as students who may require special education services (Stone, 2011). The idea is to understand what the student knows (as opposed to what they do not know) and build on the foundation of their growing knowledge profile.

Some implementations of CAT

Globally, there are many examples of CAT assessments that provide personalised and efficient evaluations. The Duolingo English Test (DET) utilises automatic item generation (AIG) and natural language processing (NLP) models to create adaptive tests that cater to individual proficiency levels (Settles et al., 2020). The Programme for International Student Assessment (PISA) employs a multi-stage adaptive testing (MSAT) approach, which adjusts the difficulty of questions based on the test-taker's performance (OECD, 2021). The National Assessment Program – Literacy and Numeracy (NAPLAN) in Australia has transitioned to an online assessment for all students in Years 3, 5, 7, and 9, enabling adaptive testing and immediate feedback (ACARA, 2023). The National English Computerized Adaptive Test (NECAT) has been developed and implemented in the public education system in Uruguay since 2014, providing a tailored assessment experience (Burtner et al., 2016).

ImagineLearning offers multi-stage adaptive assessments for Mathematics and English Language Arts (ELA), ensuring that students receive questions aligned with their skill levels (ImagineLearning, 2023).

METHODOLOGY

The overarching aim of the project is to investigate the key trajectories of academic preparedness among high school learners, incorporating the use of CAT assessments for early diagnostics. The work described in this paper is an initial exploration into the necessary setup and resources that are required for a successful CAT implementation. The CAT development and adoption process has multiple phases and considerations. It is important to evaluate: (1) access to psychometric expertise; (2) capacity (e.g., to develop extensive item banks); (3) affordability of the final assessment offering; (4) practicality of delivering mechanisms and data collection; and (5) increase in precision and security. While studying the benefits of the CAT assessments, we should also evaluate whether certain considerations could be addressed by non-CAT models (Thompson & Weiss, 2011).

Our main motivation stems from the known benefits of CAT and its potential impact on addressing learning needs at an individual level. In the context of the Grade 11 learners, the introduction of an assessment instrument offers early indicators for the development of the mathematical proficiencies required of them during their final year (Grade 12) as applicants seeking university admission. To develop such an instrument, we were guided by the NBT Mathematics test framework and proficiency indicators. As the NBTs are criterion-referenced tests, inferences about the results of test-takers should be focused on interpreting the extent to which they have met the expected standards set for each domain. It is appropriate to interpret certain (lower) levels of performance on the tests as an indicator that students will require extensive levels of academic support if they are to cope with the demands of higher education (NBT, 2023).

Table 1: NBT benchmarks and level of support

Proficient	Degree: 69% -100% Diploma: 63% - 100%	Test performance suggests that future academic performance will not be adversely affected (students may pass or fail at university, but this is highly unlikely to be attributable to strengths or weaknesses in the domains tested). If admitted, students may be placed into regular programmes of study.
Intermediate	Degree: 37% - 68% Diploma: 33% - 62%	The challenges identified are such that it is predicted that academic progress will be adversely affected. If admitted, students' educational needs should be met as deemed appropriate by the institution (e.g., extended or augmented programmes, special skills provision).
Basic	Degree: 0% - 36% Diploma: 0% - 32%	Test performance reveals serious learning challenges. It is predicted that students will not cope with degree-level study without extensive and long-term support, perhaps best provided through bridging programmes (i.e., non-credit preparatory courses, special skills provision) or FET provision. Institutions admitting students performing at this level would need to provide such support.

The Grade 11 Mathematics adaptive test is intended to use indicators against the expected progress towards the NBT Mathematics, as outlined in Table 1. The assessment instrument is designed with a specific focus on understanding how well CAT leverages adaptive technology to inform each student's demonstrated proficiency level and whether it provides better insights into students' mathematical abilities compared to traditional testing.

Pilot design

Test design

Items were selected from the item bank of questions typically used in the NBT MAT examination. The selection criteria were made per subdomain distribution, cognitive level of the items, and general prior administration item performance indicators. A total of 254 items were selected for this pilot, forming the CAT item bank for the pilot study.

IRT and theta

Item Response Theory (IRT) is a statistical framework used in educational measurement to analyse the relationship between individuals' responses to test items and their underlying latent traits or abilities. This framework is used in the NBTs to score test item responses.

Theta, often denoted as θ, is a parameter in IRT representing an individual's latent trait or ability level. Theta reflects a person's proficiency or ability level related to the specific trait or skill that the test targets. It is estimated based on the pattern of responses to test items and indicates the position of the individual along the latent trait continuum. In IRT, theta is typically assumed to follow a normal distribution with a mean of zero and a standard deviation of one, allowing for comparisons of individuals' abilities relative to the population. The CAT item bank theta distribution can be seen in Figure 2 below.

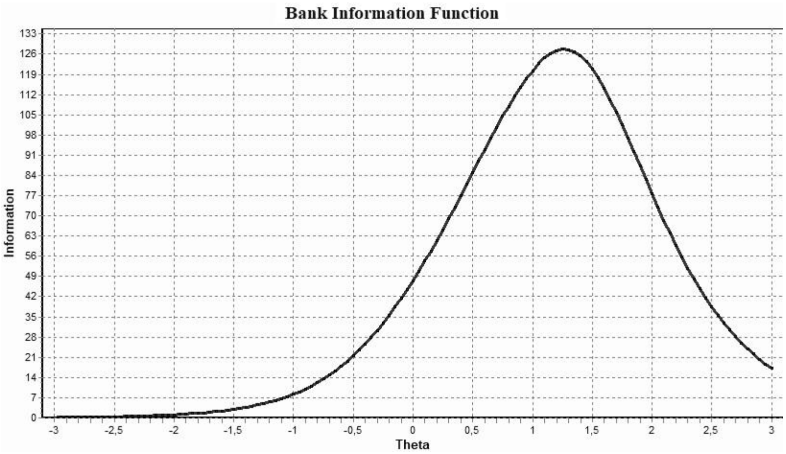

Figure 2: CAT item bank information function

Ideally, a well-calibrated item bank should yield theta estimates that are consistent across different subsets of items and assessments. The CAT item bank's theta estimates in this pilot, based on 254 items, indicate a mean of -0.146 with a standard deviation of 1.040. The range spans from a minimum estimate of -2.358 to a maximum of 3.118, reflecting the breadth of latent trait levels covered by the items (see Table 2). These theta estimates indicate the item bank's potential to assess a diverse range of ability levels accurately. A standard deviation of around 1 indicates a reasonable spread of ability levels covered by the item bank. It is slightly higher than the standard deviation in the traditional paper-based test, which may indicate that the CAT item bank covers a wider range of difficulty levels, which is desirable for adaptive testing.

Table 2: Theta estimates for CAT item bank and NBT MAT test administration

Summary statistics	Theta estimates for full CAT bank (254 items):	Paper-based MAT test (52 items):
Mean	-0.146	-0.191
SD	1.040	0.795
Minimum	-2.358	-1.861
Maximum	3.118	1.730

Table 3: CAT item bank: difficulty and cognitive levels

Item difficulty level		Cognitive level			
	L1	L2	L3	L4	Total
-2	1	0	1	0	2
-1	18	9	2	0	29
0	46	43	25	5	119
1	19	26	37	15	97
2	0	2	4	1	7
Total	84	80	69	21	254

Furthermore, the CAT item bank consisted of items at different cognitive levels and difficulty levels (see Table 3). These levels are: L1-knowledge, L2-routine procedures, L3-complex procedures, and L4-problem solving. Fewer items were selected for cognitive level 4 and difficulty level 2, because the pilot participants were still in Grade 11.

Simulations

Conducting simulations serves as a crucial preparatory stage before implementing CAT live. It enables the evaluation of different CAT testing parameters beforehand, ensuring the optimal functionality of the live CAT with the item bank calibrated using an IRT model. Multiple trials were conducted in the CatSIM package (Weiss & Guyer, 2010) using a hybrid simulations approach to select optimal CAT testing parameters. We employed the random selection of the initial theta in the interval - 1.50 to 1.50 as the method of ability estimate, and the maximum Fisher information criterion was applied for selecting the next item of the test. The standard error of the theta estimate was set at 0.350 (with the change in successive theta estimate less than or equal to 0.005), and the test length of 20 as a minimum number of items (with no maximum initially, later capped at 60 items) as stopping criteria of the adaptive test. CAT was held on the FastTest platform, developed by the Assessment Systems Corporation (ASC).

Pilot implementation

Two Grade 11 classes were selected for the pilot, and a total of 72 learners participated. These two classes were identified by the Mathematics HoD as the strongest classes in terms of their mathematical abilities. Students were very comfortable with technology and had easy access to computers at the school computer lab. Test sessions were held in two different computer labs, and were invigilated and observed by the researchers.

Unfortunately, during the implementation, the test did not stop for 15 learners, and the additional manual stopping criteria were applied to terminate the session for them. The affected participants were told to abandon the test session and their scores were recalculated manually at the 60-item cut-off point.

DISCUSSION OF FINDINGS

Test performance data was analysed upon the completion of the pilot study of Grade 11 Mathematics learners, and the class level and individual reports were shared with the teachers.

Most candidates finished the test within one hour and 40 min (see Table 4), which is a significant reduction in test time from the three hours allocated to the NBT MAT test.

Table 4: Time taken to complete the CAT test

Variable	N	Mean	SD	Min	p25	p50	p75	Max
Time spent (minutes)	72	82	36	27	55	75	103	155*

The number of administered items followed an interesting pattern, with stronger students receiving fewer items and weaker students reaching the maximum number of items, as can be seen in Figure 3. Stronger students may have received fewer items because they were correctly answering questions of higher difficulty, while weaker students may have reached the maximum number of items because they were answering questions of lower difficulty. The observed pattern is also not surprising concerning the 15 students for whom the test failed to terminate (going over the 60item point). During the invigilation, it was observed that some of these students were guessing the answers by clicking through the items.

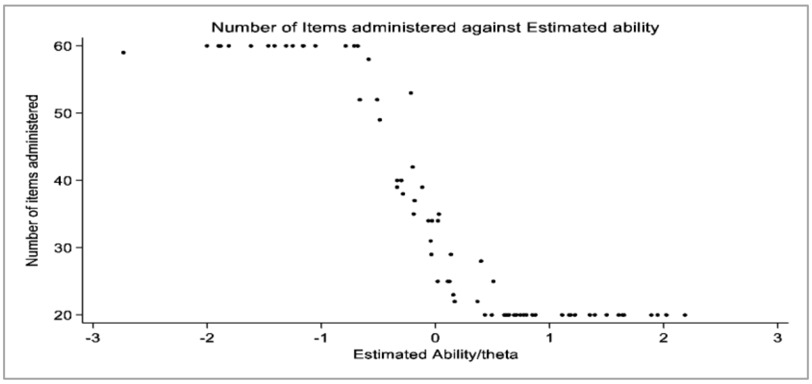

Figure 3: Number of items administered in relation to students' ability (theta)

The pattern that we observed is not uncommon in CAT testing. If a test-taker consistently answers items correctly, the algorithm may select more difficult items in an attempt to better gauge the test-taker's ability. Conversely, if a test-taker struggles with items, or perhaps guesses the answer, the algorithm may select easier items to ensure that the test-taker is not overwhelmed (Kimura, 2017).

Compared to the traditional test administration session, we observed that this CAT pilot delivered similar theta estimates, falling in the range between -2.2 and 1.6, with more Grade 11 learners with theta in the range of 1.6. Additionally, a special NBT MAT paper-based test session was held for 85 Grade 12 learners in the same year (2023): the two samples, Grade 11 and Grade 12, were similar in size and student population groups, the only difference being that an additional year of schooling separated them.

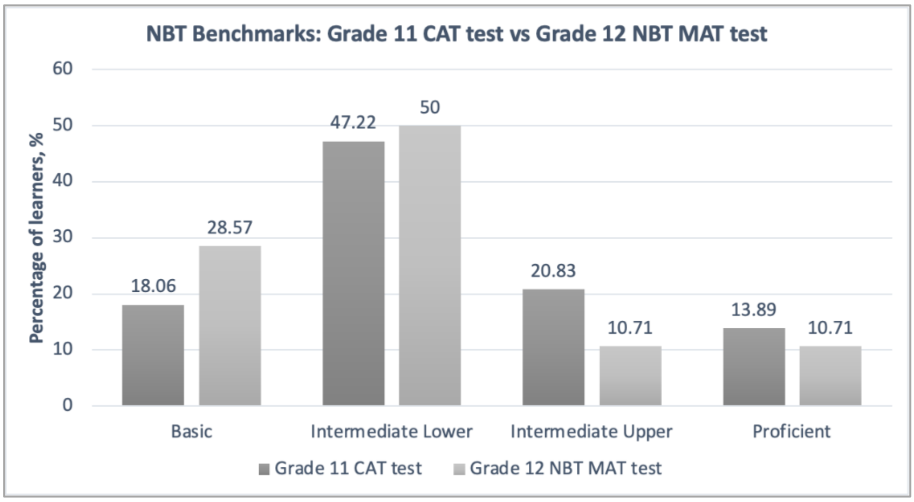

Figure 4: NBT benchmarks: G11 CAT vs. G12 NBT MAT

Compared to the Grade 12 NBT MAT special session (85 students, paper-based test) cohort, we see approximately 14% of the Grade 11 results falling into the Proficient category, and 47% of the Grade 11 results falling into the Intermediate Lower category (see Figure 4). When looking at the Grade 11 learners' placement in NBT MAT benchmarks, there are also some similarities with the overall national cohort, where only about 14% of the results in the pilot and 11% in the national 2023 cohort fall into the Proficient category (see Figure 4 and Figure 1). This trend is very persistent and the additional information provided by CAT to understand the individual profiles of the Grade 11 learners may help in better understanding the performance patterns.

Based on the individual profiles of the students, we can offer better support by providing learning opportunities to individual students and groups of students with similar profiles. By incorporating early diagnostics into our approach, we can proactively address learning challenges and design interventions that build on students' existing knowledge.

