"Beyond Right and Wrong: Textures of Mathematical Work in a High-Stakes South African Examination"

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ABSTRACT

The Grade 12 NSC Mathematics examination plays a decisive role in South African schooling, shaping who moves into further study and who does not. Much has been written about marks and performance trends, yet we know far less about how examinees actually produce their written mathematics under pressure. This article shifts the focus to the work itself and the small steps examinees take to hold difficult procedures together during the examination. This article moves beyond the binary of right and wrong by investigating the textures of mathematical work that emerge as examinees engage with the NSC examination. Drawing on an integrated ethnomethodological and Pickeringian analytic framework, the study analyses the lived work in the Grade 12 examination scripts as socio-material records of mathematical practice. Three aligned documentary datasets are examined to trace how examinees encounter resistance from mathematical structures and how accommodation is locally improvised through procedural reflexivity, reversal, targeting, and performative closure. A central finding across all three domains is the dominance of performative closure through the non-firing of resistance, where institutional demands for completion override epistemic resolution. The analysis reveals that examinees' mathematical work unfolds not as a linear conceptual progression but as a fragile negotiation of resistance, accommodation and institutional stabilisation under severe time and accountability pressures. The article advances a sociological account of high-stakes school mathematics, showing how examination conditions actively reorganise what it becomes possible to display, value and recognise as mathematical knowledge. The findings carry important implications for mathematics teaching, assessment practice and teacher education in South Africa.

Keywords: High-stakes assessment; Ethnomethodology; Textures of mathematical work; Resistance and accommodation; National Senior Certificate;

INTRODUCTION

High-Stakes Mathematics and the Production of Mathematical Work

The Grade 12 National Senior Certificate (NSC) examination holds a pivotal position in the South African education system. Its outcomes regulate access to higher education, vocational study and employment opportunities, and thus carry consequences that extend far beyond schooling. Mathematics, in particular, functions as a powerful gatekeeping subject, shaping examinees' future participation in science-, engineering- and commerce-related fields. As a result, examinees' engagement with mathematics at this level takes place under intense institutional pressure, strict time regulation and high public accountability.

Within this context, the examination script becomes the primary site where mathematical competence is displayed, judged and certified. Every written inscription, formulas, substitutions, crossings-out, restarts, graphs, tables and boxed answers simultaneously functions as a mathematical act and a social performance. The examination room is therefore not a neutral testing space but a highly regulated social setting in which particular forms of mathematical work are rendered visible, legitimate and assessable.

Much of what is written about the NSC focuses on pass rates, performance gaps and curriculum coverage. These studies are valuable, but they seldom pause to consider what examinees actually do on the page as they attempt to solve an exam question. As a result, the small choices, hesitations and shifts that make up real mathematical work often remain invisible. This article does something slightly different. Rather than judging answers as right or wrong, it looks at how examinees actually organise their work during the examination. The intention is to bring to light the different ways in which their written mathematics takes shape on the page, and what those textures reveal about assessment under pressure.

From Outcomes to Textures of Mathematical Work

This study focuses on the production of mathematical work as it unfolds through examinees' written solution-seeking pursuits. Examinees' inscriptions are not treated as passive traces of internal cognition but as active, socially organised accomplishments produced in real time under institutional constraint. Crossings-out, restarts, reversals, substitutions, re-modelling and boxed conclusions are analysed as reflexive actions through which examinees negotiate resistance, display accountability and stabilise their work in socially recognisable ways.

Conceptually, this approach foregrounds the idea of textures of mathematical work. These textures refer to recurring patterns of solution-seeking activity that are evident across examinees and content domains. Such textures include procedural reflexivity, abandonment, reversal, targeting, performative closure and the non-firing of resistance. They do not describe psychological learner traits but patterned ways in which mathematical activity is practically accomplished within the institutional logic of the NSC examination.

Trigonometry, Sequences and Series, and Functions as Comparative Domains

The article draws on three mathematical domains within NSC Mathematics: Trigonometry, Sequences and Series, and Functions. These domains provide contrasting yet complementary sites for examining the production of mathematical work under the same high-stakes institutional conditions. Trigonometry is characterised by high symbolic complexity, frequent shifts between representations, and extensive use of identities, functions, and algebraic manipulation. Examinees are required to coordinate multiple forms of mathematical meaning under severe time pressure. This makes Trigonometry a domain in which structural resistance is both common and consequential.

Sequences and Series foreground pattern recognition, inductive reasoning and structural generalisation. Examinees are required to detect numerical structure, construct general terms and reason recursively or explicitly about progression. While this domain often appears procedurally lighter than Trigonometry, it generates distinctive forms of resistance through misaligned pattern modelling and incorrect structural assumptions.

Functions, as analysed through the third empirical strand integrated into this article, place examinees in a representationally complex space where graphical, algebraic and numerical representations must be coordinated. Here, resistance frequently emerges through breakdowns in inverse reasoning, misinterpretation of transformation effects and unstable movement between representations.

By examining examinees' written work across these three domains, the study traces how different kinds of mathematical structure shape the textures of solution-seeking activity, while remaining embedded within the same high-stakes examination context.

Theoretical Orientation: Ethnomethodology and the Mangle of Practice

The analysis is grounded in an integration of ethnomethodology and Pickering's theory of resistance and accommodation. Ethnomethodology directs attention to how social order is produced in practice through members' everyday actions. In the context of written examinations, it allows examinees' inscriptions to be analysed as reflexive, accountable displays of what it means to "do mathematics properly" within the institutional order of schooling.

Pickering's work adds another angle to examinees' ways of working through agency. Seen from this view, a solution path is not a tidy application of knowledge but something that examinees negotiate as they deal with obstacles or changing interpretations. The ways examinees work are visible in the textures of their solution-seeking paths. Hence, the study seeks to make visible the practical organisation of examinees' pursuits as they unfold rather than evaluating the correctness of final answers.

Responding to the above statement, the article advances a sociologically grounded account of how mathematical meaning is produced, stabilised, redirected and abandoned under conditions of institutional pressure, moving beyond simplistic binaries of right and wrong.

LITERATURE REVIEW

High-Stakes Examinations and the Social Organisation of Assessment

High-stakes examinations are commonly defined as assessments whose outcomes carry significant consequences for examinees, teachers, schools, and education systems (Harlen & Deakin Crick, 2002; Barksdale-Ladd & Thomas, 2000). In South Africa, the Grade 12 National Senior Certificate (NSC) examination serves as such a mechanism, functioning simultaneously as a certification instrument, a gatekeeper to higher education, and a public indicator of school quality (Umalusi, 2014; Department of Basic Education [DBE], 2021). The social consequences of NSC outcomes extend beyond academic progression to include funding, school reputation, and employability (Spaull, 2013; Taylor, 2011). As a result, the NSC examination constitutes a powerful institutional structure that shapes learner participation in mathematics.

International and local studies have shown that high-stakes assessment environments intensify pressure, narrow curriculum focus, and restructure pedagogical priorities toward examination performance (Harlen & Deakin Crick, 2002; Nichols & Berliner, 2007; Mouton, 2013). Teaching and learning practices often become oriented toward rehearsal of examinable procedures, memorisation of standard forms, and strategic management of time and risk (Brodie, 2010; Umalusi, 2018). Examinees, in turn, are inducted into particular ways of working that privilege speed, surface fluency, and the production of socially recognisable answers. In such environments, the examination script becomes the primary site where mathematical competence is publicly performed and judged.

