Enacting Order in Online Mathematics Classrooms: An Ethnomethodological Study

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Abstract: This study investigates how order is enacted and maintained in online undergraduate mathematics classrooms through the lens of ethnomethodology. Conducted on the backdrop of the COVID-19 pandemic in South Africa, the research explores how learners and lecturers navigated the interactional demands of virtual learning spaces. Drawing on data from recorded lessons, chat transcripts, and semi-structured interviews across three higher education institutions, the study identifies practices that sustain interactional order, including tacit turn-taking, repair mechanisms, and the negotiation of shared reference frames. The findings reveal that online mathematics classrooms are socially co-constructed spaces where order is actively produced through mutual accountability, adaptive performances, and collaborative repair work. The study contributes to a deeper understanding of the sociological dynamics of mathematics education in digital contexts. It offers insights for developing socially responsive online pedagogies in South African higher education.

Keywords: ethnomethodology, online mathematics learning, interactional order, South African higher education, virtual pedagogy, learner–lecturer interaction

INTRODUCTION

The rapid shift to online and blended teaching after the COVID-19 pandemic fundamentally reconfigured how university mathematics is taught and learned. What began as an emergency response has, in many institutions, become a durable feature of higher education, with synchronous videoconferencing, chat, and shared digital whiteboards now woven into routine practice. Mathematics, however, poses distinctive challenges in this medium: it relies on symbolic precision, stepwise reasoning, and shared reference to specific objects (e.g., terms in an expression, points on a diagram). When cameras are off, bandwidth is variable, and several modalities (voice, chat, annotation) are in use simultaneously, the familiar cues that coordinate classroom talk, gaze, gesture, and overlapping turn-entry are attenuated. Lecturers and students must therefore recreate the conditions for an orderly lesson under new constraints. Much of the extant work on online higher education has illuminated technology adoption, access and infrastructural inequities, curriculum adaptation, and assessment integrity. Far less attention has been paid to the interactional mechanics through which a mathematics class remains recognisable as such in real time: who speaks when, how trouble is detected and repaired, and how "this term/that side" becomes unambiguous without shared physical space. In South Africa, where digital divides and multilingual repertoires shape participation opportunities, understanding these mechanics is not only a theoretical interest but an equity imperative.

This study addresses that need by examining how interactional order is enacted and maintained in online undergraduate mathematics classrooms across three South African

universities. We conceptualise interactional order as the routine methods by which participants coordinate turns, manage topics, establish and sustain shared reference, display accountability for meaning, and repair trouble. These methods, when working smoothly, are "seen but unnoticed," yet become visible at moments of disruption.

A dual theoretical frame guides the analysis. From ethnomethodology, we draw concepts of indexicality (the local work needed to make deictic references intelligible), accountability (actions made orderly and inspectable to others), and repair (members' organised methods for resolving trouble). From Goffman's (1959) dramaturgical perspective, we use roles, scripts, regions, and props to locate these micro-methods within the performance demands of an online class: rotating roles (e.g., emergent peer moderators), explicit scripts (nomination → uptake → evaluation), reconfigured regions (frontstage main room; backstage breakout/private chat), and platform "props" (mute, raise hand, chat, screen-share, annotation). Together, these lenses enable us to show how order is co-performed across modalities and constraints.

Research Aim and Questions.

To describe and explain the practical methods through which teachers and students accomplish an orderly mathematics lesson online in the South African higher education context.

Research Questions:

1. Turn-taking: How are turns launched and allocated in synchronous online mathematics classes, and how is overlap or silence handled?

2. Repair: How do participants detect and repair technical (e.g., lag, audio dropout) and epistemic (e.g., misreference, missing steps) troubles while preserving lesson progress?

3. Shared reference: What interactional work makes deictic expressions ("this term," "that side") unambiguous, and how are reference frames stabilised across voice, chat, and annotation?

4. Roles and distribution: What roles (e.g., informal peer moderation) emerge, and how do they redistribute the labour of sustaining order?