CONCLUSION AND FURTHER WORK

The results of the pilot look promising. The test time was generally reduced as expected, although not for every student. In comparison, a traditional paper-based or online NBT MAT test has a time allocation of three hours, and many test-takers use the maximum time allowed to demonstrate their proficiency in the test. The performance indicators from Grade 11 learners were also encouraging. Learners showed commitment and tried their best; there was a genuine curiosity about the adaptive test's capability – perhaps a noteworthy observation of the learners' reaction to the fact that not everyone finished at the same time and those who finished earlier might have been regarded as 'smarter'. It will be important to investigate perceptions of CAT administration with South African test-takers in the future.

This pilot will be repeated with a different group of students in 2024 to allow for a more structured study. Further analysis will be done to link this data to other assessment instruments.

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EXPLORING GRADE 12 MATHEMATICAL LITERACY LEARNERS' UNDERSTANDING OF AUTHENTIC ACTIVITIES

WISANI HLANGWANI

This case study explores four conveniently sampled Grade 12 learners' conceptualisation of authentic activities in making informed decisions. The study is foregrounded in a cognitive apprenticeship theory, which is a lens for comprehending the dynamics of learning and knowledge acquisition within the context of an authentic learning activity. The findings of the study revealed that there is a need to improve learners' mathematical knowledge in order to enhance their understanding of authentic activities. Moreover, the study highlights the potential value of integrating authentic activities into curricula to enhance numeracy skills essential for navigating modern challenges. Consequently, the scope of the study is restricted to a single school and a minority of four participants, necessitating future research endeavours to replicate it using a broader sample.

Keywords: Authentic activities; Cognitive apprenticeship theory; Mathematical Literacy; Numeracy.

Introduction

An overview of the South African curriculum shows that learners can choose between Mathematics and Mathematical Literacy. The study is limited to Mathematical Literacy (ML), that is the ability to make sense of, participate, and contribute to real-life problems (Department of Basic Education, 2011). The understanding of ML should enable learners to become functioning individuals who reason, make decisions and solve problems. Therefore, the conceptualisation of this definition calls for authenticity in learning ML, which is captured through authentic activities as a key element. Reeves et al. (2002) posit that authentic activities are tasks with real-world relevance. Similarly, Mhakure (2020) stresses that these are tasks drawn from genuine and realistic situations. This study seeks to explore learners' understanding of authentic activities. The study posed one research question: *How proficient are mathematical literacy learners in numeracy to make informed decisions?*

Theoretical underpinnings

This study is foregrounded by the cognitive apprenticeship theory (CAT), which is a lens for comprehending the dynamics of learning and knowledge acquisition within the context of an authentic learning activity (Mhakure, 2020). CAT posits that learning is optimally facilitated through social interactions rather than solitary endeavours (Lyons et al., 2017). Within the CAT paradigm, learning is conceptualised as a progression towards membership in a community of practice, where learners garner knowledge and skills through active engagement in authentic activities. Thus, within an authentic learning context, learners are afforded opportunities to immerse themselves in authentic learning activities and are tasked with responsibility of employing their cognitive competencies to tackle authentic activities. Consequently, the cognitive apprenticeship theory furnishes a pertinent theoretical scaffold for elucidating the mechanisms of learning and knowledge acquisition within authentic learning settings (Mhakure, 2020). The leveraging of this theoretical framework in the context of authentic activities affords an avenue to evaluate the numeracy proficiencies, and ascertain learners' readiness to make informed decisions through their mathematical knowledge.

Methodology

This study employed a case study design, adhering to Merriam's (1998) framework for conducting in-depth investigations of limited phenomena. Four conveniently sampled Grade 12 learners from Mopa High School (pseudonym) in Mopani West District, Limpopo Province form part of this study. The criteria for selecting the participants were established based on several factors: proximity of the school to the researcher, learners' performance in a preliminary assessment (Controlled Test 1), and the school's commendable performance. Qualitative data were collected using text analysis of learners' responses to an authentic activity and analysed through content analysis.

Learners' understanding of authentic activities

This section presents learners' understanding of authentic activities and examines the solutions provided. The aim is to derive conclusions that address the overarching inquiry: *How proficient are mathematical literacy learners in numeracy to make informed decisions?* The questions presented to the learners are detailed in Figure 1 below.

Authentic Activity

1. The price options of sugar from Makro are given below. Which of the following options gives the best value for money? Show your calculation to justify your answer.

Option 1: A 2,5 kg bag of sugar will cost R54,95

Option 2: A 5 kg bag of sugar will cost R104,95

Option 3: A 10 kg bag of sugar will cost R199,95

2. Makro sells a case of 24 Coca-Cola cans for R259,95. While Pick n Pay sells a six-pack of Coca-Cola cans for R69,99. Would it be cheaper to buy a case of 24 from Makro or the six-pack from Pick n Pay? Show your calculation to justify your answer.

Figure 1: Learners' authentic activity

The learners' authentic activity required them to employ their mathematical knowledge in practical contexts, facilitating the formulation of informed decisions. The activity mandated them to assess the value proposition of various options, thereby discerning the most cost-effective choice. Consequently, the activity served as a test for learners' numeracy proficiencies, and gauged their ability to make reasoned decisions grounded in mathematical insight.

In tracing learners' cognitive aspects in the authentic activity, the study sought to elucidate their cognitive dimensions of thought processes by analysing the solutions provided by the four selected participants. These solutions are presented in Figure 2 below. Initially, the study scrutinised learners' responses to question 1, as documented in Figure 2 below.

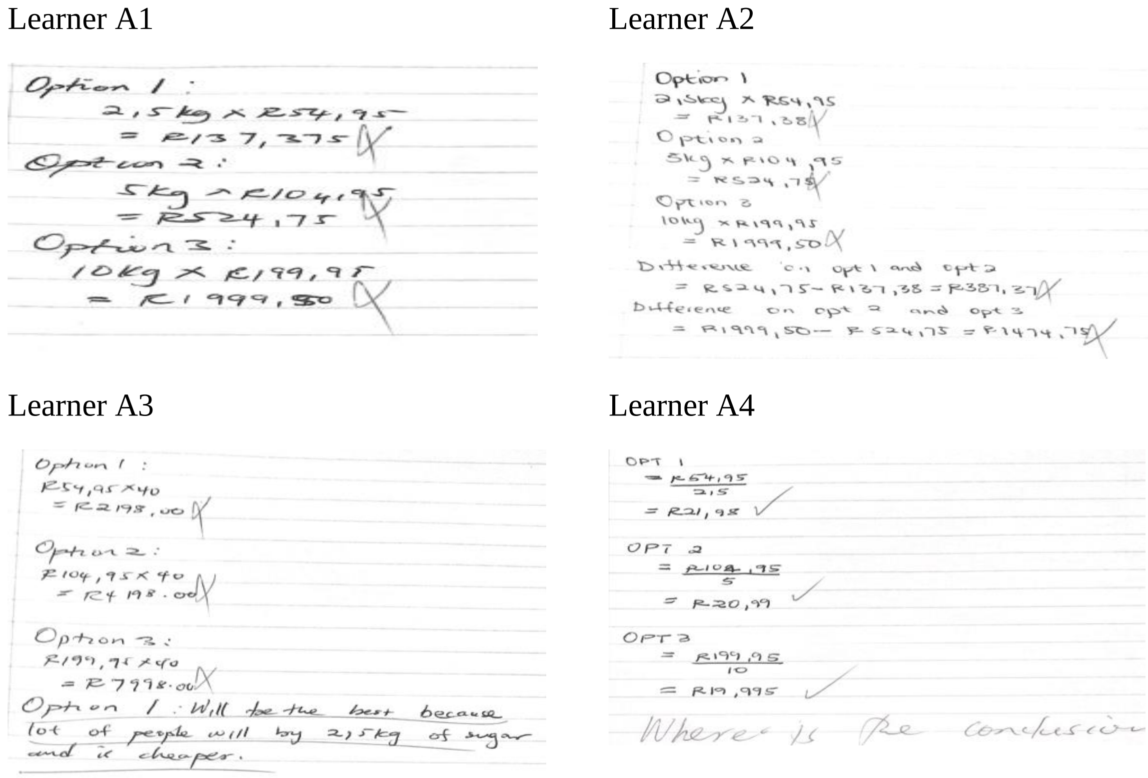
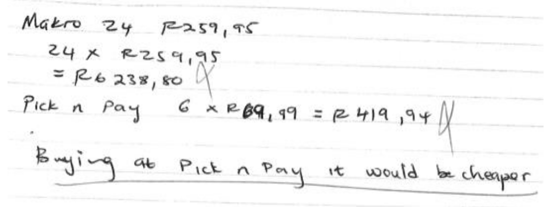


Figure 2: Learners solutions to question 1 of an authentic activity

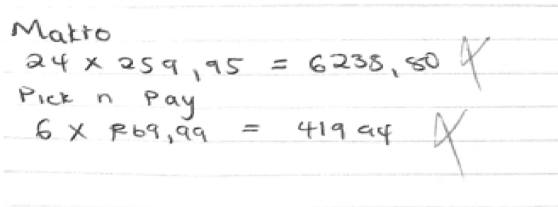
The learners encountered various obstacles while engaging with the authentic learning activity, indicating divergent challenges that they faced. For instance, learners A1 and A2 mistakenly assumed that the cost of one kilogram of sugar was R54.95. Additionally, learner A3 erroneously attempted to mitigate the discrepancy in sugar quantities by multiplying the number of individuals by 40, overlooking the essential comparison of sugar quantities. Lastly, while learner A4 successfully determined the price of sugar per kilogram, they failed to directly address the query posed by the learning activity. Upon reflecting on their responses as seen in Figure 2, it becomes evident that each learner adopted a distinct problem-solving approach. Nonetheless, each method encountered certain barriers, echoing findings by Wendt et al. (2020), who highlighted cognitive barriers inherent in solving authentic activities. These cognitive hurdles are tangible in learners' responses, such as the inclination to multiply quantity by price, indicating a deficiency in fully grasping the requirements of the activity. This analysis underscores the notion that while learners may engage in contextual activities, their ability to comprehend both the context and the problem at hand may be compromised. This phenomenon was noted by Blum and Leiβ (2007) as a cognitive barrier in the learning process.

Following the examination of learners' responses to the first question, the study proceeded to scrutinise their solutions to the second question. In this phase, the study sought to elucidate their cognitive dimensions of thought processes by analysing the solutions provided by the four selected participants. These solutions are presented in Figure 3 below.

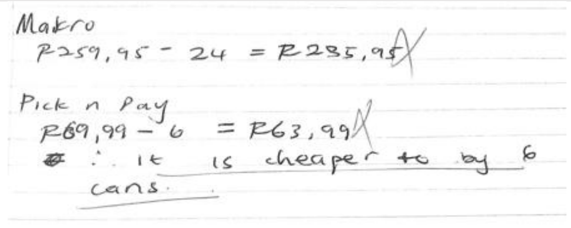
Learner A1



Learner A2



Learner A3



Learner A4

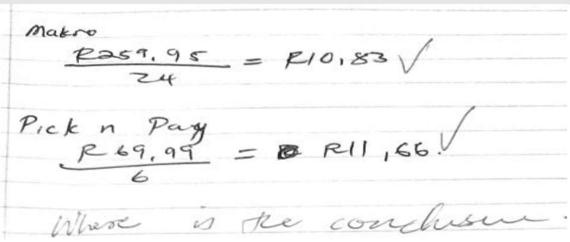


Figure 3: Learners solution to question 2 of an authentic activity

The learners' solutions, as depicted in Figure 3 above, reveal the complexities encountered when addressing authentic learning activity. Notably, learners A1 and A2 persisted in employing the method of multiplying quantity by price. However, while learner A1 offered a conclusion based on this method, learner A2 did not. Conversely, learner A3 opted to subtract the quantity from the price and subsequently derived a conclusion from the resultant value. Contrary to these approaches, learner A4 successfully executed the method of determining the price per quantity. Nonetheless, similar to learner A2, learner A4 did not provide a concluding remark. Examining the solutions of the four sampled learners as seen in Figure 3, it becomes apparent that they may struggle to apply their mathematical knowledge. Even though the activity was authentic, the learners failed to understand them. Hence, the failure to understand authentic activities demonstrated by these learners contradicts Frith et al.'s (2010) assertion that for one to understand mathematics, context should be prioritised through learning activities relevant to real-world settings. In adherence to this principle, the present study ensured that the learning activity was grounded in familiar contexts, with learners utilising items and shop names that were familiar to them. This approach aligns with Mhakure and Jakobsen's (2021) proposition that mathematics should be contextualised within realistic and familiar settings, thus eschewing contrived scenarios.

Conclusion

Thus, the amalgamation of these findings facilitates a response to the overarching inquiry: *How proficient are mathematical literacy learners in numeracy to make informed decisions?*

Primarily, it is evident that learners face challenges in applying their mathematical knowledge effectively in real-world contexts. Secondly, there exists an imperative to reformulate the pedagogical approaches in mathematics education to prioritise the advancement of authentic activities. Lastly, the integration of authentic activity into our educational curriculum should be obligatory to adequately equip learners to make informed decisions. However, it is pertinent to note that this conclusion warrants further validation with a larger sample size. Consequently, the scope of the study is restricted to a single school and a minority of participants, necessitating future research endeavours to replicate it using a broader sample.

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MISCONCEPTIONS AMONG GRADE 12 STUDENTS WHEN LEARNING DIFFERENTIATION RULES

JAMESON G, MACHABA, M.F. FASINU, V.G

It is empirically confirmed that some grade 12 learners learning differentiation are found struggling with the differentiation rules, and these include power rule, quotient rule, chain rule and product rules. Because of these, some students came up with some misconceptions which eventually resulted to students having multiple errors when learning the rules of differentiation. The reason associated with these common errors are not far from their failure to model some prerequisite knowledge in the laws of logarithm into their learning of laws of differentiation. And this has resulted to the poor performance of some students in mathematics since calculus carries about 40% in the overall grade in mathematics as a subject at grade 12 level in South Africa CAPS curriculum. On this note, the purpose of this paper is to present and analyse the grade 12 students' errors and misconceptions in learning differentiation rules. The study was conducted among grade 12 students preparing for NSC examination in a high school in Limpopo South Africa. And the data was initially collected from 35 worksheets among grade 12 students learning the topic of differentiation and differentiation rule. A qualitative approach was considered, and the data collected was analysed, focusing on product rules, quotient rules and chain rules and the errors committed. The result of the study indicated that some grade 12 students make some errors and misconceptions in differentiation rules. And these were because of poor conceptual understanding, poor mathematics language understanding, and some other error. It was also confirmed that the results of this study highlight some common mistakes and errors students make when learning differentiation rules, and these errors are; conceptual, systemic, language, and generalization errors.