Although we know a great deal about how high-stakes testing affects achievement and motivation, far fewer studies look closely at how these conditions shape the actual doing of mathematics. Much of the existing research treats a learner's written answer as a static product. (Harlen & Deakin Crick, 2002; Spaull, 2013; Umalusi, 2018). What gets lost is the unfolding work, the crossings-out, changes in direction and signs of struggle, that sit underneath the final line written in the answer space. (Simons, 2015; Bheki, Simons, & Khuzwayo, 2023).

Mathematical Performance, Errors, and Cognitive Deficit Framings

Research on learner performance in NSC Mathematics has traditionally been dominated by analyses of error patterns, misconceptions, and content-specific weaknesses (Van der Walt & Maree, 2007; De Villiers, 2004; Brodie, 2010). In trigonometry, studies frequently report learner difficulties with functional interpretation, identity manipulation, and algebraic fluency (Gür, 2009; Chinnappan, Nason, & Lawson, 1996). Similarly, in sequences and series, examinees often struggle with pattern generalisation, recursive reasoning, and the construction of general terms (Stacey, 2005; Roberts & Brown, 2017). These difficulties are typically interpreted through cognitive or conceptual deficit frameworks that locate error within individual reasoning processes.

While such studies have deepened understanding of common stumbling blocks in these domains, their analytic emphasis remains largely corrective and diagnostic. Learner work is usually assessed against an idealised normative solution, and deviations from this norm are catalogued as deficits to be remedied (Schoenfeld, 1985; Stacey, 2005). This approach risks reducing learner activity to a collection of mistakes while overlooking the strategic and adaptive dimensions of how examinees engage with mathematical tasks under real examination conditions.

More importantly, deficit-oriented framings tend to abstract learner cognition from the institutional contexts in which mathematical work is produced (Brodie, 2010; Umalusi, 2018). They seldom account for the pressures of time limitation, the performative demands of the examination script, or the tacit social rules that govern what counts as a legitimate solution. As a result, the examination context itself is too often treated as a neutral backdrop rather than as an active structuring force in examinees' mathematical activity (Simons & Wibawa, 2021).

Mathematical Work as a Situated, Produced Accomplishment

An alternative body of scholarship has sought to shift attention from mathematical performance to mathematical practice (Lave, 1988; Lampert, 1990; Julie, 1992). From this perspective, mathematical activity is understood as actively produced through situated interaction with tasks, tools, inscriptions, and institutional expectations. Rather than viewing learner responses as mere outputs of internal cognition, this approach treats written work as a visible trace of ongoing sense-making, negotiation, and decision-making (Julie, 2003; Livingston, 2008).

Within mathematics education, this turn toward practice has foregrounded the importance of studying examinees' solution paths, representations, revisions, and strategic choices (Lampert, 1990; Schoenfeld, 1985). Earlier work in mathematics education shows that examinees seldom follow a straightforward path through a problem. They often try something, stop, change their mind, and attempt another route. These shifts are not signs of confusion alone; they are part of how examinees make sense of the task in front of them (Julie, 2003; Simons, 2015).

In high-stakes contexts, however, the visibility of such practices becomes constrained by the institutional demand for polished final answers (Barksdale-Ladd & Thomas, 2000; Harlen & Deakin Crick, 2002). Examinees must balance exploratory activity with the need to present solutions that conform to socially sanctioned formats within a limited time. As a result, much of the production of mathematical work is compressed, hidden, or prematurely stabilised through performative acts of closure such as boxing an answer or terminating a pursuit (Simons, 2015; Bheki et al., 2023).

ETHNOMETHODOLOGY AND "WAYS OF WORKING" IN MATHEMATICS

Ethnomethodology, first developed by Garfinkel (1967), focuses on the everyday methods people use to make their actions understandable to others. In this study, foregrounding the practical ways in which examinees shape their written work so that it appears recognisably mathematical to an examiner (Coulon, 1995; Button, 1991).

In educational research, ethnomethodology has been used to examine classroom interaction, instructional routines, and the social organisation of learning activities (Livingston, 2008; Dourish & Button, 1998). Within mathematics education specifically, it has provided tools for analysing how mathematical meaning is constructed through interaction with tasks, diagrams, symbols, and inscriptions (Julie, 1992; Simons, 2015).

A key idea here is reflexivity: the way in which a learner's writing both shows what they are doing and helps to shape what counts as doing mathematics correctly. When a learner crosses out a line, restarts a calculation, or boxes an answer, these moves are not neutral. They show how the learner understands the expectations of the examination room and what they believe will be recognised as legitimate mathematical work.

Closely related is the concept of accountability. Examinees' inscriptions are produced in ways that make their reasoning publicly inspectable to an examiner (Garfinkel, 1991; Coulon, 1995). Even when examinees are uncertain or confused, their written work is shaped by the need to appear procedurally competent and mathematically aligned with institutional expectations (Julie, 2003; Simons, 2015).

Documentary Analysis and the Written Examination Script

Because high-stakes examinations are confidential and non-interactive, researchers are typically denied access to examinees' real-time thinking during the writing of the examination. In such contexts, documentary analysis becomes a particularly valuable methodological strategy (Bowen, 2009). Documentary analysis involves the systematic examination of pre-existing artefacts, such as examination scripts, to infer the practices through which they were produced.

From an ethnomethodological standpoint, written examination scripts are not treated as impoverished substitutes for talk-in-interaction. Rather, they are understood as rich documentary traces of practical reasoning (Garfinkel, 1967; Livingston, 2008). Cancelling of produced work, substitutions, overwriting, restarting procedures, and incomplete attempts all serve as visible traces of the solution-seeking pursuits in which examinees are engaged (Simons, 2015; Bheki et al., 2023).

In this sense, the examination script is not merely a carrier of answers but a document showing the practical achievement. It bears the sediment of examinees' engagements with procedures, representations, and structural demands. Documentary ethnomethodology thus provides a means of accessing the lived production of mathematical work even in the absence of direct interactional data (Bowen, 2009; Livingston, 2008).

Pickering's Resistance and Accommodation in Mathematical Practice

Pickering's (1995) theory of the mangle of practice conceptualises scientific and mathematical activity as an ongoing dialectic between agency and resistance. Human actors pursue goals through material and symbolic systems that, in turn, push back through constraints, breakdowns, and non-alignment. Progress emerges through cycles of resistance and accommodation as actors adjust their strategies in response to what the system affords or blocks.

In the context of school mathematics, resistance may arise from structural features of symbols, algebraic relationships, representational demands, or conceptual misalignments (Julie, 2003; Simons, 2015). Examinees respond to such resistance through various forms of accommodation, such as changing strategies, switching models, restarting procedures, or abandoning a path altogether (Simons & Wibawa, 2021).