Design Overview and Contribution

We conducted a qualitative, interpretivist multi-site case study across three universities, assembling a corpus of lesson recordings, aligned chat logs, semi-structured interviews, and field notes. Analysis followed conversation-analytic sensibilities adapted to online settings, enabling fine-grained accounts of sequence organisation and multimodal coordination. The study makes four contributions. Empirically, it provides data-proximal descriptions of how online mathematics lessons actually proceed turn by turn in a bandwidth-constrained, multilingual context. Theoretically, it integrates ethnomethodology with dramaturgy to model classroom order as a co-performance of micro-methods and performance arrangements. Practically, it surfaces designable routines, turn-taking protocols, repair

packages (recap → re-voice → annotate), and indexical scaffolding (labelling, numbering, cursor tracing); and clarifies how peer moderation can be leveraged without gatekeeping. From an equity perspective, it legitimises chat and annotation as first-class sites of mathematical work, not mere fallbacks for voice, thereby widening legitimate participation under low-bandwidth conditions.

Scope and Article Outline

The focus is on synchronous undergraduate mathematics sessions; we do not measure learning outcomes, but rather explicate the methods that make participation and progress possible. Section 2 reviews relevant scholarship and positions the gap. Section 3 elaborates the theoretical framework. Section 4 details the methodology. Section 5 presents findings across four themes, accompanied by anonymised extracts. Section 6 discusses implications for pedagogy and theory. Section 7 offers conclusions and concrete recommendations for teachers, course designers, and institutions.

LITERATURE REVIEW

Online Mathematics Education in Higher Education

The rapid migration to online and blended learning during and after the COVID-19 period reconfigured the organisation of teaching and learning in higher education. Global reviews documented both the flexibilities gained (asynchronous access, multimodal resources, geographic reach) and the frictions that emerged (new cognitive demands on students, heightened teaching workload, difficulties sustaining presence, and integrity concerns in assessment) (Bozkurt et al., 2020; Engelbrecht et al., 2020). In mathematics, these frictions are amplified by the field's reliance on symbolic precision, cumulative reasoning, and the need to reference shared objects (e.g., diagrams, algebraic expressions) at specific moments. Studies have shown that while online platforms can extend opportunities for collaborative problem solving, they also redistribute participation across modalities (voice, chat, annotation), sometimes privileging those with stronger connectivity, better devices, or greater confidence in digital spaces (Engelbrecht et al., 2020; Roschelle & Teasley, 1995). In South Africa, the move online intersected with long-standing structural inequalities, including uneven access to stable internet, device availability, and quiet study spaces, creating a differentiated capacity to engage in online mathematics learning (Czerniewicz et al., 2020). At the same time, lecturers and students had to relearn interactional routines (who speaks when, how to signal understanding, how to repair misunderstandings) while coping with affective pressures (Cutri et al., 2020; MacIntyre et al., 2022). The literature, therefore, positions online mathematics teaching as a site where pedagogy, infrastructure, and interaction mutually shape one another. This study builds on this view by focusing specifically on interactional order and the routine methods through which participants accomplish a recognisable mathematics lesson in digitally mediated settings.

Interactional Order and Classroom Communication

Interactional order refers to the routinised norms and methods that enable participants to coordinate actions in social encounters, who speaks, how turns are allocated, when repair

is initiated, how topics are maintained, and how accountability for meaning is displayed. In classrooms, these methods are often backgrounded by co-presence (e.g., gaze, gesture, subtle turn-entry cues). Online, by contrast, lag, audio artefacts, platform constraints, and camera-off practices attenuate or remove many of these resources, requiring participants to assemble platform-sensitive equivalents (Hampel & Stickler, 2012). Research in computer-mediated discourse shows how turn-taking and topic management are re-coordinated through typed chat, reactions/emojis, "raise hand" tools, and explicit summons forms ("Mpho, could you take this one?"), while shared reference is maintained through on-screen annotation and verbal deictic repair ("the *left* bracket after x^2") (Herring, 2004).