Keywords: Misconceptions, errors, differentiation, rules, conceptual, systemic

Introduction

It empirically confirmed that there are some common misconceptions and errors that grade 12 students often encounter when learning differential rules (Makonye & Luneta, 2016). These misconceptions can hinder their understanding and application of differentiation concepts in a real-life situation. It is on this note that some researchers reported some common misconception among high school students (Maharaj & Ntuli, 2018). And some of these are: Procedural and systemics errors in differentiation rules-which is a form of error frequently committed by grade 12 students when struggling with the application of differentiation rules correctly. Apart from this, common procedural errors arise when the students failed to use the quotient rule appropriately when finding derivatives of fractions. In addition to this, when applying a chain Rule, there is tendency of misapplying the chain rule, especially in composite functions, and this may result to a common error among them.

More so, in Power Rule, there may be errors committed due to mistakes making among the students such as adding one to the power instead of subtracting, incorrectly bringing down the power, or failing to find the required derivative (Chikwanha, te al., 2022). Furthermore, it was also reported that the causes of misconceptions and errors among the students when learning differentiation are lack of prior knowledge, which may because of an inadequate prior knowledge of differentiation, logarithmic laws, proportionality, and integration concepts. More so, the sources of errors could also be due to students lack the foundational understanding on pre-differentiation concepts which may lead to struggle among the students when learning some complex differentiation rules (Chikwanha, et al., 2022). It is on this note that some researchers further argued that the conceptual misunderstandings may cause a form of struggling among the students when it comes to recognize the relationships between variables or understand the underlying principles (Chikwanha, et al., 2022). Because of this, some students have resulted to memorization and rote learning approach of learning differential rule which had led to a short-term success without a solid conceptual foundation (Oktaç et al., 2019). And these challenges could be resolved by identifying the correct variables, applying the chain rule, and simplifying expressions can be problematic (Kandeel, 2021). However, research by Chigede (2016) on advanced level high school learners' misconceptions in differentiation focused on students' ability to use the different rules and techniques of differentiation, for instance, the power rule, product rule, quotient rule and other rules. He reveals that some students have problems in distinguishing a power function from an exponential function, this implies they had a misconception on when to use the power rule to find derivatives. While $f(x) = x^3$ is a power function and the power rule can be employed to find the derivative, it is not appropriate in $f(x) = 3^x$ which is an exponential function. His studies also revealed that students struggled with applying the product and quotient rules when surds and fractional exponents were involved. These misconceptions resulted from a shallow understanding of surds, and rational exponents that should have been mastered during algebra lessons (Chigede, 2016). This research was guided by a research question stated below:

- What are the errors and misconceptions had by Grade 12 students when learning differentiation rules in calculus?

Conceptual framework

This section presents a framework adopted from a recent work of Jameson and others which reports some areas of errors committed by some grade 12 students, and all these errors are reported below in a diagrammatic illustration in figure 1.

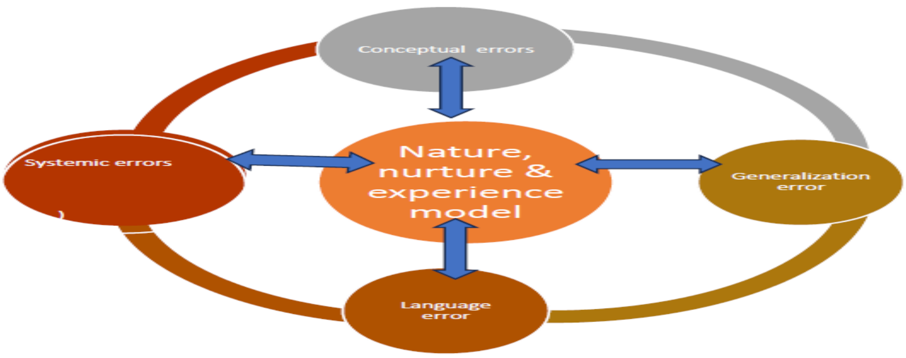

Figure 2: Differentiation rule misconception model (Jameson, Machaba and Fasinu, 2024).

Methodology:

This study was carried out using a purposive and convenient sampling and was done by selecting the Grade 12 mathematics learners at one of the secondary schools in Limpopo province. One of the researchers was an educator at the institution, and it was easy and convenient to reach the students. The grade 12 mathematics curriculum includes differential calculus hence the selected sample provided the required information. A survey questionnaire was adopted in collecting the views of grade 12 students learning differential rules. After which the views of 5 students were collected to get the insights of the grade 12 students when learning differential rule. All the participants contributed to the researchers' understanding on the misconceptions among grade 12 students when learning differentiation rules in calculus. In achieving the goal of the study, a qualitative approach of data collection was adopted to properly describe the misconception of grade 12 students. Furthermore, a sample of a worksheets of the students were collected and interpreted coupled with an interview section for a better understanding of the participants' insights on the misconception and errors committed by grade 12 students when learning differential rules.

Data presentation

This section of the study presents a short summary on the data gathered from then grade 12 students from a secondary school in Limpopo South Africa. And the result of 5 participants used were listed below. The sample question displaced below was used to test the grade students' misconceptions when answering questions on differential rule.

Question 1. *Given the following problem: Differentiate*

(i) $f(x) = (x^3+1)(x -5)$

(ii) $y= \frac{\sqrt{x}\ -\ 4}{\sqrt{x}}$

(a) Identify and explain the errors in the following solutions

Learner A

(i) $f(x) = (x^3 + 1)(x - 5)$

$f^{/}(x) = (3x^2)(1)$

$= 3x^2$

Learner B

(ii) $y= \frac{\sqrt{x}\ -\ 4}{\sqrt{x}}$

$\frac{dy}{dx} = \frac{x^{\frac{1}{2}-4}}{x^{\frac{1}{2}}}$

$= \frac{\frac{1}{2}x^{\frac{-1}{2}}}{\frac{1}{2}x^{\frac{-1}{2}}}$

$=1$

Write the correct solutions for both (i) and (ii)

Figure 1: Sample question used in testing the misconceptions on derivatives rules.

Question 1 was intended to check on the learners' procedural knowledge of differentiation using the rule that if $f(x) = ax^n$, then $f^/(x) = anx^{n-1}$. The question also tested the learners' conceptual knowledge of surds and the laws of exponents, as well as their algebraic skills of simplifying fractions, surds and exponents by finding derivatives of (i) $f(x) = (x^3 + 1)(x - 5)$ and (ii) $y = \frac{\sqrt{x}\ -\ 4}{\sqrt{x}}$. In resolving this problem, some learners in this group of nineteen learners, (19), found derivatives of each bracket and then multiplied to get the final answer as reflected in the worksheet submitted.

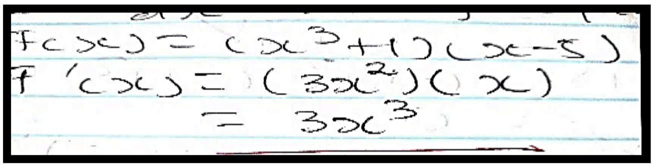

Figure 2-24: L24's solution to question 3b(i)

The result of the participants coded L24, show that there are forms of errors made, which include the generalisation or transfer error, as $\frac{d}{dx}f(x)g(x) \neq \frac{d}{dx}f(x)\frac{d}{dx}g(x)$. From the result, it shows that the student coded *L24*, found the derivative of each bracket separately first but committed yet another error on derivative of (x-5) which was given as x instead of 1. Strategies learnt earlier are overgeneralised and applied in calculus where they do not apply and this was compounded by a weak foundation on rules of exponents.

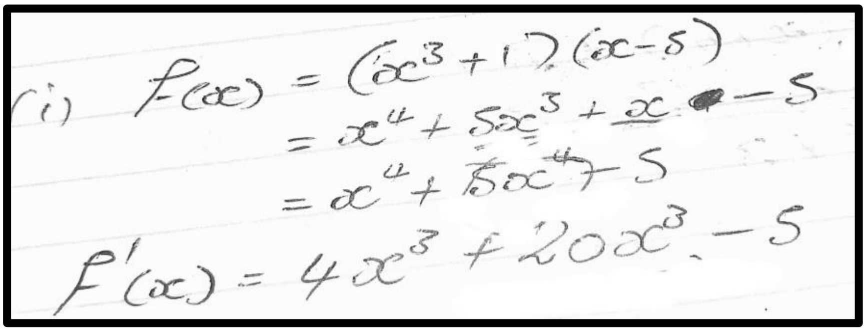

Figure 3-29: L29's solution to question3b(i)

Some students in this group of nine learners, group 9, failed to expand $(x^3 + 1)(x - 5)$ or failed to simplify the resultant algebraic expression as reflected in the work of L29 in Figure 4.19 above. This sample in Figure 3.29 demonstrated the impact of a weak foundation on extrinsic calculus concepts like algebraic skills on the learning of other concepts such as derivatives. This student coded L29, had problems applying the general rule for derivatives which state that when g*iven* $\boldsymbol{f(x) = ax^n}$, then $\boldsymbol{f^/(x) = anx^{n-1}}$, because of a poor grasp of algebraic skills where unlike terms are wrongly grouped, and addition is replaced by multiplication. While f$(x) = x^4 - 5x^3 + x - 5$ was correct, the derivative $f^/(x) = 4x^3 + 20x^3 - 5$ was incorrect as a result flaws in the learner's algebraic skills. One major challenge exposed by this question was learners' weak grasp of laws of exponents. A large group of twenty-seven learners, **(**ce4.3) (27), struggled with the application of laws of exponents and surds. Exponents and surds are extrinsic calculus concepts which are required as prior knowledge for the successful learning of new concepts in calculus. Some learners in this group gave the following solutions: From $f(x) = x^4 - 5x^3 + x - 5$, the derivative was given as $f'(x)=4x^3-15x^2+x$ or

$f'(x) = 4x^3 - 15x$. Others simplified y= $\frac{\sqrt{x}\ -\ 4}{\sqrt{x}}$ to y $=\frac{x^{\frac{1}{2}}-4}{x^{\frac{1}{2}}} = \frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} - \frac{4}{x^{\frac{1}{2}}} = x - 4x^{-\frac{1}{2}}$ *or* $y= \frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} - \frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} = 0 - 4x^{-\frac{1}{2}}$; as confirmed by the following four samples

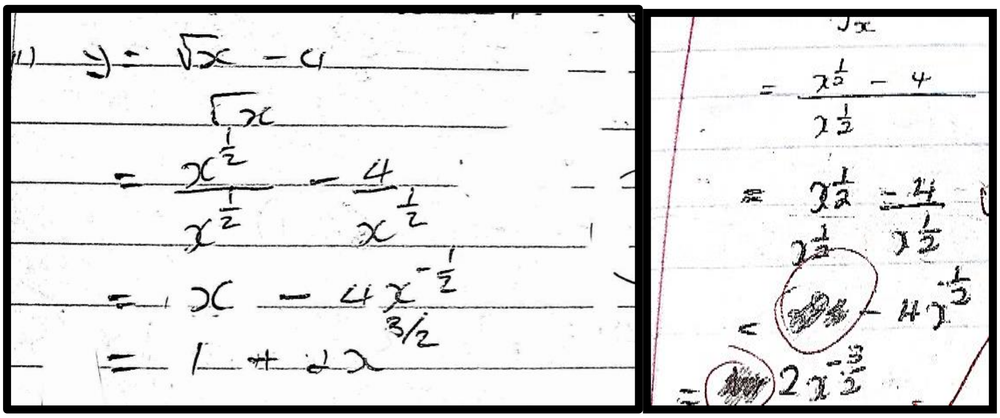

Figure 4.8

From the above samples in Figure 4.L8 *(a)* $\frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} = x$ for *L8*, and in Figure 4.20 (b), $\frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} = 0$ for *L9*; and the derivative of $f(x) = x^4 - 5x^3 + x - 5$ was given as $f'(x) = 4x^3 - 15x^2 + x$ in Figure 4.20 (c) for L2 , and the derivative of $f(x) = x^3 + x - 5x^2 - 5$ was given as $f'(x) = 3x^2 - 10x$ in Figure 4.20 (d*)* for L23. All the four samples in Figure 4.20 confirm the existence of a misconception on the derivative of *x* or the value of x^0 where wrong answers of $x^0=x$ and $x^0=0$ were often given instead of the correct answer of $x^0=1$.This misconception is a result of flaws in the learners' knowledge of laws of exponents which impact negatively on the learners' efforts to acquire new mathematical knowledge on calculus.

Interview on grade 12 students' misconceptions in the derivatives rules

The five learners *L8, L9,L10,L11* and *L12,* were requested to clarify their written responses to Question 3 out of the whole participants that participated in the study. And the extract of their views was reported below.

Learner 8'S misconceptions on rules of derivatives

The extract of students coded L8 shows that he demonstrates some understanding of the rules of derivatives for products and quotients, that $\frac{d}{dx}f(x)g(x) \neq \frac{d}{dx}f(x)\frac{d}{dx}g(x)$ and $\frac{d}{dx}\left(\frac{f(x)}{g(x)}\right) \neq \frac{\frac{d}{dx}(f(x))}{\frac{d}{dx}(g(x))}$. However, the learner had a flawed understanding of the laws of exponents where, for him, $x^0=x$ instead of $x^0=1$, and this misconception impacted negatively on his resolution of calculus questions. The second misconception in L8's solution is where $y=f(x)=f'(x)$, in this statement $y = x - 4x^{\frac{-1}{2}} = 1 + 2x^{-\frac{3}{2}}$. This is an incorrect statement as *f(x)* $\neq$ *f*$^{/}$*(x). This was extracted from the view of the participant as stated below.*

Researcher: *Can you please explain what you mean by 'derive before factorizing' in 3(a)?*

L8: *Learner A is finding derivative of each bracket without removing the factors first. Learner B should not substitute when there is a fraction from* $\frac{x^{\frac{1}{2}}-4}{x^{\frac{1}{2}}}$ *to* $\frac{\frac{1}{2}x^{-\frac{1}{2}}}{\frac{1}{2}x^{-\frac{1}{2}}}$.