Importantly, resistance does not always fire in a way that leads to conceptual adjustment. Examinees may accommodate resistance performatively by stabilising incorrect procedures through socially recognisable forms of completion (Simons, 2015; Bheki et al., 2023). The integration of Pickering's framework with ethnomethodology, therefore, allows for a fine-grained analysis of how agency, resistance, and accommodation unfold within the written traces of examination work.

Research Gap and Contribution of the Study

Despite extensive research on learner errors and performance in NSC Mathematics (Brodie, 2010; Umalusi, 2018), there remains a significant gap in studies that examine how mathematical work is actively produced under high-stakes conditions (Simons, 2015; Simons & Wibawa, 2021). Few South African studies have combined ethnomethodological analysis with a theory of resistance and accommodation to investigate examinees' written solution paths across different mathematical domains.

Moreover, existing research tends to focus on isolated content areas without exploring how solution-seeking practices vary across domains with different structural demands. There is also limited work that treats the examination script itself as a sociologically meaningful artefact through which mathematical work is publicly accomplished (Bheki et al., 2023).

This study addresses these gaps by providing a documentary ethnomethodological analysis of examinees' ways of working in two contrasting NSC domains: Trigonometry and Sequences and Series. By integrating Garfinkel's (1967) concepts of reflexivity and accountability with Pickering's (1995) theory of resistance and accommodation, the study offers a novel account of how mathematical work is produced, redirected, abandoned, and stabilised under high-stakes examination pressure. In doing so, it advances understanding of school mathematics not merely as a cognitive enterprise, but as a socially organised, institutionally shaped practice.

METHOD

Research Design

This study adopts a qualitative interpretive research design, grounded in documentary ethnomethodology (Garfinkel, 1967; Livingston, 2008) and informed by Pickering's (1995) theory of resistance and accommodation. The design is oriented toward analysing examinees' written examination scripts as primary sites of social and mathematical action, rather than as static indicators of cognitive outcome (Bowen, 2009; Creswell, 2014).

The study draws on three documentary datasets from the same National Senior Certificate (NSC) examination context, focusing on Trigonometry, Sequences and Series, and Functions, all analysed using the same analytic principles and theoretical framing.

Data Sources and Context

The data consist of authentic Grade 12 NSC Mathematics examination scripts collected from schools in the Western Cape, written under formal NSC examination regulations (Department of Basic Education [DBE], 2021; Umalusi, 2018). All scripts originate from the same high-stakes assessment context.

The datasets comprise three content-specific subsets:

1. Trigonometry
2. Sequences and Series
3. Functions

Across all three domains, the scripts preserve the full line-by-line construction of examinees' solution paths, including crossings-out, abandoned attempts, restarts, substitutions, diagrams and boxed final answers (Bowen, 2009; Simons, 2015).

Sampling and Ethical Considerations

The examination scripts were obtained through institutional permission from participating schools and district authorities, in line with national and institutional ethical guidelines (DBE, 2021; Umalusi, 2018). All learner identities were anonymised at the point of collection, and no personally identifying information appears in the analysis. Ethical clearance for the collection and analysis of examination scripts was obtained through the relevant university research ethics committee (De Vos, Strydom, Fouché, & Delport, 2011).

The Functions dataset integrated from (2024) study was generated under separate ethical clearance and is used here as a formally declared secondary dataset. Only fully anonymised script material was incorporated into the present analysis. No script appears in more than one dataset. The study therefore, satisfies institutional requirements for:

- Anonymity,
- Secondary data use,
- And protection of learner confidentiality (Lincoln & Guba, 1985; Mouton, 2013).

Unit of Analysis

The primary unit of analysis is the examinee's written solution-seeking pursuit as it unfolds across the examination script. This includes:

- Initial procedural entry,
- Points of symbolic resistance,
- Instances of abandonment and reversal,
- Method switching and targeting,
- And finalisation moves, including boxed answers.

Rather than treating the script as a static artefact of achievement, each solution path is treated as a temporally unfolding sequence of practical mathematical actions (Garfinkel, 1967; Livingston, 2008; Simons, 2015).

Analytical Framework

The analysis integrates two complementary theoretical lenses:

1. Ethnomethodology (Garfinkel, 1967)

Ethnomethodology directs attention to how examinees' written actions are produced as reflexive and accountable displays of doing mathematics within the institutional order of the NSC. Crossings-out, restarts and finalisation moves are interpreted as members' methods for producing recognisable mathematical order in a high-stakes setting (Livingston, 2008; Julie, 2003).

2. Pickering's (1995) Theory of Resistance and Accommodation

Pickering's mangle of practice makes it possible to examine how examinees' agency encounters resistance from mathematical structures and how accommodation emerges through re-organisation, abandonment, constrained re-entry or performative closure. This framework has previously been shown to be productive for making sense of high-stakes mathematical work in South African contexts (Simons, 2015; Bheki et al., 2023).

The integration of these perspectives allows the analysis to conceptualise examinees' scripts as socio-material records of scientific mathematical practice, rather than as mere repositories of answers (Latour & Woolgar, 1979; Pickering, 1995).

Analysis

Analysis proceeded through the following stages across all three datasets, following principles of qualitative document analysis and inductive pattern identification (Bowen, 2009; Creswell, 2014):

1. Initial familiarisation

were repeatedly read to trace each learner's full solution-seeking trajectory rather than only final answers.

2. Identification of resistance points

Moments were identified in which symbolic incompatibility, representational breakdown, or structural misalignment disrupted progress, in line with the notion of resistance in the mangle of practice (Pickering, 1995).

3. Tracing of accommodation moves

Examinees' responses to resistance were tracked, including reversal, method switching, targeting, abandonment and performative closure. Particular attention was paid to instances in which resistance did not fire in the sense described by Simons (2015) and in which closure was achieved through institutional performance rather than epistemic resolution.

4. Construction of textures of mathematical work

As the scripts were analysed, certain repeated ways of working became noticeable across many examinees. These recurring moves, such as restarting, switching methods, or closing off a question, were then described as textures because they reflected how the work tended to unfold across topics (Simons, 2015; Bheki et al., 2023;).

5. Cross-domain comparison

The three content domains were compared to examine how different mathematical structures shape the production of these textures under the same high-stakes conditions (Julie, 2003; Umalusi, 2018).

The purpose of the analysis was not to generate frequency counts of errors but to build a theoretically grounded account of how mathematical work is practically accomplished in examination conditions (Latour & Woolgar, 1979; Garfinkel, 1967; Pickering, 1995).

Trustworthiness

Trustworthiness was established through:

- Prolonged engagement with the scripts across multiple cohorts and domains,
- Repeated analytic cycling between theory and data,
- Use of multiple aligned datasets under the same institutional conditions,

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- And theoretical triangulation through the integration of ethnomethodology and Pickering's framework (Lincoln & Guba, 1985; Mouton, 2013).

The study does not seek statistical generalisation but aims for theoretical generalisation, illuminating how high-stakes examination context reorganises the doing of mathematics across structurally different domains (Scott, Yeld, & Hendry, 2007).

RESULTS

Trigonometry

In the trigonometry questions, many examinees showed early signs of strain when working with identities and algebraic structure. What looked like simple mistakes often marked the moment where their initial plan stopped working. From there, the work shifted, sometimes abruptly, as examinees tried to regain control of the problem (Simons, 2015).