Researcher: *Is learner B not finding derivatives?*

L8: *Learner B must not put the derivatives in a fraction, he must remove fraction first.*

This implies that there is misconception and error among grade 12 student.

Learner 9's misconceptions on rules of derivatives

On her part, the extract from student coded *L9* demonstrates that she understood the rule that $\frac{d}{dx}\left(\frac{f(x)}{g(x)}\right) \neq \frac{\frac{d}{dx}(f(x))}{\frac{d}{dx}(g(x))}$, but had a flawed understanding of laws of exponents. From her explanation that $x^{\frac{1}{2}}$ must be "*taken above",* her solution was expected to show $\frac{x^{\frac{1}{2}}-4}{x^{\frac{1}{2}}} = (x^{\frac{1}{2}} - 4)x^{-\frac{1}{2}}$ followed by the appropriate simplification using laws of exponents. The error in the solution for the derivative is a result of a weak foundation on laws of exponents where $\frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} = 0$ instead of $\frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} = x^0 = 1$ thereby committing a systemic error. However, when presented with a numerical fraction $\frac{2^2}{2^2}$, L9 got the correct answer.

This was extracted from this view of the participants as indicated below.:

Researcher: When you wrote that "learner B must take numbers below and take it above", which number are you referring to?

L9: Learner B must remove x^(1/2) below so there is no fraction.

Researcher: In your answer you wrote x^(1/2)/(x^(1/2)) – 4/x^(1/2) = - 4x^(-1/2), how did you get nothing or zero from x^(1/2)/x^(1/2) ?

L9 : When you subtract exponents 1/(2) - 1/(2) = 0 , from x^(1/2)/x^(1/2) final answer is 0.

This implies that there is misconception and error among grade 12 student.

Learner 10’s misconceptions on rules of derivatives

The participants coded L10’s misconception on the derivatives rules as indicated by his worksheet was because of a flawed understanding of laws of exponents, specifically the law which states that $x^0 = 1$. From $\frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} = x^{\frac{1}{2}-\frac{1}{2}} = x^0 = 1$, L10 did not appreciate he must simplify exponents of x and that $x^0 \neq 0$. The second error of $\frac{4}{x^{\frac{1}{2}}} = 4x^{\frac{1}{2}}$ is also a result of the learner’s failure to realize that $\frac{4}{x^{\frac{1}{2}}} = \frac{4x^0}{x^{\frac{1}{2}}} = 4x^{0-\frac{1}{2}} = 4x^{-\frac{1}{2}}$. Therefore, a weak background knowledge of the laws of exponents impacted negatively on the learner’s progress in understanding new calculus concepts.

This was extracted from his view stated below.

Researcher: *In your answer, you wrote* $\frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} - \frac{4}{x^{\frac{1}{2}}} = 0 - 4x^{\frac{1}{2}}$, *how did you get zero from* $\frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}}$ *and* $4x^{\frac{1}{2}}\, from\ \frac{4}{x^{\frac{1}{2}}}$?

L10: *I used laws of exponents which says subtract exponents when you divide,*

$\frac{1}{2} - \frac{1}{2} = 0$ *, so I wrote 0 to simplify.*

This view of the participant shows that there is misconception and error among grade 12 student When learning differential rules.

Learner 11’s misconceptions on rules of derivatives

Similarly, participant coded *L11* misconceptions on the learning of the derivatives rules emanates from a poor mastery of laws of exponents and surds. Firstly $\left(\sqrt{x}\right)^{\frac{1}{2}} = \left(x^{\frac{1}{2}}\right)^{\frac{1}{2}}$, which is not what the learner wanted here when he wrote $\frac{(\sqrt{x})^{\frac{1}{2}}-4}{(\sqrt{x})^{\frac{1}{2}}} = \frac{x^{\frac{1}{2}}-4}{x^{\frac{1}{2}}}$. The intention was to remove $\sqrt{\ }$ and replace it by exponent 1/2, but writing both at the same time changes the mathematical statement and

$\frac{(\sqrt{x})^{\frac{1}{2}}-4}{(\sqrt{x})^{\frac{1}{2}}} \neq \frac{x^{\frac{1}{2}}-4}{x^{\frac{1}{2}}}$. The second misconception is about x^0, which, *L11* equates to *x*, yet $x^0 = 1$ so that $\frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}} = 1$. While the student can deal with $\frac{3^2}{3^2} = \frac{9}{9} = 1$, he failed to generalise to $3^{2-2} = 3^0 = 1$. On this note, the student’s progress in acquiring new knowledge and resolving problems in calculus is negatively affected by earlier misconceptions developed in learning concepts in surds and exponents. Thereby committing a systemic error in his calculations.

This was extracted from the view below.

Researcher: *Explain what you mean by "did not substitute the $f^{/}(x)$"*

L11: *$f^{/}(x)=(3x^2)(1)$ is only derivative of x^3, he must remove brackets to get the correct derivative.*

Researcher: *You wrote* $\frac{(\sqrt{x})^{\frac{1}{2}-4}}{(\sqrt{x})^{\frac{1}{2}}} = \frac{x^{\frac{1}{2}-4}}{x^{\frac{1}{2}}}$, *explain why.*

L11*:* *Where there $\sqrt{x}$, it means 'square root of x' and using exponent.*

The views of the participant shows that there is misconception and error among grade 12 student when learning differential rules.

Learner 12's misconceptions on rules of derivatives

Despite the challenges encounter by other participants the student coded *L12* has mastery of the mathematical rules governing the determination of derivatives of products and quotients of functions, i.e. $\frac{d}{dx}f(x)g(x) \neq \frac{d}{dx}f(x)\frac{d}{dx}g(x)$ and $\frac{d}{dx}\left(\frac{f(x)}{g(x)}\right) \neq \frac{\frac{d}{dx}(f(x))}{\frac{d}{dx}(g(x))}$. The student's reference to "equation" in his explanation appears to be a grammatical error as opposed to a mathematical misconception. And this could be regarded as a language error which may contribute to a misconception if care is not taken when learning derivatives rule.

From the analysis of the data stated above, four out of the five interviewed learners, *L8*, *L9*, *L10* and *L11*, have been struggling with the question of whether $\boldsymbol{x}^{\frac{1}{2}-\frac{1}{2}} = \boldsymbol{x}$, or $\boldsymbol{x}^{\frac{1}{2}-\frac{1}{2}} = 0$, both of which are incorrect, as the correct answer is $\boldsymbol{x}^{\frac{1}{2}-\frac{1}{2}} = x^0 = 1$. While the students can give the correct answer of 1 for $\frac{4}{4}$ or $\frac{3^2}{3^2}$, they fail to generalise the principle to $\frac{x^{\frac{1}{2}}}{x^{\frac{1}{2}}}$. This is evidence that the students' knowledge of laws of exponents is instrumental as opposed to their relational knowledge. students have doubts on the laws of exponents, then they are likely to struggle with mastering calculus concepts where the standard rule for derivatives is defined in terms of exponents, i. e. for $\boldsymbol{f(x) = ax^n}$, $\boldsymbol{f^{/}(x) = anx^{n-1}}$. Hence a lack of a strong foundation on working with exponents and surds creates a barrier for the learner to deal successfully with calculus concepts. This was extracted from the view of participant stated below.

Researcher*:* *When you were identifying errors in Learner B's working, you mention that he "*did not remove the equation from fraction", *explain what you mean.*

L12*:* *He should remove x from the bottom of this fraction* $\frac{x^{\frac{1}{2}-4}}{x^{\frac{1}{2}}}$ *before finding derivative. He must divide each term at the top by* $x^{\frac{1}{2}}$

The view of the participant shows that there is misconception and error among grade 12 student when learning differential rules.

Discussion and Conclusion

The misconceptions found among the grade 12 students when learning differentiation rules include generalisation or transfer errors, conceptual error, wrong hypothesis used to learn new concepts (Hypothesis error), and systemic errors due to a procedural mistake. Gathering from sample question 1 adopted, it was intended to address the issue of generalisation or transfer errors on finding the derivative of products of functions and quotients of functions. Secondly, the question also intended to assess the algebraic skills of algebraic multiplication and division and the laws of rational exponents. This study shows that some Grade 12 learners have the misconception that the derivative of the product of two functions is equal to the product of the derivatives of the functions. Some students interpreted the derivative of a quotient of functions to be equal to the quotient of the derivatives of the function.

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DIGITAL LITERACY PRACTICES IN SCHOOL LEARNERS: EXPLORING CURATION AND ANNOTATION WITH E-TEXTBOOKS

E. RZYANKINA AND A. M. MSOMI

E-textbooks have become increasingly popular in recent years, thanks to their advanced digital features and easy accessibility. This shift has led to the emergence of innovative digital literacy practices, particularly curation and annotation, aimed at enhancing learners' understanding of various subjects. These practices offer three key benefits: they help manage information overload, allow teachers to provide additional context, and offer a structured learning framework for learners. This study, which focuses on these benefits in e-textbooks, used qualitative data from interviews with grade 12 learners at a high school. The findings suggest that these new literacy practices have significant potential for improving learners' understanding of various subjects.

Keywords: school learners, e-textbooks, curation and annotation, literacy practices, reading, technology

Introduction

Digital literacy, the ability to use technology efficiently and with confidence, is crucial in our current technological environment. As we progress further into the digital era, the ability to utilise digital tools - such as computers, tablets, software, and the internet - becomes increasingly important. With the advancement of contemporary education, e-textbooks have become essential tools for learners, providing an interactive aspect that goes beyond traditional books. They enable learners to not only highlight and annotate but also to customise their learning through curation and annotation. Despite the widespread use of e-textbooks, there is still a research gap regarding their digital literacy benefits.

South African high schools have recognised the importance of providing learners with both knowledge and technological access to digital learning tools. However, there's a scarcity of data on their interactions with e-textbooks. The complex nature of subjects such as engineering requires learners to not just consume but critically evaluate digital content, using it to construct convincing arguments. The intricate nature of these tasks calls for additional guidance and in-class support for these learners. In this context, e-textbooks should offer adaptive assistance as learners grapple with complex concepts.

E-textbooks' capabilities include features like curation and digital annotation (Chen & Tsay, 2017). Curation helps learners sift through and organise digital content, enabling them to prioritise essential information. Annotation allows for reflective note-making, assisting learners in understanding and connecting diverse ideas. These practices enhance comprehension and retention, equipping learners with skills that go beyond the classroom and prove invaluable in their future pursuits.

The aim of this study is to explore in depth the benefits of e-textbooks, specifically annotation and curation; to contribute this knowledge to the scientific body of knowledge; and to offer this as a tool for future learners to better comprehend digital learning material and make connections between various or different ideas.

Literature review

As teachers, we anticipate that learners will transition smoothly between different modes. It's vital to establish a comprehensive vocabulary that encapsulates the various dimensions of texts. This includes elements such as movement, sound, dynamics, and the implicit aspects inherent in both visual and verbal print texts. This requires a deep understanding of representational modes, which include means of making meaning like speech, writing, images, gestures, music, sound, and simulations. Additionally, it's crucial to be familiar with both traditional and emerging media for disseminating these meanings, such as books, magazines, computer screens, social media posts and vlogs (like those on Instagram and Twitter), videos (with the use of filters and masks), films, stories (found on platforms like Instagram and TikTok), and radio. To achieve this, we must examine the unique affordances of each mode and medium—understanding what each facilitates or restricts—and grasp the inherent logic of texts. This refers to the text cohesion that ensures coherence, as elaborated by Bearne and Kress (2001).

Digital annotation is a vital tool for our digital times. It enables users to instantly attach comments, feedback, and additional digital insights to electronic documents. This functionality aids in processing the vast digital data we encounter daily. Such annotations enhance the structure, legibility, and comprehension of documents, assisting users in monitoring their activities and swiftly identifying relevant details. Moreover, digital annotation fosters teamwork, simplifying the exchange of thoughts and collective efforts on tasks. The utility of digital annotation in today's world is undeniable and warrants universal adoption. When compared with traditional paper-based annotations, the digital method stands out. Digital annotations are more streamlined, allowing for immediate additions without the need for printouts. They also promise greater security by archiving notes on protected servers instead of physical paper. Collaborative tasks benefit from the ease of sharing and joint access. Plus, the convenience of accessing annotations from any web-connected device surpasses traditional methods.

Given the slow nature of the publishing process and limitations of storage, traditional paper books in the modern world do not allow for sufficiently fast access to information and constitute only one of many possible resources for studying. In the modern world, the information we receive and the process of searching become much faster than we experienced before. Fake news, untrustworthy websites, and the circulation of extremist propaganda suggest the need for a new kind of critical reading (Luke, 2018). Any learning requires the acquisition of knowledge, and today, knowledge is accessible through a variety of resources and platforms, not only the books that are prescribed. Learners can choose to learn from a variety of platforms and resources, then use those tools to evaluate their comprehension and meaning and confirm what they have learned. On the one hand, by choosing and navigating the text, learners have control over their learning. On the other hand, not all learners are adept at evaluating and curating materials to identify those that are most reliable and connect with the reader in terms of comprehension and authorial style. In order to assimilate the information and comprehend the concepts, the reader must also pay attention and develop new literacy skills of critical reading to recognise fake news, untrustworthy websites, and the circulation of extremist propaganda (Luke et al. 2018).

Research comparing print and digital mediums often focuses on memory retention (Matraf et al., 2015). Generally, findings suggest that learners recall more from paper-based readings. However, this might be due to a lack of efficient reading techniques in digital environments. Digital annotations in e-textbooks offer a transformative approach to learning. They enable learners to highlight, comment, bookmark, and even share insights, streamlining their learning process. Moreover, they can access multimedia resources like videos, audio, and quizzes, enhancing comprehension. The essence of digital annotation is its customisation, enabling learners to emphasise relevant content, fostering deeper engagement. Sharing notes also promotes collaborative learning, making digital annotation an essential tool for maximising educational experiences.

Digital curation in e-textbooks is a significant advantage for learners. It empowers them to tailor content to their preferences, ensuring a more personalised educational journey. Such curation enables swift topic searches, content organisation, and ensures they remain up-to-date with current academic advancements. The highlight of digital curation is its adaptability, allowing learners to access and focus on relevant content while maintaining organisation. This tailored learning approach grants learners' autonomy, enhancing their engagement with materials.

However, research reveals a discrepancy: learners aren't fully utilising the capabilities of e-textbooks, based on interviews and observations. This highlights the prevailing challenge: understanding the reluctance of learners toward e-textbooks and their rationale.

Conceptual frameworks

The underpinning philosophy for this study's use of Mediated Discourse Analysis (MDA) (Scollon, 1998; 2001; 2014) is grounded in the Cultural-Historical Activity Theory (CHAT). Theorists such as Vygotsky (1980) and Leont'ev (1974) developed CHAT, arguing that cultural artefacts and historical contexts significantly influence human activities. With this viewpoint, MDA emerges as an effective methodology for qualitative investigations, with its strength lying in its ability to decipher the nuances present in complex learning situations.

In research fields, it's common to be overwhelmed with large amounts of observational data, particularly when exploring the complexities of real-world contexts. Navigating this vast volume necessitates a strategic method like MDA. By focusing on discourse as a mediator, MDA assists in drawing meaningful conclusions from copious data, ensuring a thorough interpretation of the observed phenomena.

The inclusion of MDA in this study was not merely coincidental. It was selected for its proficiency in addressing queries related to societal actions. Within the scope of this research, societal interactions are predominantly mediated via e-textbook content. Therefore, reading is more than an individual act; it links the individual with the broader community. As participants navigate this digital landscape, they employ specific digital literacy techniques. Decoding these methods and their associated discourse is crucial to understanding contemporary learning environments.

Methodology

This research adopted a qualitative approach, drawing inspiration from the foundational work of Lincoln & Guba (1985). This method was chosen to delve deeper into the experiences of participants, yielding insights that might be more detailed than those from quantitative approaches.

Case Study Design

In accordance with Yin's guidelines (2003; 2009), the investigation was structured as a single case study, comprising two interconnected analytical units. Each unit, while distinct, was related to the other, facilitating a comparative study of the central theme. The primary sample involved learners studying Chemical Engineering, focusing on pupils from the Chemical Engineering faculty. The secondary sample included Nautical Science learners, focusing on those from the Department of Maritime Studies.

Participant Selection and Data Collection

From the two aforementioned departments, twelve first-year engineering learners were purposefully selected for participation, ensuring a balanced representation with six learners from each department. The selection criteria were their willingness to participate and their provision of informed consent, ensuring the ethical integrity of the research. Upon securing their agreement and signed consent forms, a series of interactions were initiated. I conducted individual interviews with the participants, aiming to understand their experiences, perceptions, and challenges related to reading digital Physics e-textbooks. Additionally, observations were made as they engaged with these e-textbooks, providing a comprehensive view of their reading habits, strategies, and potential areas of struggle. By combining both interviews and observations, this study was designed to capture a comprehensive picture of the participants' experiences, shedding light on the nuances of digital textbook usage among budding engineers in two distinct academic disciplines.

Data Analysis

Before moving data transcripts into ATLAS.ti, I performed automatic transcription via Otter.ai software and manually corrected where the meaning and spelling were not correct due to accent and pronunciation of the diverse participants. Then, data analysis was done in ATLAS.ti software in two cycles: first, I coded inductively, and after that, I coded the same data deductively using theoretical concepts from MDA. Interviews comprised the qualitative data that will be analysed through MDA (Scollon, 1998; 2001; 2014) procedures.

The method of MDA procedures includes three steps of data analysis. The first step is engaging with nexus of practices. The analysis of data does not constitute discrete processes: the researcher analyses (parts of) the data during the process of gathering data, which in turn makes her see what other kinds of data might be useful. Following Scollon (1998), I kept in mind that this step constitutes how the learners engage in digital and social literacy practices. In the second step, I navigated the nexus of practice. In this study, MDA applied in the following way where the researcher will engage with data from the audio and visual recordings. This will allow a more detailed analysis of not just phonological and grammatical aspects of language but also the non-verbal and contextualised language use of the participants. The third step comprises changing the nexus of practice. By engaging with data, the researcher may produce a positive social change in practices. In other words, I explored how the nexus of practice has already changed over the course of the research and how the relationship between the researcher and participants has changed. In this study, this approach will be applied by the findings of the study and writing the recommendations for future investigation.

Ethics

A letter of invitation was given to all registered learners, explaining the requirements for learner participation and the research purpose of this study. Those learners that volunteered to be part of this study were asked to sign an informed consent form, and return it to the user analyse.

Data Analysis and Discussion

In this section, we delve into two crucial aspects of digital literacy in the realm of e-textbooks: curation and annotation. Both elements play a significant role in how learners interact with digital content, and understanding their nuances can provide educators with insights on how best to guide their learners in the digital age.

Curating

In this section, I discuss digital curation as a reading strategy and why it is important to train learners on how to read digital text and curate the information. With the abundance of available information and resources, it can confuse or even mislead the learner. For example, Learner 13 expressed a preference for accessing all of the idea presentation options in an e-textbook from a single location where they may read text, view videos, and annotate. *... I don't just watch videos that are random. I watch videos which are in the e-textbook then I note down*.

It was noticed that learners do not know how to check the information. For instance, Learner 13 has full trust that Google provides accurate answers. However, other learners experienced problems with the plethora of available resources, and selecting the correct one becomes a challenge . *Because it's well known that Google gives accurate answers*. Learner 11 shared their experience of getting confused when different videos explain the same topic in different ways. They prefer to listen to multiple explanations and try to interpret the information in their own way.

I get confused. Because sometimes they will explain things. And then I would get it. And then when I watch another video, though, explain. They don't explain it in the same way they do the difference. Let's say that when I watch this topic, they're more dynamic. So let's say when I go to YouTube and search for it, there will be different platforms on which I can watch this video. So they show different views. I choose when I want to listen first. When I don't understand the first one, I prefer to go to the next one

A similar view of not being sure how to curate the information was expressed by Learner 9. They believe that one cannot be certain if the information is correct. However, if they read a sentence from the e-textbook, they start to get a sense of the meaning. If they see another description, they can see some correlation if the descriptions mean similar things. So, they wouldn't just simply go straight to the internet, but if they do go to the internet, they go to a well-known website, or a name they've seen before, not just anything.

I don't think you can know for sure if it's right. But if you read a sentence from the e-textbook, you will start to get a sense of the meaning. And if you see another description, you can see that there is some correlation if they do mean similar things, just that one you understand more.

Annotation

The function of annotation as an affordance represents one of the emerging capabilities of an e-textbook, an aspect that prior research on e-textbooks has not fully explored. Within this discourse, we will delve into how the capacity for annotation serves as a learning tool when school learners utilise an e-textbook.

Annotation serves to facilitate comprehension during reading and subsequently aids in the process of articulating thoughts through writing about key concepts. Utilising an e-textbook, readers can also engage in collaborative interactions with other readers and texts. A learner expressed this sentiment, affirming the value of sharing notes: *I think I watched the video many times to make a note by writing it down. So it is it will be better for me to understand and write it down.* Similarly, another learner articulated their approach: *When I'm watching videos on YouTube, I pause the video and take notes. So that's how I do* commencing with reading the text followed by transcribing notes onto paper. Thus, annotation enhances accessibility to knowledge for this learner, fostering robust engagement and facilitating learning.

E-textbooks empower learners to actively engage with the text through various forms of annotation, encompassing commentary, highlighting, and even the use of emoticons. This digital medium allows students to annotate diverse elements such as text, images, videos, and audio, facilitating the identification and categorisation of concepts for study purposes. These novel modes of annotation present fresh avenues for learning. For instance, one learner outlined their study methodology: first consulting diagrams, then reviewing textual guidance …*there might be other words that I don't understand. So I tried to think if I put it in a way that I can understand, I'm trying, by all means, to understand what is written and annotate the text.* Consequently, to grasp the authors' intended message, they absorb information from textual tips while simultaneously making notes. *I'm looking at videos. As the video goes on, I'll pause at some point where it gets important information. Then I write it down. Honestly, I believe in just putting things down so that I can clearly understand it…*

These notes serve as intermediaries between reading and writing, comprising a variety of media formats that communicate through different modes, including video transcripts, symbolic representations of practical examples, and imagery. This student elucidates their study routine through a sequential interaction model: diagrams → tips (succinct summaries) → annotation. Within this framework, the act of annotation transitions from a passive to an active stance, leveraging the affordances of digital text, particularly graphical presentations.

Moreover, the e-textbook platform permits users to employ comments, including emoticons, to engage with the text. The interplay between annotation and comments, both common modes of communication, furnishes valuable contextual insights and personal reflections concerning the text. The integration of emoticons into the learning process is exemplified by one student's use: ... *my hand needs to be busy*. employing emoticons while reading the text. This participant employs emoticons for commentary purposes, labelling sentences and paragraphs to denote clarity or areas necessitating further elucidation. Consequently, the participant can revisit these annotations and modify emoticons, transitioning from expressions of surprise or dissatisfaction to satisfaction. The utilisation of emoticon icons serves as a rapid means for the reader to express personal sentiments regarding specific aspects of the text. Here, emoticons primarily function as markers for revisiting sections for further study.

Conclusion

The function of annotation as an affordance represents one of the emerging capabilities of an e-textbook, an aspect that prior research on e-textbooks has not fully explored. Within this discourse, I will delve into how the capacity for annotation serves as a learning tool when school learners utilise an e-textbook.

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WORKSHOPS

PROBLEM SOLVING IN THE SENIOR PHASE WITH A SPECIAL FOCUS ON GRADE 7

The Answer Educational Publishers

JENNY CAMPBELL & SUSAN CARLETTI

Maths is more than procedural application. Let's change the mindset of our learners by helping them discover the joy of effective problem solving without the restrictions imposed on them by more formal algebraic approaches. We need formal proof to verify and confirm our solutions and theories, but we don't need to solve every problem in a prescribed way. Grade 7s are just beginning to solve equations and are still encouraged to solve them by inspection, so how do we help them to problem solve in the absence of formal equation solving techniques? The first challenge is rethinking our own strategies and stripping ourselves of approaches not available to Grade 7 learners. This will be a hands-on, collaborative and interactive workshop, so come prepared for a mind-blowing experience.

Problem solving techniques & strategies [20 minutes]

What are the most effective options for tackling problems? This is an open-ended question, but with the help of some suggested strategies and input from participants, we plan to create a toolbox of options that will serve as an initial starting point.

Practical applications of different strategies [25 minutes]

We will tackle at least one question per strategy to develop an understanding of the decisions we need to make when problem solving. There will be an opportunity for participants to share their approach and discuss alternatives.

Mixed problem -solving questions [60 minutes]

Participants will tackle questions in groups, working at their own pace.

This session will be facilitated and interactive, with discussions around different approaches and techniques. Participants will be invited to share different options and to discuss their ideas.

Wrap up and closing comments [15 minutes]

Resources will include:

1) Questions for the SAMC papers

2) Adapted questions from the new Grade 7 Answer Series book

NBTS – A MOTIVATED TEACHER'S SECRET WEAPON & A CO-OPERATIVE LEARNER'S GOLDEN OPPORTUNITY

The Answer Educational Publishers

JENNY CAMPBELL & SUSAN CARLETTI

Maths NBTs can cause anxiety in learners, parents and teachers. Some tutors and organizations are jumping onto the band wagon and "creating opportunities for learners to prepare" for these tests. This may be good business practice, but a very strong case can be made about the potential "widening of the gap" between the well-resourced schools and the lower quintile schools. It is our belief that a better understanding of the NBTs will contribute to teachers adapting their style of teaching to include the type of thinking required for NBTs, as well as an improved number sense in our learners. We plan to highlight those areas in our teaching that provide opportunities for our learners to develop confidence in their abilities, as well as to equip them with the basic skills needed in the absence of calculators.

WHAT ARE NBTS & what is their purpose? [20 minutes]

This will be an interactive introduction and provide an opportunity for everyone to share their learners' experiences of the NBTs, as well as their own perceptions. We will fill in any gaps in this discussion to ensure that we are all on the same page in terms of our understanding of the official information available to us.

Maths NBTs

https://nbt.uct.ac.za/content/what-nbts

Questions taken from the NBT Website [30 minutes]

(3 pages document attached)

We will look at a few questions together and then split up into small groups.

Each group will be given a few questions to do and then to provide feedback on the following:

- Should the content of the questions be familiar to the learners?
- Are there specific skills needed because of the absence of calculators?
- Are different skills needed for multiple choice questions?
- What can we do differently in our teaching to ensure that our learners are well prepared for the style of testing in the NBTs

Questions taken from the Olico Website [30 minutes]

(1 page document attached)

https://learn.olico.org/

- 4 online tests each with 60 questions (with detailed solutions)

- Free 80 page, downloadable and printable NBT MAT booklet with detailed solutions

Essential skills needed for Maths NBTs [30 Minutes]

- allocate different grades to different groups and ask groups to do the following:
    - identify "number sense" skills that should be reinforced
    - identify calculation techniques that need to be developed
    - identify basic areas of learning such as
        - special triangles
        - ratios
        - percentages
        - calculations involving number sense
- if time permits, encourage online research (both the UCT website and Olico) to check that all areas have been covered

If any of the above discussions take less than their allocated time slots, then there will be time for a discussion on QUANTITATIVE LITERACY.