A dominant initial texture across the trigonometry scripts is procedural reflexivity. The examinee frequently begins solution attempts by immediately implementing formulas, often without prior structural interrogation of the problem. For example, in equation-solving tasks, the examinee commonly substitutes identities such as

sin (2x) = 2 sin(x) cos (x)

sin(x) + cos(x) = 1

1 + tan? (x) = sec? (x)

as default opening moves. This rapid procedural entry reflects the historicised orientation toward identity-driven compliance, characterised by repeated exposure to assessment, in which time pressure and formulaic recall are institutionally rewarded (Brodie, 2010; Scott, Yeld, & Hendry, 2007; Simons, 2015).

8.2	Consider the expression: $\frac{1-\cos 2x-\sin x}{\sin 2x-\cos x}$	
	8.2.1 Prove that: $\frac{1-\cos 2x-\sin x}{\sin 2x-\cos x}=\tan x$	(4)

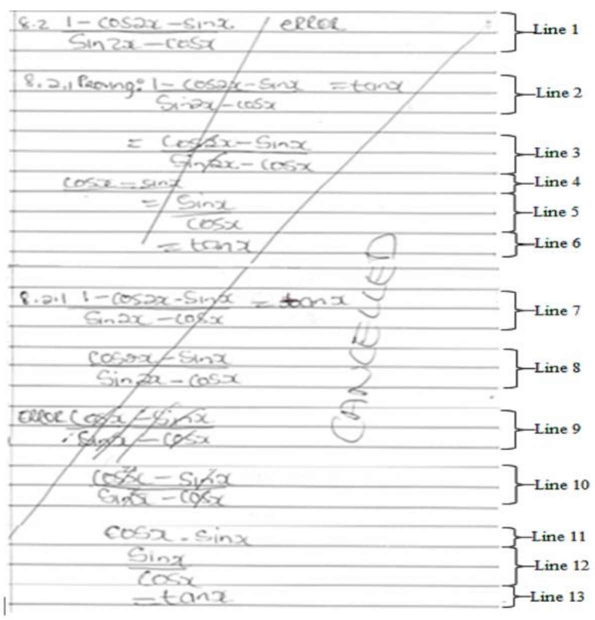

Figure 1: Structural breakdown

However, this reflexive use of identities often results in symbolic overload, especially when examinees lose control over inverse relationships, compound substitutions, or algebraic restructuring. At such moments, resistance manifests as irreducible expressions, incompatible chains of equality, or circular manipulations (Chinnappan, Nason, & Lawson, 1996; Julie, 2003). These breakdowns destabilise the initial procedural trajectory and compel examinees to engage in visible reorganisation.

One prominent response to such resistance is reversal. Reversal is marked by the reflexive abandonment of an entire solution trajectory, and the examinees return to an earlier expression in the problem. This texture is visible where examinees fully cross out extended lines of identity manipulation and restart the solution from the original trigonometric form. Reversal constitutes an accountable public display that the prior method has been rendered no longer defensible within the institutional order of the examination (Garfinkel, 1967). Rather than persisting blindly with a failing procedure, examinees here demonstrate how agency is exerted and how they re-enter the problem space in search of an accommodative path.

Alongside reversal, instances of targeting are also observed in trigonometric work, particularly where examinees alternate between function-based reasoning and identity-based manipulation. In such cases, examinees initially attempt numerical substitution, graph interpretation or direct functional evaluation, encounter resistance, and then re-enter the task using identity transformation as a second strategy.

This back-and-forth switching between approaches shows how examinees try to keep the problem alive after their first plan collapses. Their methods shift in fragments, rather than in one smooth adjustment.

Targeting thus reveals that accommodation in response to Trigonometry problem text is often non-linear and survival-oriented, rather than conceptually smooth.

Despite these moments of re-entry and methodological switching, a substantial portion of trigonometric work culminates in performative closure through the non-firing of resistance. In such cases, examinees encounter persistent symbolic contradictions, such as cancellation, circular identity usage, or unresolved functional misalignment, yet terminate the solution by boxing a final answer. This closure is achieved not through epistemic repair but through institutional finalisation, in which the imperative to complete the script overrides the imperative for structural coherence. The non-firing of resistance thus represents a form of institutionally induced order, rather than conceptual achievement.

Trigonometric functions and transformations introduce an additional layer of resistance through representational coordination. Examinees are required to interpret graph shifts, reflections, and amplitude changes while maintaining algebraic control over function form. Across the scripts, breakdowns frequently occur between graphical reading and algebraic transformation, particularly with inverse trigonometric reasoning and compound transformations. These breakdowns often precipitate procedural reflexivity (return to formulaic manipulation) or direct performative closure without reconciliation between representations.

Taken together, the trigonometry scripts reveal an interaction between:

- Procedural reflexivity,
- Symbolic resistance,
- Reversal,
- Targeting,
- And non-firing of resistance.

Rather than linear progressions toward correct solutions, examinees' trigonometric work is organised as a symbolic action under pressure, shaped by historically procedural habits and the institutional imperatives of the NSC examination (Umalusi, 2018; Nichols & Berliner, 2007). Trigonometry thus emerges not only as a cognitively demanding content domain but as a sociological site of mathematical work, where resistance and accommodation are continuously negotiated in the examination scripts.

Sequences and series

In contrast to the symbolic characteristic of Trigonometry, examinees' engagement with Sequences and Series in the NSC examination is organised around pattern recognition, inductive generalisation, and accomplishments of mathematical structures. While this domain often appears procedurally more accessible, the analysis reveals that it generates its own distinctive forms of resistance and accommodation, particularly at the point where examinees are required to move from numerical patterning to valid algebraic structure (Julie, 2003; Brodie, 2010).

Across the analysed sequences of scripts, initial solution attempts are frequently marked by procedural reflexivity in the form of term-by-term inspection. The examinees typically begin by computing successive terms, examining common differences or ratios, and ing surface regularities.

This shows that many examinees begin by looking for a pattern in the numbers in front of them. They rely on what the terms seem to be doing locally before turning to the sequence's general structure. (Mason, 1996; Tall & Vinner, 1981).