(7 pages document attached)

Wrap up and closing comments [10 minutes]

References

UCT **https://nbt.uct.ac.za/content/what-nbts**

Olico **https://learn.olico.org/**

ADDRESSING GRADE 8 MATHEMATICS CONTENT BACKLOGS THROUGH THE SIYAVULA ED-TECH PLATFORM.

LINDIWE TSHUMA & **NICKY ROBERTS**

UNIVERSITY OF THE WITWATERSRAND & STELLENBOSCH UNIVERSITY

- **Target audience**: Senior Phase Teachers
- **Duration**: 2 hours
- **Maximum number of participants**: 50
- **Motivation for the workshop**: The objectives of this workshop are to:
  - Discuss how the Siyavula Mathematics Backlogs platform addresses content backlogs in South African secondary schools,
  - Guide Senior Phase (SP) teachers on how to identify content backlogs at Grade 8 level using the Siyavula platform,
  - Strengthen SP teachers' approaches to addressing Mathematics content backlogs using Ed-tech; and
  - Give teachers a voice of their experience in addressing Mathematics content backlogs.
- **Description of content of workshop**: 5 minutes discussion on the importance of addressing mathematics content backlogs at Grade 8 level, 25 minutes discussion on how to use the Siyavula online platform to consolidate the Grade 8 mathematics content taught in class, 60 minutes practical activities: administration of the ESPMA on computers or tablets, 20 minutes feedback / question and answer session, 10 minutes workshop evaluation.

The presenters will use the Siyavula Mathematics Backlogs Ed-tech platform to introduce the workshop. Teachers will be guided on how to use the Siyavula platform in groups of five. Teachers will attempt the ESPMA, which consists of 60 test items on the content areas algebra and number divided into four sections (multiple choice questions 58%, EGMA Senior Patterns 8%, EGMA Senior quantity comparisons 17%, and EGMA calculations 17%), following a discussion session. The ESPMA is mapped against the Global Proficiency Framework for mathematics in primary schools. Teachers will take the ESPMA individually using laptops or tablets, or they can use the worksheets provided. The workshop will be concluded by discussing how teachers can use the ESPMA to identify mathematics content backlogs at the Grade 8 level.

- **Activities and worksheets to be used during the workshop**:

Copies of Teacher Worksheets:

- ESPMA: Early Senior Phase Mathematics Assessment

- **An abstract describing the level, nature and content of the workshop** (200 words)
  Note: Only this abstract will be published in the Congress Proceedings.

Mathematical foundational knowledge gaps in the early grades have resulted in cumulative learning backlogs and are a major cause of the subpar mathematics learning outcomes in South African schools. A solid understanding of material from earlier grades facilitates the effective learning of mathematics concepts in later grades. Quintiles 1 to 3 schools have the highest backlogs, in part due to inadequate resources for addressing backlogs and low parental involvement. Inappropriate teaching and learning resources, along with the density of CAPS—which is difficult for most teachers to finish while guaranteeing strong conceptual understanding—also add to backlogs. The ESPMA enhances traditional classroom teaching through the use of educational technology. Teams of researchers and educators determined that this instrument possessed the necessary content validity. It was subsequently used on a sample of Grade 7 learners, and the reliability score of 79%, or 0.79, falls within the suggested range of 0.70 to 0.95 (Tavakol & Dennick, 2011). Through this workshop, teachers should be able to explain how to address learning backlogs at the Grade 8 level in order to improve mathematics outcomes. Resolving learning backlogs at this stage could result in better mathematics comprehension, more learners participating in mathematics at the FET level, and better mathematics results for the NSC.

DECOMPOSING COMBINATIONS TO DEVELOP COMPUTATIONAL THINKING

H. TSHESANE

University of the Witwatersrand

Combinations are often taught using the formula for Combinations($^n_rC = \frac{n!}{r!(n-r)!}$). Whilst this formulaic approach to calculating Combinations has been tried and tested to produce correct answers, introducing students to Combinations through the formula does little to foster conceptual understanding. Moreover, the formulaic approach to computing Combinations does not require of the solver to break down the problem into smaller more manageable parts (decomposition), to look for similarities among and within problems (pattern recognition), extract general properties from particular and specific situations (abstraction), nor does it promote a step-by-step generation of the solution (algorithm). In short, the failure of the formulaic approach to prioritize the four cornerstones of computational thinking (decomposition, pattern recognition, abstraction and algorithm) means that the opportunity to develop computational thinking in students is lost. In this workshop, I offer an approach designed to develop computational thinking in students in the course of learning about combinations. The approach makes use of a method of expressing ^n_rC calculations as weighted sums and uses Pascal's triangle to find the values by inspection. The workshop will provide participants with a practical and interactive experience in which they can try out the method across a set of carefully chosen problems.

What will be done in the workshop?

The central focus of this workshop will be on using the method to solve the following types of problems involving combinations:

If a committee has 10 women and 7 men,

a) in how many ways can a subcommittee of four members be formed such that:

b) what is the probability that a subcommittee of four members can be formed where:

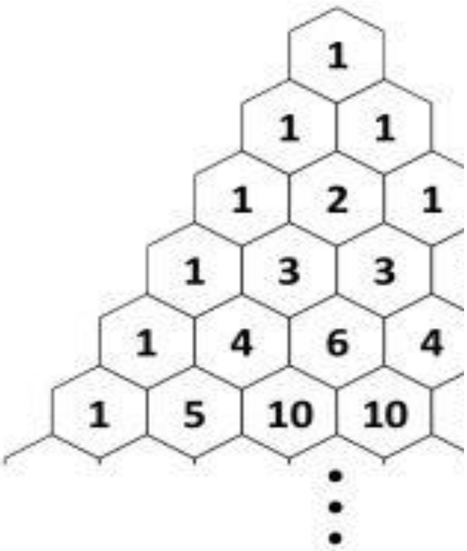
i. All four members are men,

ii. Two are men and two are women

iii. At least one member is a woman,

iv. At most three members are women.

<u>The tool for finding the values of combinations by inspection</u>



Breakdown of timeslot

A problem-solving approach will be adopted and the time will be split as follows:

Time	Activity
First 15 min	Introducing the concepts
Next 15 min	Examples with entire class
Next 20 min	Participants work in pairs on the exercise set
Last 10 min	Consolidation

The activities and worksheets to be used in the workshop

Problem#	Understand the Problem	Make a Plan	Solve the Problem
Q#1	Determine the number of ways you can sample 2 different fruits out of 4 different fruits.	Consider the collection of all of the fruits as a set, then consider only the subsets that have 2 elements in them. This then turns into a problem of how many two-element subsets there are in a set of 4 elements.	There are 6 two-element subsets in a set of 4 elements. Thus, there are 6 different ways that 2 fruits can be selected from 4 fruits.
Q#2	Determine the number of ways you can sample 2 different vegetables out of 5 different vegetables.	Consider the collection of all of the vegetables as a set, then consider only the subsets that have 2 elements in them. This then turns into a problem of how many two-element subsets there are in a set of 5 elements.	There are 10 two-element subsets in a set of 5 elements. Thus, there are 10 different ways that 2 vegetables can be selected from 5 vegetables.

Q#3	Determine the number of possible three-person subcommittees that can be formed from a six-person Committee.	Consider the collection of all members on the student council as a set, then consider only the subsets that have 3 elements in them. This then turns into a problem of how many three-element subsets there are in a set of 6 elements.	There are 20 three-element subsets in a set of 6 elements. Thus, there are 20 three-person subcommittees that can be formed from the six-person Committee.
Q#4	Determine the number of possible three-person committees that can be formed from a seven person student council.	Consider the collection of all members on the student council as a set, then consider only the subsets that have 3 elements in them. This then turns into a problem of how many three-element subsets there are in a set of 7 elements.	There are 35 three-element subsets in a set of 7 elements. Thus, there are 35 three-person committees that can be formed from the seven-person student council.

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LEARNER-CENTERED ACTIVE LEARNING THROUGH CONSTRUCTIVISM

THAPELO P PITSO

This educational approach flips the script on traditional learning. Learners actively build their understanding by doing, not just listening. This aligns with constructivism, where learners engage with experiences to create their own knowledge.

Instead of teaching, learners solve problems, explore ideas together, and reflect on their learning journey. The teacher becomes a guide, helping students connect new information to what they already know.

This approach fosters deeper understanding, stronger critical thinking, and a lifelong love of learning. Active learning strategies put these ideas into action, keeping students engaged through discussions, group work, and activities that make them think critically.

This approach to education emphasizes active learning within a learner-centered environment. It draws on the principles of constructivism, a theory positing that learners build their own understanding by actively engaging with experiences and information.

Traditionally passive knowledge transmission is replaced with strategies that encourage students to:

Formulate hypotheses

Conduct investigations

Solve problems collaboratively

Reflect on their learning journey

The instructor acts as a facilitator, guiding learners as they construct their own knowledge base. This fosters critical thinking, problem-solving skills, and a deeper comprehension of the subject matter.

Constructivism is a theory of education that emphasizes the importance of learners actively constructing their own knowledge as opposed to passively receiving information.

Core of Constructivism:

Learners actively build their own knowledge [What Is Constructivism?]. They don't passively receive information from a teacher.

New knowledge is integrated with existing experiences and understanding.

Learners reflect on their experiences and question to make meaning.

Constructivism in Action:

Imagine a science class studying ecosystems. Instead of a lecture, the teacher might:

Benefits of Learner-Centred Constructivism:

Deeper understanding and retention of knowledge.

Development of critical thinking and problem-solving skills.

Increased motivation and engagement in learning.

Fosters independent and lifelong learners.

Overall, constructivism empowers learner-centered education by placing students at the center of their learning journey.

Active learning is the perfect partner to constructivism in the learning process. Constructivism lays the theoretical groundwork, while active learning provides the engaging methods for students to truly "build" their understanding. Here's how they work together:

Constructivism: The Why

Knowledge Construction: Constructivism emphasizes that learners aren't blank slates. They actively construct their understanding by integrating new information with their existing knowledge and experiences.

Active Learning: The How

Engaged Activities: Active learning strategies move away from passive lectures and involve students in tasks that get them thinking, doing, and reflecting. This can include discussions, problem-solving activities, group work, or simulations.

Social Interaction: Constructivism, particularly social constructivism, highlights the importance of social interaction in learning. Active learning strategies often encourage collaboration and discussion among students, allowing them to share perspectives and build understanding together.

Constructivist-based active learning promotes:

Deeper understanding: Learners actively build knowledge rather than passively receive it.

Improved critical thinking: Learners analyze information, solve problems, and justify their reasoning.

Enhanced collaboration: Learners work together, share ideas, and learn from each other.

Increased motivation: Learners take ownership of their learning and are more engaged in the process.

This approach empowers learners to become self-directed and fosters a love of lifelong learning.

Benefits of Learner-Centered Constructivism:

Deeper understanding and retention of knowledge.

Development of critical thinking and problem-solving skills.

Increased motivation and engagement in learning.

Fosters independent and lifelong learners.

Overall, constructivism empowers learner-centered education by placing students at the center of their learning journey.

Active learning describes instructional methods that engage students in the learning process. Active learning strategies can include discussions, debates, simulations, problem-solving activities, and group work.

By combining these three elements, educators can create learning environments that are both effective and engaging for students. Here are some of the benefits of learner-centered active learning:

Deeper understanding: Students who are actively involved in the learning process are more likely to develop a deep understanding of the material.

Critical thinking skills: Active learning strategies encourage students to think critically about the information they are learning.

Problem-solving skills: Active learning can help students develop problem-solving skills that they can use throughout their lives.

Motivation: Learners are more likely to be motivated to learn when they are engaged in the learning process.

Learner-Centered Approach:

Focuses on the learner's interests, needs, and prior knowledge.

Encourages active participation through discussions, projects, and investigations.

Fosters collaboration and peer learning.

Learner-Centered Approach:

Focuses on the learner's interests, needs, and prior knowledge.

Encourages active participation through discussions, projects, and investigations.

Fosters collaboration and peer learning.

Teacher acts as a facilitator, guiding learners in their construction of knowledge.

ADDITIVE CALCULATION STRATEGIES: VISITING THE TENS

WORKSHOP

LUISA TEMBE MHLANGABEZI MBALA & QETELO MOLOI

University of Johannesburg & Kelello Consulting

Introduction

The fluency and competence of Foundation Phase learners in South Africa is significantly inhibited by learners' over reliance in using calculating strategies that involve counting in ones (Venkat & Roberts, 2022). The Curriculum and Assessment Policy (CAPS) offers different calculating strategies that move beyond counting in one's. However, teachers may experience difficulty in teaching learners how to represent and use these strategies. The strategies that form part of the additive calculation trajectory in a level of increasing complexity include count-all, count-on, jump, visit the tens, moving to flexibility, efficient strategy and the split. This workshop offers foundation and intermediate phase teachers a prospective on the visiting the tens strategy. The strategy is the fourth level of the additive calculation trajectory. At this level learners are required to have mathematics fluencies such as knowing the bonds of ten and breaking down the second number to form a ten. This strategy offers learners an opportunity to perform more sophisticated calculations that move towards an abstract understanding of mathematics.

Motivation for workshop

In the CAPS curriculum, Number Operations and Relationships have a higher weighting of content than other key content areas. Within Number Operations and Relationships, additive relations are the core focus of development in the foundation phase (Roberts, 2016). Learners are expected to progress from a dependence on concrete objects to solve additive relation problems in Grade R and gradually move towards more mental/ abstract strategies to calculate additive relation problems. However, even with this suggested progression in the CAPS curriculum, learners are not being exposed to strategies that allow them to engage with these abstract strategies of calculations (Roberts, 2022). Since these strategies depend on the development of mathematical fluencies that also follow a learning trajectory, the persistent use of the counting in one's fluency is one of the core reasons that inhibit learners' mathematics progression.

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WORKING SMART WITH NUMBER FLUENCY TO MAKE THE TRANSITION TO ALGEBRA EFFORTLESS

OLICO MATHS EDUCATION

WENDY Z. SITHOLE & APHIWE NCAYIYANA

Introduction

In this workshop, we will guide participants through a series of activities and games that are specifically designed to give Senior Phase learners a solid foundation in numbers. This foundation will enable them to have a strong entry point to algebra. The activities are related to the two aspects of numbers for algebra, as discussed by (Bowie & Pournara, 2021): fluency with basic whole number facts and preparation for algebraic thinking. Participants will have hands-on experience with both online and offline games and activities that have been used successfully in our after-school classes with Senior Phase learners as part of the OLICO Mathematics Education program. These games and activities are designed to be both enjoyable and engaging, while also connecting number fluency to algebra. Although the workshop is targeted towards Senior-Phase mathematics, it will be suitable for both senior primary and secondary mathematics educators.

Motivation

Mathematics is a crucial subject that allows students to be more successful. To show even a small amount of competency in the subject, students need to work on improving their ability to add and subtract. Understanding these basic operations lays the foundation for more complex concepts such as algebra, which requires abstract reasoning. For many students, algebra is the first topic that demands significant abstract thought, which can make it difficult to learn. In algebra, the focus shifts from arithmetic operations to the use of symbols to represent mathematical relationships and numbers. However, we believe that improving fluency in basic arithmetic operations will make it easier for students to understand algebraic expressions and equations. In our classes, we have found that incorporating fun activities and games into our lessons makes the learning process much easier. In this workshop, we intend to use these strategies to encourage students to better understand algebra.

We will demonstrate how fluency in basic math skills can improve students' understanding of algebraic fundamentals in high school. Studies have shown that even before the COVID-19 pandemic, there was already a backlog of students struggling with almost every mathematical concept. After the pandemic, students are behind by 95% to 106% of a school year in Mathematics (Hoadley, 2023). This has resulted in a cumulative learning backlog, with students moving to the next grade with a lack of basic mathematical skills. Our organisation, OLICO, is dedicated to addressing this issue, especially for disadvantaged students. In this workshop, we will be using resources from the OLICO website https://learn.olico.org/, as well as online and offline games to help students catch up on the skills they may have missed due to the pandemic.

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FINDING THE ROUTE TO CONCEPTUAL UNDERSTANDING IN MATHS.

PAUL R SONDERGAARD

The introduction to how misunderstanding impacts learners, the method of approaching what is observed in class and the key points to achieving conceptual understanding of maths language and terminology.

a. WHAT WILL BE DONE IN THE WORKSHOP

Three practical exercises covering

i. The effect of a misunderstanding,
ii. Handling common maths words
iii. Finding that uncommon word and establishing understanding of it.

b. ACTIVITIES AND WORKSHEETS USED IN THE WORKSHOP

Two worksheets introduced that cover both common and uncommon maths words and how to handle their understanding.

c. PAGES OF ACTIVITIES ATTACHED

2. An abstract describing the level, nature and content of the workshop The introduction of how words cause the inability to think and the subsequent effect of this on a learner, or any person, as well as the culmination of many such misunderstandings and the effect on that individual.

Then looking at how one observes the phenomena that result from misunderstanding and how to bring it down to exactly what was misunderstood.

Then taking it to the solution and the application of that solution in gaining the understanding needed.

The workshop would include two practical exercises for teachers to apply this basic technology in establishing how to better understanding in their classrooms.

3. **Participants**

Maths teachers.

The session begins with an exercise in the realization of how misunderstanding is experienced and observed.

There are two word exercises then done during the session for understanding of the power of words and their impact when not understood.

4. Sources

My Maths Buddy mathematics dictionary and associated publications and resources

ADDITION & SUBTRACTION OF INTEGERS USING TWO NUMBER LINES AND COINS

M. RANOHA & M.A PHELANYANE

Introduction

Integers are a collection of all natural numbers including their additive inverses as well as zero (0). The word integer is derived from a latin word which means “whole” or “intact”. Integers cannot have fractional parts **Splash learn**)

Why is the workshop important?

This workshop is targeting grade 7-9 participants. Manipulatives such as number lines and coins will be used to model integers. Participants will be working in groups to experience hands-on activities on the use of two number lines and coins to teach the concept of addition and subtraction of integers. In the research that was carried out at 2 junior high schools on the teaching of addition and subtraction of integers, the first school was taught using the conventional approach and the other school was taught using number line rules and it was found out that the school that was taught using the number lines rule performed better in their post test. The study shows that the usage of of number lines rules is more time-efficient, simple to learn and practical. As a results it was suggested that teachers employ the number lines rule to teach mathematical concepts particularly addition and subtraction of integers (D.O KWAKYE & JUSTICE AGGREY). This workshop will follow the CPA (Concrete, Pictorial, Abstract) approach.

How will it help participants?

Through hand-on activities, this workshop will help participants to gain experience and confidence when they go back to their classes to teach their learners. It will help them to be more practical and to facilitate as their learners will be manipulating as they will be trying to get solutions on their own.

Description of content of workshop

This workshop contains activities suitable for use by grade 7-9. The approach of the workshop is on the utilization of number lines and coins for teaching the concept of addition & subtraction of integers. Participants will receive the two number lines which they can duplicate for their learners when they get back to their institutions.

What will be done in the workshop?

In this workshop the facilitators will be demonstrating how to use the two number lines and coins to teach the concepts of addition and subtraction of integers. The participants in their groups will be having those number lines and coins. On the usage of coins the data projector will also be used to demonstrate.

How will the time slot be broken up?

Item	Duration
The purpose of this workshop.	10 Minutes
Have participants spread the algebra tiles on their worktables and examine them.	15 Minutes
Activity 1: Adding Integers using number lines	20 Minutes
Activity 2: Subtracting Integers using number lines	20 Minutes
Activity 3: Adding integers using coins	20 Minutes
Activity 4: Subtracting integers using coins	20 Minutes
Workshop Closing: Recapping	15 Minutes
	120 Minutes

ENCOURAGING MATHEMATICS LEARNING THROUGH AN AUTOMATED AND INTERACTIVE HOTLINE

PATRICK IROANYA AND THABISO MOLEFE

Poor performance in mathematics by learners has been a concern both globally and locally. This has necessitated developing countries to come up with initiatives to help improve learners' performance in mathematics (Nomsa, 2021). One of the reasons for poor performance in mathematics is that learners spend little or no time practicing their mathematics daily (Nomsa, 2019). Our goal is to use technology to encourage the practice of mathematics through OLICOs Whatsapp maths hotline. There have been mixed conclusions about the impact of the use of technology in the teaching and learning of mathematics. Ikhlas (2021) concluded that WhatsApp is ineffective for online learning of mathematics at Grade 8 level while Muhassanah and Lukman (2021, p. 216) inferred that "the affective assessment of online learning through WhatsApp" groups was good for mathematics learners. Sigmundsson et al (2013) showed if a learner wants to improve in mathematics, they have to practice all different kinds of mathematics. This workshop aims to share how some of the mathematics resources on the OLICO's WhatsApp hotline can help encourage learner practice of mathematics.

In this workshop participants will be exposed to an innovative use of WhatsApp which allows learners to practice mathematics and get immediate feedback on a platform that is familiar and accessible. In an era where digital connectivity shapes the experiences of education, the OLICO Whatsapp Maths Hotline provides an avenue for learner support and engagement. In South Africa, the need for regular maths practice among learners plays an important role in improving mathematics performance. However, there are barriers such as resource constraints, lack of access to quality educational support, and socio-economic disparities. Consequently, there is a pressing need to address these barriers and cultivate a culture of sustained daily maths practice, particularly among marginalized communities. By leveraging the accessibility, affordability and convenience of the Whatsapp platform, learners are encouraged to practice their maths on a day-to-day basis thereby becoming catalysts for transformative learning experiences, fostering a culture of mathematical resilience and excellence among South African learners. Participants in this workshop will have hands-on experience of this learning tool and be able to provide feedback and consider different possible use scenarios.

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THE EQUAL SIGN: IT'S MEANING AND USE IN EARLY GRADE MATHEMATICS IN BOTH ENGLISH AND ISIXHOSA

QHAMA NGCOBO & NOBUNTU MAZEKA

NELSON MANDELA INSTITUTE

South African children learn about mathematics in English and in African languages. In both cases, the precise register of what the equal sign means is seldom used correctly, and seldom introduced to learners. Many teachers and teachers in training don't know the meaning of the equal sign. The Curriculum Assessment Policy (CAPS) for Foundation Phase makes mention of the equal sign in the overview but it is not explicit and detailed in meaning and interpretation. There is a need for teachers and learners to understand the meaning of the equal sign – considering both its relational and operational meaning to promote early algebraic thinking. This workshop for Foundation Phase teachers is packed with activities that build the conceptual skills learners need to bridge the gap from arithmetic to algebra. The equal sign is needed in all topics of mathematics in CAPS – and especially in key connections between "Numbers, Operations and Relationships" and "Patterns Functions and Algebra" Examples of practical activities and carefully designed learning and teaching materials which have been trailed in isiXhosa and English, in the Eastern Cape, are available for teachers to use.

Motivation for the workshop

Poor or inadequate instructional methods of delivering a lesson in the classrooms have characterized how teachers conduct themselves when teaching thought-provoking and controversial concepts in early-grade mathematics, including but not limited to the meaning of an equal sign. A considerable amount of literature attempts to demystify the meaning of the equal sign and further make interpretations and applications of the operation. A study by Prediger (2010) categorizes the meaning of equal sign into operational meaning ('makes' or *zenza*) and relational meaning ('is the same as' or *zilingana*). Many researchers working on mathematics education in English have tried to include a symmetric and relational use of the equal sign in the primary school curriculum. However, in isiXhosa-dominated classrooms, the meaning of the equal sign has been taken to refer to the much-ness of objects, things, or sum of and 'make'. 'Makes' translated as '*zenza*' in our vernacular being the popular expression amongst teachers and learners in early grade mathematics teaching.

Incidents, where teachers unpack the meaning of the equal sign, are limited only to a few vocabulary lists of '*zilingana*' (equal to) and *ifana* (equivalent or same as). The popular 'makes' or *zenza* is a precursor to the introduction of the symbol =. This symbol represents **equality** in mathematical expressions. For example, in the equation **5 = 2 + 3**, the equals sign indicates that **5** is equal to the sum of **2** and **3**. Roberts (2012) explores the meaning of equal by deliberately detailing that equals means 'is the same as'. The equals sign is like a balance. Knuth et al, (2008) warn against the shortcomings by referring to the limited conception of what the equal sign means as one of the major stumbling blocks in learning algebra.

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TRANSFORMING THE GR R CLASSROOM PRACTICES IN GAUTENG PROVINCE FOR GR R LEARNERS TO BE READY FOR GRADE 1 CURRICULUM

Tsakane Baloyi, Sherline Pillay, Ntombikayise Daphne Mokoena, Ingrid Harris Tholisa Matheza & Ashley Manuels

GDE, SDU at UCT) & JET Education Services

It is a well-known fact that the foundation of any meaningful learning is based on the mastery of the basic literacy and numeracy skills. The impactful injection of these skills to learners in the reception years is through trained, supported, motivated, confident and competent teachers and practitioners. The Gauteng Department of Education (GDE), in partnership with Gauteng Education Development Trust (GEDT), Zenex Foundation and the United States Agency for International Development (USAID) all had the same objective of ensuring that they have Gr R teachers who meet the above criteria. As a result, JET Education Services was appointed as the project management office to ensure the design and implementation of a well thought of and structured intervention which is informed by a similar externally evaluated project. The main objective of the intervention is for these teachers to be able to produce Grade R learners who are ready for the grade R curriculum. The focus of the intervention is on developing the Home Languages and Mathematics content and pedagogic competencies of all the Gr R teachers in public ordinary and special needs schools in Gauteng province as well as for teachers from registered ECD community-based sites.

Materials used from the externally evaluated project were versioned into eleven official languages used in Gauteng province, in consultation with GDE which also quality assured and approved the materials. This was followed by a structured training program at three different levels (Master trainers, teacher trainers and Gr R teachers) with external evaluation conducted for the last two levels. The external evaluation also focused on baseline and end line evaluation of each component (Home languages and Mathematics) of the project. The general feedback/conclusion from the external evaluation is that:

- Children in the MLIP programme demonstrate remarkable increase in their literacy skills from the begin to the end of Grade R, with the highest improvements observed among children who are at the appropriate age to be admitted into Grade R.
- Teacher knowledge and skills have improved, buy in in schools is high, learner outcomes have improved, and learners are ready for grade 1.
- Some schools are implementing the story-based approach in the whole of the Foundation Phase
- The MLIP has been implemented with quality, as evidenced by positive feedback from stakeholders and improvements in teacher knowledge and pedagogy

ENHANCING GEOMETRY INSTRUCTION FOR GRADE SIX TEACHERS: A WORKSHOP APPROACH TO PROFESSIONAL DEVELOPMENT

CHRISTINAH MOKENTI MACHABA

This workshop paper explores professional development tailored for grade six teachers, aimed at enhancing their proficiency in teaching geometry. Drawing upon research by Blank & de las Alas (2009), Cordingley et al. (2015), Desimone (2009), Dunst et al. (2015), Timperley et al. (2007), Walter & Briggs (2012), Wei et al. (2009), as well as supplementary references including Hiebert & Grouws (2007), National Council of Teachers of Mathematics (2000, 2014), Boaler (2016), Cobb et al. (2003), Leikin & Zazkis (2006), National Research Council (2001), Simon & Tzur (1999), and Usiskin (2003), the paper emphasizes the significance of active engagement in professional development endeavors. It underscores the Department of Basic Education's (DBE) expectation for teachers to be competent in teaching space and shape concepts, fostering understanding and appreciation of patterns, precision, achievement, and beauty in natural and cultural forms at the primary level (DBE, 2011). The workshop aligns with this expectation by focusing on properties, relationships, orientations, positions, and transformations of two-dimensional shapes and three-dimensional objects, addressing the interests of teachers who voluntarily choose to attend (Sims & Fletcher-Wood, 2019:3). Through collaborative discussions, interactive sessions, and research-based strategies, the workshop aims to empower grade six teachers with the subject knowledge and practical tools necessary to enhance their geometry instruction, ultimately fostering improved student learning outcomes.