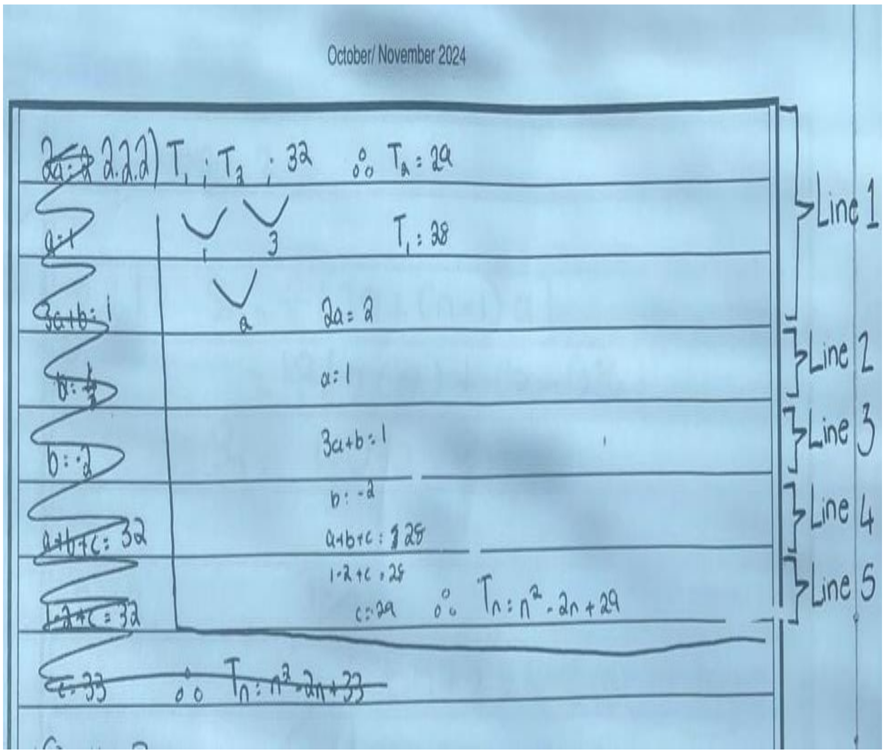

Figure 2: Reversal

Resistance emerges when examinees are required to formalise a general term. The breakdown occurs when this pattern must be reconstituted as an algebraic expression in *n*. At this juncture, examinees produce structurally incompatible general terms, conflating differences with ratios or misaligning additive and multiplicative structures. These moments of misalignment represent structural resistance in Pickering's (1995) sense, where the mathematical object fails to yield to the learner's intended procedural strategy.

One prominent response to such resistance in the sequences domain is constrained reversal. Unlike the extended reversals observed in Trigonometry, reversals in sequences tend to be local and tightly bounded. Examinees cross out a single incorrect general term and immediately attempt a nearby variant by adjusting coefficients or constants while leaving the underlying structure unchanged. This produces a series of accommodations that display continued commitment to the original patterning frame even when it has already become unstable (Simons, 2015).

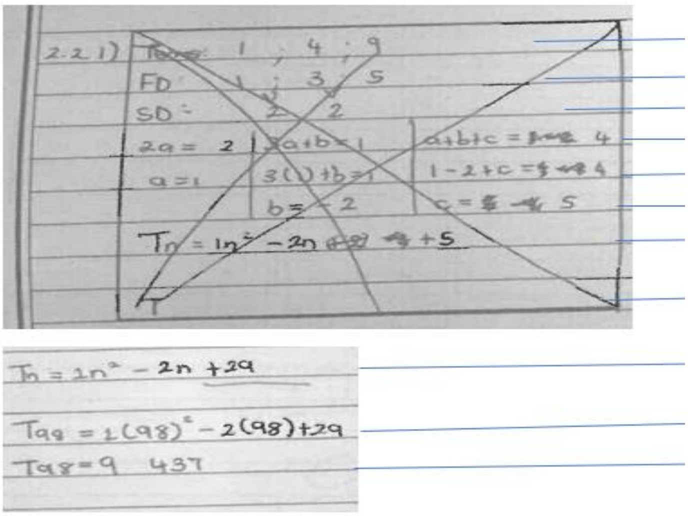

Figure 3: Tagetting

Targeting is also present in sequence work, but it takes a form distinct from that observed in Trigonometry. Here, examinees alternate between recursive and explicit modelling strategies. After encountering resistance with a general term, the examinees revert to recursive expansion (e.g., generating further terms numerically), before re-attempting algebraic formalisation. This iterative pursuit between numerical extension and symbolic generalisation reflects a temporally distributed accommodation process, where resistance is negotiated incrementally rather than in a single decisive move (Pickering, 1995; Mason, 1996).

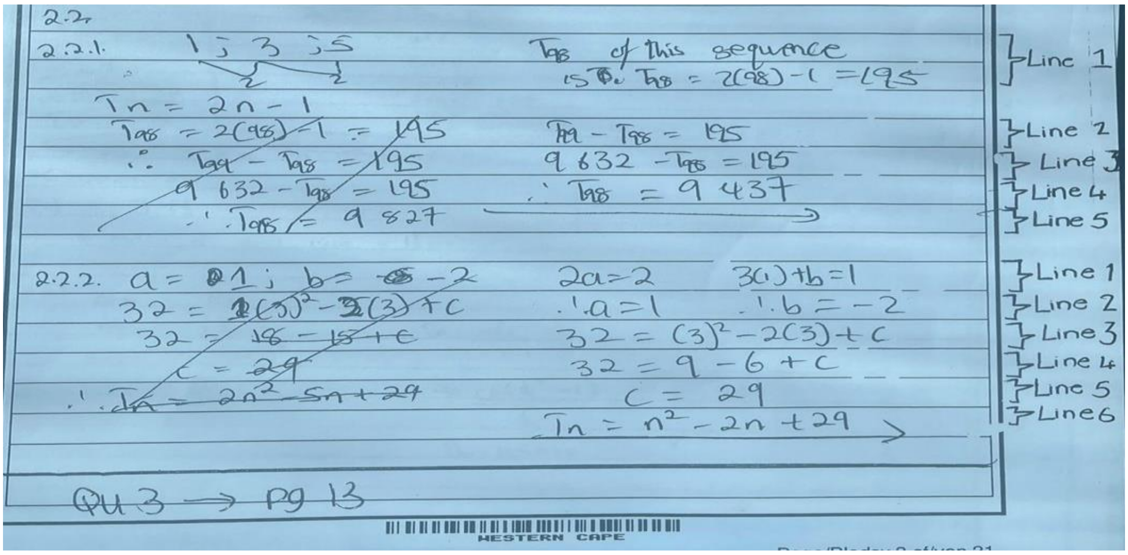

Figure 4: Targeting

Despite these iterative efforts, a large proportion of sequence responses culminate in performative closure through the non-firing of resistance. The examinee box general terms that remain structurally invalid when additive and multiplicative processes are conflated. In such cases, resistance is not epistemically resolved but is instead institutionally neutralised through finalisation, as examinees stabilise their work into an assessable form without achieving internal structural coherence (Nichols & Berliner, 2007).

Series questions introduce an additional layer of structural demand by requiring coordination between the summation structure and term generation. Here, examinees often demonstrate procedural reflexivity by substituting directly into standard formulas for arithmetic or geometric series without verifying that the resulting series aligns with the underlying sequence structure. Resistance becomes visible where the summation formula does not yield meaningful results due to prior mis-modelling of the general term. Rather than reconstituting the model, examinees frequently proceed toward closure through mechanical substitution and final boxing.

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What distinguishes Sequences and Series from Trigonometry is therefore not the absence of resistance but the form it takes and the kinds of accommodation it affords. While trigonometric resistance is often symbolically explosive and leads to extended reversals or method switching, sequence resistance tends to be structurally quiet but persistent, producing constrained micro-adjustments and gradual procedural drift. Across both domains, however, performative closure remains a dominant institutional endpoint.

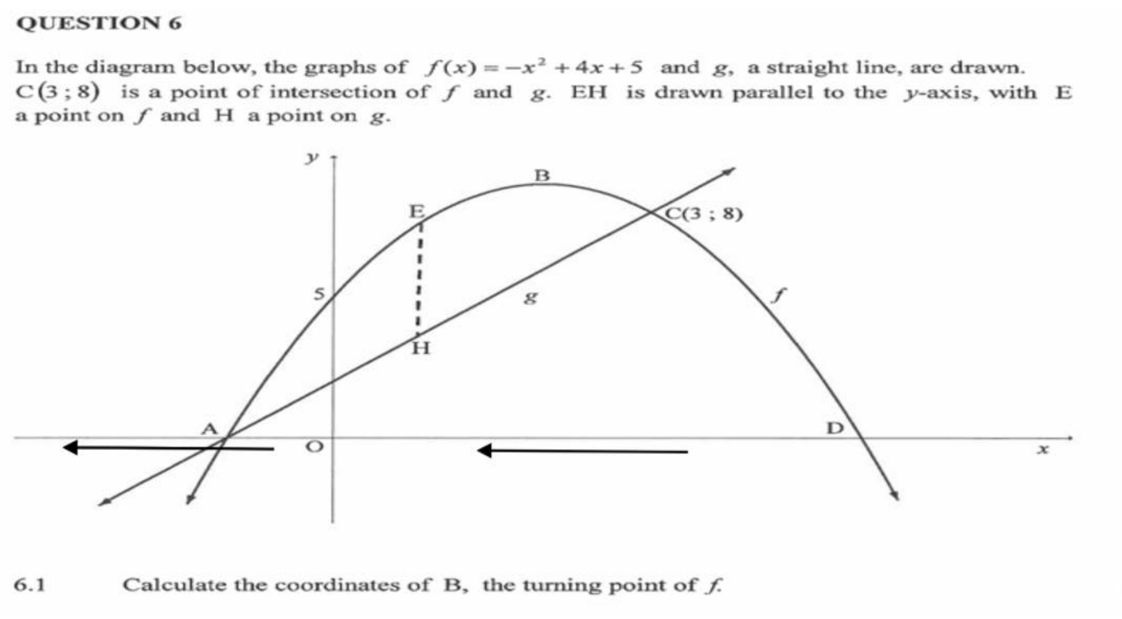
Taken together, the analysis of Sequences and Series reveals how examinees' pattern-oriented reasoning is shaped and constrained by the high-stakes assessment environment. Rather than supporting sustained structural interrogation, the examination context tends to reward rapid empirical patterning and premature algebraic closure, even in the absence of stabilised mathematical structure (Scott et al., 2007). As a result, the textures of mathematical work in this domain are characterised by empirical induction, constrained accommodation, and institutionally driven finalisation, rather than by fully articulated structural

Functions

Examinees' engagement with Functions in the NSC examination involves a distinct form of resistance centred on coordinating multiple representations, including algebraic expressions, graphical forms, and numerical tables. Unlike Trigonometry, where resistance is mainly driven by symbolic density, and Sequences and Series, where resistance revolves around inductive generalisation, Functions places examinees within a layered mathematical space where meaning must be continuously translated across semiotic systems (Duval, 2006; Tall, 2004).

Across the Functions scripts, the initial solution attempts are commonly marked by procedural reflexivity in representational choice. Examinees frequently commit early to either a graphical strategy (reading values, intercepts and turning points) or an algebraic strategy (substitution into formulaic forms) without first establishing stable coordination between these representations. This reflexive representational commitment reflects historically sedimented classroom routines in which representations are often treated as parallel rather than mutually constraining meaning systems (Tall & Vinner, 1981; Duval, 2006).

Resistance becomes particularly visible at points where examinees are required to reason inversely or to track the effects of transformations such as reflections and translations. The analysis shows that examinees frequently encounter breakdowns when attempting to reconcile algebraic transformation rules with the corresponding graphical effects. For example, examinees may correctly identify the algebraic form of a transformed function while simultaneously producing a graph that violates the same transformation conditions. These mismatches constitute representational resistance in Pickering's (1995) sense, where the mathematical object fails to yield coherent coordination across semiotic forms.


QUESTION 6

In the diagram below, the graphs of $f(x) = -x^2 + 4x + 5$ and g, a straight line, are drawn. $C(3\,;8)$ is a point of intersection of f and g. EH is drawn parallel to the y-axis, with E a point on f and H a point on g.

6.1 Calculate the coordinates of B, the turning point of f.

Solution:

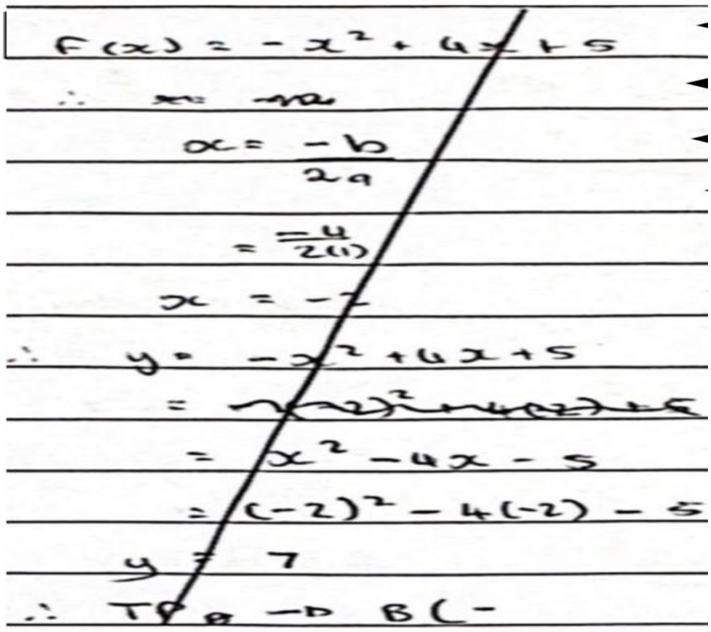


Figure 6: Targeting

A prominent texture of accommodation in the Functions domain is representational reversal. At moments of misalignment, examinees often abandon a graphical trajectory and revert to algebraic manipulation, or vice versa. These reversals are marked by visible crossings-out of graphs, redrawing of axes, or a fresh algebraic restart from the original function expressions. As in Trigonometry, reversal operates as a publicly accountable display that prior meaning coordination has become untenable within the institutional logic of the examination (Garfinkel, 1967; Simons, 2015;).

In the Functions scripts, examinees often move between a graph, a table and an equation in quick succession. Each shift marks another attempt to get the problem back on track after something goes wrong in their earlier work:

- Graphical inspection,
- Algebraic substitution,
- And numerical tabulation,

often in a fragmented sequence. Each switch signals a new attempt at accommodation following representational resistance. However, this targeting frequently remains locally adaptive but globally unstable, as examinees adjust isolated features of the representation without reconstituting the full functional structure (Duval, 2006; Pickering, 1995).

One of the most analytically significant textures emerging from the dataset is reflexive-normative abandonment, a form of performative closure that aligns closely with what is described elsewhere in this article as the non-firing of resistance. In such cases, examinees terminate function questions through the ritualised production of final algebraic expressions, boxed coordinate pairs, or completed sketch frames, despite unresolved representational contradictions (; Simons, 2015). Here, resistance does not fire epistemically, as inconsistencies between algebraic and graphical forms are not repaired. Instead, resistance is institutionally neutralised through the production of assessable final forms.