Geometry constitutes a foundational component of the mathematics curriculum, yet effectively teaching it can present challenges for educators. Recognizing the importance of engaging students in meaningful geometry learning experiences, this workshop targets Grade six educators, offering them practical, hands-on strategies to enhance geometry instruction. Drawing upon research by Van de Walle et al. (2019), Clements & Sarama (2004), National Council of Teachers of Mathematics (2000, 2014), National Research Council (2001), Boaler (2016), Hiebert & Grouws (2007), Usiskin (2003), Riordan & Noyce (2001), and Cai & Lester (2010), among others, this workshop aims to equip educators with interactive activities and worksheets that cater to diverse learning styles. By providing participants with a toolkit of resources and strategies, including manipulatives, teaching aids, and recommended teaching strategies, the workshop empowers educators to create dynamic and stimulating geometry lessons. Ultimately, this initiative seeks to enhance educators' confidence and effectiveness in teaching geometry, leading to improved student engagement and learning outcomes.

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NUMBERS, OPERATIONS AND RELATIONSHIPS (PLACE VALUE)

MARY-ANN KESWA

Place value is a real-world connection-It is important to help learners connect the concept of place value to the real world. Often learners do not see how mathematical concepts apply to their individual lives. When teaching place value, manipulatives and coins are useful for achieving this connection.

What is place value?

Place value can be identified as the value represented by a digit in a number on the basis of its position in the number. For example: The place of *7* in the number *743 is hundred and the value is 700.*

Teacher issues –Teachers may have difficulty teaching place value if they do not personally understand those concepts. They must have a thorough understanding of place value and the number system.

Two types of mistakes learners make when learning place value: Errors and misconception.

Errors - are mistakes made due to lack of attention, working too fast, missing an important part of a problem. With these types of errors, learners can usually identify their mistakes and correct them.

Misconceptions stem from a learner's misunderstanding of the central concept. They tend to be consistent; identifiable from the mistakes made repeatedly in the course of the learner's work.

Abstractness – In order to avoid difficulty in place value, using manipulatives such as ten base blocks can help learners connect the abstract with more concrete representation. Many children are concrete learners meaning they need sensory experiences to develop their learning.

Reversals – Learners often reverse places within a number. e.g 14 identified as 41. This misconception typically stems from the lack of understanding that 14 is equal to 10+4 and 41 is 40+1.Learners need to master breaking up of numbers in-order to excel in place value.

What am I going to do in the talk?

Present in a practical manner by using manipulatives such as ten base blocks, place value chart, number cards or flash cards, notes and coins.

Consolidate re- arrangement of numbers in order to check critical understanding of how to sort and order digits based on their place and value.

Teaching of mathematical language.

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❖ Few tips for teachers that develop place value:

1. Use place value mats to make reading and writing numbers easier.
2. Provide opportunities to count by groups of 10’s and 100’s.
3. Use a daily place value warm up to build confidence.

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TEACHING INTEGERS AND ALGEBRAIC EXPRESSIONS USING ALGEBRA TILES

FUSI RANTENE

Algebra is a crucial domain in mathematics. It is a generalized version of arithmetic in which letters and signs are employed to achieve the generalization. It is undeniably an abstract domain due to the utilization of letters and signs. Algebra is regarded as a difficult branch of mathematics due to the nature of generalization and abstraction. (Pranada, Dizon & Sabalza, 2019).

The workshop is targeting grade 8&9 participants who are involved in teaching or supporting teachers. Manipulative such as algebra tiles will be used to model integers and algebraic expressions. Algebra tiles are rectangular shapes that provide area models of variables and integers.

Participants will be working in pairs to experience hand on activities on the use Algebra tiles to teach integers and expressions. By the end of the workshop participants will be able to teach addition and subtraction of integers and expand and simplify algebraic expression using algebra tiles. The knowledge gained may be extended further by exploring use of these tiles in teaching algebraic equations.

This workshop will further enhance teacher' knowledge of using algebra tiles as a teaching tool to improve learners' skills (Pranada, Dizon & Sabalza, 2019).

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ADDRESSING GRADE 8 MATHEMATICS CONTENT BACKLOGS THROUGH THE SIYAVULA ED-TECH PLATFORM

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This workshop targets two types of grade 8 teachers, those who have used the Siyavula Platform, and those who have not. Participants will be arranged into groups of five containing those who have and those who have not used the platform. After introducing the platform; in groups of five, teachers will be guided on how to navigate the Siyavula platform, how to access lower grade mathematics content to address backlogs; how to use assessments provided on the platform and how to use teacher report generated on the a platform to inform daily practices in mathematics teaching and learning. The group demonstrations and practical activities will be followed by a feedback session. Practical activities will be conducted in groups using participants' own devices (laptops, tablets, cellphones), or the computer laboratories at the venue. The Siyavula Platform is Zero-rated and designed to be cellphone friendly. The workshop will be concluded by discussing how teachers can use the Siyavula platform in their own classrooms to identify mathematics content backlogs at the Grade 8 level.

Mathematical foundational knowledge gaps in the early grades have resulted in cumulative learning backlogs and are a major cause of the subpar mathematics learning outcomes in South African schools. A solid understanding of material from earlier grades facilitates the effective learning of mathematics concepts in later grades. Quintiles 1 to 3 schools have the highest backlogs, in part due to inadequate resources for addressing backlogs and low parental involvement. Inappropriate teaching and learning resources, along with the density of CAPS—which is difficult for most teachers to finish while guaranteeing strong conceptual understanding—also add to backlogs. The Siyavula platform has endeavored to make their content more relevant by adding a series of content reaching into earlier grades. Learners are directed to this content by an algorithm. Through this workshop, teachers should be able to improve their awareness of the newly adapted Siyavula platform, effectively navigate the platform and use the embedded teacher support functions (assessments and teacher reports) to address learning backlogs at Grade 8 level and ultimately improve mathematics outcomes. Resolving learning backlogs at this stage could result in better mathematics comprehension, more learners participating in mathematics at the FET level, and better mathematics results for the NSC.

HOW DO TEACHERS CONNECT ARITHMETIC AND RELATIONAL THINKING WELL IN TEACHING?

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In many countries, official curriculum documents now endorse the building of closer relationships between the study of number in the primary school and the development of algebraic thinking. Algebraic thinking is not the same as the use of algebraic symbols. It is about identifying generalizations and structural relations in number sentences and operations. This is very different to what in the past was seen as the study of arithmetic.

In the national curriculum standards of many countries, they present Number and Algebra as a single content strand for the compulsory years of school. Official documents in both countries clearly endorse a more coherent treatment of number sentences and operations and the development of algebraic thinking in the primary and early years of secondary school; and we argue that teacher capacity is a key dimension in realising that goal. However, the implementation of curriculum change is never simply from the top down. Teachers' interpretations and responses at the level of practice are never simple reflections of what is contained in official curriculum documents. While curriculum documents set out broad directions for change, any successful implementation of these "big ideas" depends on teachers' capacity to apply subtle interpretations and careful local adaptations (Datnow & Castellano, 2001). Teachers' professional insight and agency in translating these ideas into practice must frame any definition of teacher capacity (Smyth, 1995).

The following sections set out our rationale for choosing teacher capacity as a key organising idea for this research. As we will show, our use of this term is not intended to imply some generic notion of teaching ability. We define teacher capacity as professionally informed judgement and disposition to act; and in the context of this study we apply this construct in terms of national curriculum reform in mathematics.

In this workshop, following the Teacher Capacity framework (Zhang & Stephens, 2013), we will need the participants to read carefully 7 responses of Grade 6/7 students and think and discuss on several questions relating to mathematics teacher capacity.

PLAYMATHS GRADE 1 WORKSHOP

URQUHART, ELTON NELSON, WAHIDA LABANI, and SONJA TITUS

We teach parents and teachers how to play Maths games that build number concept using only materials that would typically be found in any home (cards, paper, pen , beans etc.)

Workshop structure:

The presentation will include a short introduction on why we play games highlighting how games promote Maths fluency (number flexibility, conceptual understanding and computational efficiency), confidence, language development, enjoyment, revision, inclusivity, engagement, strategic thinking and parental involvement.

Thereafter we will break into small groups and teach games suitable to grade one learners.

Examples of the sorts of games we will play:

Draw a Face- certain numbers on a dice give certain parts of your face. Try to finish your face first

Domino sums – clear the dominoes in your hands if they sum to or differ by the card turned up

Make up your own story sums using pictures.

Making graphs by asking for choices.

Bonds of 10 snap

Song about bonds of 10

Rhythm clapping

Stack 6 – taking turns to place cards in correct suite and in sequence.

Math jack (making sums with your cards that match the upturned card)

Before or after- clear the cards in your hands if the card is the number before or after the upturned card.

Traffic jam – a variation of tic-tac-toe

Bonds of 10 solitaire.

3x3 number sentences

Question my answer – You get given an answer and you must make a question that gives that answer.

“Little Kitten”- turn over circle of cards, keep the cards if the number or suite is the same, estimate cards and then count for winner.

Memory game- place in rectangular array. Take turns turning over two cards to find matching pairs

Make a helicopter.

Do some Maths gym (exercises that help build neural pathways)

Teachers will be provided with a pack of notes that give the written instructions for the games played.

Teachers will be invited to join a PlayMaths teachers WhatsApp group where games will be posted on a weekly basis and teachers will be able to share their games ideas with each other.

VISUAL AND FUN WAYS TO LEARN MATHS CONCEPTS OF PLACE VALUE, COMPUTATIONAL FLUENCY AND EARLY STRATEGIC THINKING.

URQUHART, ELTON NELSON, WAHIDA LABANI, and SONJA TITUS

We teach parents and teachers how to play Maths games that build number concept using only materials that would typically be found in any home (cards, paper, pen , beans etc.) Games make it possible to consolidate and repeat concepts without becoming boring. Games build confidence and make Maths learning more enjoyable. Games encourage maths talk and increase levels of engagement.

Workshop structure:

The presentation will include a short introduction on why we play games highlighting how games promote Maths fluency (number flexibility, conceptual understanding and computational efficiency), confidence, language development, enjoyment, revision, inclusivity, engagement, strategic thinking and parental involvement.

Thereafter we will break into small groups and teach games suitable to grade two learners.

Examples of the sorts of games we will play:

1. More or less- play for biggest/smallest two-digit card
2. Target 20 – place cards to make as many 20s as possible.
3. Bonds of 10 SNAP
4. Quick count using bonds of 10
5. My secret card – take 10 guesses to find my number building number-line concept
6. Bump- sum two di to own a circle. Your first counter can be bumped off but after two counters you own the circle.
7. Ordering numbers by placing on Measuring tape/number line
8. Bonds of 10/100 – pack cards in Pyramid shape and see if you can clear making bonds of 10/100
9. 3x3 grid make your own choice to use as many cards as possible to make two- digit sums.
10. 2-digit Maths Jack- making sums from your hand that make the 2-digit number cards upturned.
11. Magic square, place the cards 1 – 9 in a 3x3 grid such that all the rows and columns sum to 15.
12. Play for 15-Take turns placing cards 1 – 9 such that the first person to have a line of 15 wins.

13. Target shoot – players use two of any three cards to get as close as possible to a 2-digit number
14. Salute- identify the number on your head when you know the sum and you can see the other person's card.
15. The silent game- try to place everyone's cards by placing two-digit numbers in increasing order without speaking at all.
16. Closest multiple of 10 – take turns choosing which multiple of 10 to play the closest to.
17. Fishing for two digits – Start with 8 cards each. The one with the least cards after 20 numbers have been called wins.
18. Rectangle 10- place numbers so that columns and rows all have the same sum.
19. "Own the square" – Spotted grid, take turns joining dots own the squares as you finish, estimate and then count.
20. Shishima- Players start with three pieces each on right or left of octagon wheel. Move without jumping to get three in a row.

Teachers will be provided with a pack of notes that give the written instructions for the games played.

Teachers will be invited to join a PlayMaths teachers WhatsApp group where games will be posted on a weekly basis and teachers will be able to share their games ideas with each other.

VISUAL AND FUN WAYS TO LEARN MATHS CONCEPTS OF PLACE VALUE, COMPUTATIONAL FLUENCY, LOGIC AND WORKING WITH MONEY.

URQUHART, ELTON NELSON, WAHIDA LABANI, and SONJA TITUS

We teach parents and teachers how to play Maths games that build number concept using only materials that would typically be found in any home (cards, paper, pen , beans etc.) Games make it possible to consolidate and repeat concepts without becoming boring. Games build confidence and make Maths learning more enjoyable. Games encourage maths talk and increase levels of engagement.

Workshop structure:

The presentation will include a short introduction on why we play games highlighting how games promote Maths fluency (number flexibility, conceptual understanding and computational efficiency), confidence, language development, enjoyment, revision, inclusivity, engagement, strategic thinking and parental involvement.

Thereafter we will break into small groups and teach games suitable to grade two learners.

Examples of the sorts of games we will play:

1. 10-40 solitaire (quick calculations)
2. Skunk-count cards as high as you dare until an Ace takes you out!
3. Target 100 – use 4 out of 6 cards to get you as close to 100 as possible.
4. HTU board game, move around a board placing you card in H, T or U position trying to get the biggest number.
5. Shopping board game-correctly buy and pay for products from each food group.
6. Rectangle 10 – place numbers 1 – 10 in a rectangle in such a way that all four sides sum to the same number.
7. “Whose line is it?”- Draw a 10 to 1 spotted pyramid. Take turns owning dots and scoring by completing lines.
8. Fizz Pop- go around the room counting but saying fizz instead of multiples of 3 and pop instead of multiples of 5.
9. Clapping game to the 3x table
10. Dancing game to the 4x table
11. Halve or Double your money Game- draw cards for an amount pack out that much money and then turn the spinner to either halve double, add R19 or subtract R23 to your money.

12. Robots- 3x3 grid place red on grid, change red to orange and orange to green. Aim to get three of the same colour in a row.
13. Frog jump – famous game of needing to swop lined and spotted frog positions by sliding or jumping.

Teachers will be provided with a pack of notes that give the written instructions for the games played.

Teachers will be invited to join a PlayMaths teachers WhatsApp group where games will be posted on a weekly basis and teachers will be able to share their games ideas with each other.