This institutional stabilisation is particularly evident in transformation questions, where examinees have to transformed function equation or graph without reconciling the inverse relationships that underpin the transformation process. The examination context thus actively shapes the endpoint of mathematical work, privileging completion over conceptual coherence (Nichols & Berliner, 2007; Umalusi, 2018).

What distinguishes the Functions domain from both Trigonometry and Sequences and Series is therefore the centrality of representational coordination as a site of resistance. Whereas Trigonometry foregrounds symbolic manipulation and identity structure, and Sequences foregrounds inductive generalisation, Functions foregrounds the fragile alignment between form, image and number. Across all three domains, however, the same institutional logic operates: resistance is continuously encountered, accommodation is locally improvised, and closure is frequently achieved through performative rather than epistemic means.

Taken together, the Functions analysis reinforces the article's central claim that examinees' mathematical work in high-stakes examinations is not best understood through correctness alone. Instead, it unfolds as a socio-material negotiation of meaning under institutional pressure, in which representational breakdown, constrained accommodation and normative finalisation shape the textures of what ultimately becomes visible as "mathematics" on the examination script (Pickering, 1995; Garfinkel, 1967; ; Simons, 2015).

DISCUSSION

Beyond Right And Wrong In High-Stakes Mathematics

High-Stakes Assessment and the Reorganisation of Mathematical Work

Looking across the three topics, it becomes clear that examinees are not simply applying knowledge step by step. Their work shifts back and forth as they respond to what the problem allows, what breaks down, and what the examination expects them to show. These movements shape the path of their solutions just as much as the underlying mathematics does (Nichols & Berliner, 2007; Umalusi, 2018; Scott, Yeld, & Hendry, 2007).

If we move away from the habit of reading answers simply as right or wrong, a different picture appears. Examinees' work shows repeated attempts to regain control when a method breaks down, and these attempts follow recognisable patterns. This tells us more about how examinees try to cope with the pressures of the exam than about their underlying competence alone.

Resistance and Accommodation as the Engine of Examination Practice

Pickering's (1995) theory of resistance and accommodation provides a use way for interpreting how examinees' agency encounters the recalcitrance of mathematical structures in each domain. In Trigonometry, resistance is driven by symbolic density and identity coordination; in Sequences and Series, by the fragile transition from empirical patterning to algebraic generalisation; and in Functions, by the unstable coordination of representations and inverse transformation reasoning (Duval, 2006; Tall, 2004).

In all three areas of the syllabus, examinees tried to work around breakdowns in ways that made practical sense to them at the time. They restarted parts of their work, shifted between methods, or made small adjustments simply to keep going. These moves were less about building deep understanding and more about getting the problem to a point where they could continue writing (Simons, 2015;).

The prevalence of these accommodative moves indicates that resistance is not an anomalous interruption of examination work but its constitutive engine. Under high-stakes conditions, examinees are continuously negotiating what will "work" within the limited temporal and symbolic space of the script, rather than pursuing mathematical coherence in any deep sense.

The Non-Firing of Resistance and Performative Closure

A pattern that surfaced across all three areas is the way examinees often bring a question to a close even when the underlying problem has not been sorted out. Instead of fixing the difficulty, they settle the work in a form that looks complete on the page (Simons, 2015;).

From an ethnomethodological perspective, this form of closure constitutes a normatively accountable action rather than a cognitive failure (Garfinkel, 1967; Livingston, 2008). Examinees display what counts as a "complete" answer within the institutional order of the NSC, even when epistemic resolution has not been achieved. The boxed answer thus functions less as a signal of knowledge and more as a ritualised completion move, oriented to the social requirements of examinability.

This reframes what is often interpreted as a persistent misconception as a structural outcome of examination pressure, a social fact linked to the mathematics classroom. The examination context actively rewards visible completion over conceptual stability, thereby shaping the production of mathematical work toward performance rather than inquiry (Nichols & Berliner, 2007; Umalusi, 2018).

Representational Coordination and the Fragmentation of Mathematical Meaning

The Functions domain makes especially visible the fragility of representational coordination under high-stakes conditions. Examinees' oscillation between algebraic, graphical and numerical representations without establishing stable semantic alignment illustrates what Duval (2006) identifies as the central challenge of mathematical understanding: the transformation and coordination of semiotic systems.

Within the examination context, however, this challenge is intensified by time pressure and procedural normativity. Examinees frequently treat representations as parallel procedural spaces rather than as interdependent meaning systems. This produces cycles of representational reversal and targeting that fragment mathematical meaning into locally workable but globally unstable segments (Tall & Vinner, 1981; Tall, 2004). The result is a form of distributed but unintegrated mathematical activity, where partial coherence is repeatedly achieved and then abandoned in favour of institutional closure.

A Sociological Account of "Beyond Right and Wrong"

When viewed as a whole, the findings suggest that we need to look beyond individual misconceptions. Examinees' written work is strongly shaped by the conditions under which they write, the time pressure, the marking system and the need to show something complete. These pressures influence how the mathematics appears on the page.

From this perspective, "right" and "wrong" are not neutral epistemic categories but institutionally produced outcomes shaped by:

- Time regulation,
- Mark allocation,
- Procedural normativity,
- And the demand for visible completion and
- The Historicise-self

The textures of work identified in this study thus reveal how mathematical meaning is produced, constrained and stabilised within the social machinery of the NSC examination. This aligns with broader sociological accounts of scientific and mathematical practice as situated, negotiated and materially organised (Latour & Woolgar, 1979; Pickering, 1995).

Cross-Domain Convergence and Domain-Specific Intensification

While Trigonometry, Sequences and Series, and Functions each introduce distinctive mathematical demands, the same institutional logic of high-stakes performance operates across all three. Resistance is inevitable, accommodation is locally improvised, and closure is frequently performative rather than epistemic.

At the same time, each domain intensifies this logic in specific ways:

- Trigonometry amplifies symbolic overload and identity instability,

- Sequences and Series foregrounds the fragile move from empirical patterning to algebraic structure,
- Functions expose the deep vulnerability of representational coordination.

This convergence-with-variation underscores the argument that it is not the content alone that produces these textures, but the interaction between content structure and institutional examination pressure.

Implications for Understanding Mathematical Learning

The sociological lens developed in this article challenges dominant deficit-oriented readings of examination performance. What appears as persistent error or conceptual fragility may, in fact, be a rational response to the institutional demands of high-stakes assessment. Examinees are not simply failing to understand; they are learning how to survive symbolically within a tightly regulated system.

This reframing opens new possibilities for thinking about mathematics teaching and assessment in South Africa. If examinees' work is shaped as much by institutional pressures as by conceptual difficulty, then pedagogical interventions that focus exclusively on "fixing misconceptions" risk missing the deeper social organisation of mathematical activity.

Cross-Domain Synthesis: Shared Textures of Mathematical Work Across Three NSC Domains

Across Trigonometry, Sequences and Series, and Functions, examinees' mathematical work is organised less as linear conceptual progression and more as a fragile negotiation of resistance, accommodation and institutional closure under high-stakes conditions. While each domain introduces structurally distinct mathematical demands, symbolic density in Trigonometry, inductive generalisation in Sequences and Series, and representational coordination in Functions, the same core textures of mathematical work recur across all three domains.

Procedural reflexivity emerges as a common entry point in all domains. In Trigonometry, examinees reflexively deploy identities; in Sequences and Series, they engage in term-by-term empirical patterning; and in Functions, they commit early to either algebraic or graphical strategies. In each case, examinees begin by enacting historically sedimented procedural routines rather than by interrogating underlying structure.

Resistance then arises in domain-specific ways: symbolic incompatibility in Trigonometry, structural misalignment in Sequences, and representational breakdown in Functions. Despite these differences, resistance functions similarly across domains as a moment of destabilisation that interrupts forward procedural flow.

Examinees respond to such resistance through reversal and targeting, though these take different forms. In Trigonometry, targeting is organised through alternation between identity-based and function-based methods. In Sequences and Series, it appears as an oscillation between recursive numerical expansion and algebraic generalisation. In Functions, it is structured through iterative switching between graphical, algebraic and numerical representations. Across all three domains, these shifts reflect temporally distributed accommodation rather than sustained conceptual reconstruction.

Most strikingly, all three domains converge in the dominance of performative closure through the non-firing of resistance. Examinees stabilise their work through boxed answers, completed general terms or finalised transformed functions even when structural contradictions remain unresolved. This closure is best understood not as conceptual resolution but as institutionally normative completion, oriented to the social demands of examinability rather than to epistemic coherence.

Taken together, the cross-sectional analysis shows that the textures of mathematical work are not primarily content-driven but institutionally organised. High-stakes assessment conditions systematically shape how resistance is encountered, how accommodation is improvised and how closure is achieved across structurally different mathematical domains.

IMPLICATIONS AND CONCLUSION

Implications for Mathematics Teaching

The findings of this study carry significant implications for the teaching of Mathematics in the South African senior secondary context. Across Trigonometry, Sequences and Series, and Functions, examinees' work was shaped far more by procedural reflexivity, symbolic survival strategies, and institutionally driven closure than by sustained conceptual reconstruction. This suggests that many examinees have been socialised into a form of mathematical participation that prioritises procedural display over structural sense-making (Brodie, 2010; Julie, 2003; Simons, 2015).

For classroom practice, this implies the need for pedagogies that explicitly disrupt performative closure and create spaces for examinees to remain with resistance long enough for conceptual accommodation to occur. Teachers need to work deliberately with:

- Moments of breakdown,
- Incorrect generalisations,
- Representational contradictions,

not as failures to be immediately corrected, but as productive sites for structural interrogation (Mason, 1996; Tall, 2004).

In Trigonometry, this requires sustained engagement with identity structure, inverse reasoning and functional meaning beyond formula recall. In Sequences and Series, it requires deliberate movement from empirical patterning to algebraic structure, supported by multiple representations and justifications. In Functions, it requires explicit teaching of representational coordination, ensuring that algebraic, graphical and numerical forms are treated as mutually constraining meaning systems rather than parallel procedural spaces (Duval, 2006). Unless such pedagogical shifts occur, high-stakes assessment will continue to reproduce procedural survival strategies rather than deep mathematical understanding.

Implications for Assessment Practice

The dominance of performative closure, achieved through the non-firing of resistance across all three domains, raises urgent questions about the epistemic messages communicated by the NSC examination itself. When examinees are rewarded, even partially, for producing boxed final answers that remain structurally unresolved, the assessment system implicitly legitimises completion without coherence (Nichols & Berliner, 2007; Umalusi, 2018).

This suggests the need for assessment designs that:

- Reward structural reasoning and justification,
- Make partial reasoning visible and assessable,
- And reduce the procedural advantages of premature closure.

More open-ended items, structured-reasoning marks, and tasks that explicitly require explaining representational coordination may weaken the grip of purely performative strategies. Without such shifts, the examination will continue to function as a powerful mechanism for shaping what counts as legitimate mathematical work, often in ways that conflict with curriculum intentions for conceptual understanding (DBE, 2021; Scott, Yeld, & Hendry, 2007).

Implications for Teacher Education and Professional Development

The identified work textures also have important implications for initial teacher education and continuing professional development (CPD). If teachers themselves were socialised through the same high-stakes performative regimes, they may inadvertently reproduce the very procedural reflexivity and closure practices that constrain examinees' conceptual development.

Teacher education programmes need to engage prospective and practising teachers with:

- Ethnomethodological analyses of learner work,
- The logic of resistance and accommodation,
- And the sociological organisation of the classroom and the examination of mathematics.

Working explicitly with authentic learner scripts, as done in this study, provides powerful opportunities for teachers to re-learn how to see mathematical meaning as socially produced rather than merely cognitively possessed (Garfinkel, 1967; Simons, 2015). This is particularly important within South African CPD initiatives aimed at strengthening conceptual teaching in mathematically under-resourced contexts.

Theoretical Contributions: A Sociological Reading of School Mathematics

The study adds to the literature by offering a sociological reading of mathematical work in high-stakes assessment, rather than treating it solely as a record of individual cognition. By integrating ethnomethodology with Pickering's (1995) mangle of practice, the article demonstrates that mathematical meaning is not simply applied by examinees but is negotiated through resistance, accommodation, institutional stabilisation, and social facts.

Across three structurally distinct mathematical domains, the same core textures of work recur:

- Procedural reflexivity,
- Reversal,
- Targeting,
- And the non-firing of resistance.

This cross-domain convergence strengthens the argument that these textures are not content-specific accidents, but structural products of the institutional conditions under which mathematics is examined. In this sense, school mathematics under high-stakes conditions can be understood as a performative scientific practice, shaped as much by assessment regimes as by disciplinary knowledge itself (Latour & Woolgar, 1979; Pickering, 1995).

Limitations and Directions for Future Research

While this study draws on three aligned NSC domains, it remains confined to a specific assessment regime and regional context. Future research could:

- Extend the analysis to other mathematical domains such as Probability, Financial Mathematics and Analytical Geometry,
- Compare high-stakes and low-stakes assessment contexts,
- And investigate how these textures of work shift across schooling phases and into post-school mathematics.

Longitudinal studies that trace how examinees' textures of work evolve across repeated assessment cycles would also deepen understanding of how institutional regimes shape mathematical participation over time.

Conclusion

This article set out to move beyond the binary of correct and incorrect by examining how examinees' mathematical work is practically organised under the institutional pressure of the NSC examination. Through an integrated analysis of Trigonometry, Sequences and Series, and Functions, the study has shown that examinees' work is structured less by linear cognitive progression than by a dense choreography of resistance, accommodation and performative stabilisation.

Talking about "textures of work" helps to show the kinds of moves examinees make while trying to solve exam questions, moves that are usually hidden by final marking schemes.

To truly move beyond right and wrong, South African mathematics education must confront not only what examinees know, but how the institutional organisation of assessment shapes what it becomes possible to know, display and value as mathematics. Only then can teaching, assessment and curriculum work together to support mathematical meaning-making that is not merely performative, but genuinely structural and transformative.

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