Participants' methods for addressing trouble in speaking, hearing, or understanding play a central role in sustaining order. Classic work identifies self- and other-initiated repair as preferred resources for maintaining the progressivity of talk (Schegloff et al., 1977). In online mathematics lessons, trouble sources expand to include technical disruptions (audio dropout, screen-share delays) and epistemic issues (misaligned symbolic reference, missed steps in derivations). Consequently, lecturers and students routinely deploy repair packages that combine repetition, step-by-step recap, revoicing of peer contributions, and real-time annotations. The literature thus suggests that interactional order in online classrooms is neither given nor merely transferred from face-to-face contexts; it is actively produced through adaptive repertoires that fit the affordances and constraints of the platform (Hampel & Stickler, 2012; Roschelle & Teasley, 1995).

Ethnomethodology in Educational Research

Ethnomethodology (EM) investigates the ordinary methods by which social actors produce and recognise the orderliness of everyday activities (Garfinkel, 1967). Three concepts are especially generative for classroom analysis. First, indexicality highlights how utterances and actions rely on local contexts for their sense-making in mathematics, where participants say "this term" or "move that to the other side," presupposing shared frames of reference. Second, accountability foregrounds how actors make their actions intelligible and inspectable, for instance by showing their working or justifying a step in a proof. Third, repair describes members' organised ways of dealing with trouble to preserve the recognisability of the activity.

Applied to education, EM and allied conversation-analytic approaches shift attention from intended pedagogy to the situated work through which pedagogy is accomplished, turn by turn, line by line. In mathematics, this complements perspectives that conceptualise learning as participation in disciplinary discourse (Sfard, 2008) by revealing how students and lecturers display uptake, contestation, and alignment in real time. EM is thus well-suited to online classrooms where interactional practices are flowing; it allows researchers to describe what participants actually do to keep the lesson going, rather than what pedagogical designs presume they will do.

Goffman's Dramaturgical Perspective

Goffman's dramaturgical framework views social interaction as performance, organised around roles, scripts, audiences, and props (Goffman, 1959). In educational settings, lecturers and students work to maintain a viable frontstage (a recognisable lesson with

orderly participation) while managing backstage contingencies (confusion, disconnection, resource limitations). Online platforms reconfigure these layers. Cameras, microphones, and screen-sharing functions serve as props; breakout rooms and private chats introduce backstage spaces within the frontstage; and the visibility of silence (e.g., black tiles, muted icons) becomes a delicate part of face-work. Dramaturgical analysis helps explain why participants sometimes over-specify procedures ("First, unmute, then read line 3, then pause…") or rely on role delegation (informal peer moderators monitoring chat) to preserve the impression of a smoothly progressing class.

In South African higher education, dramaturgical demands intersect with institutional expectations about assessment and performance (Luckett & Sutherland, 2000). When interaction falters due to connectivity issues or a misaligned reference, participants risk losing the "thread" of the lesson, threatening both face and progress. The dramaturgical lens, therefore, complements ethnomethodology by showing how frontstage order is an achievement that draws on backstage coordination and the strategic use of props, scripts, and roles.

Online Mathematics Education in South Africa

South African scholarship has highlighted the double bind of emergency remote teaching: while online modalities extended reach and continuity, they also exposed and sometimes deepened inequities (Czerniewicz et al., 2020). In mathematics education, researchers documented both innovations, for example, leveraging LMS tools and recorded explanations for asynchronous revision, and fragilities, such as uneven participation when students lacked data or devices, or when language demands and symbolic complexity collided in bandwidth-constrained contexts (Engelbrecht et al., 2020; Bansilal, 2021). The local literature further notes the pedagogical challenge of creating collaborative mathematical spaces online that mirror the sense-making of in-person tutorials, especially for first-generation students negotiating disciplinary discourse and academic literacies.

While these studies have advanced understanding of technology access, curriculum adaptation, and assessment, fewer have explored the micro-interactional mechanics that make an online mathematics lesson recognisable as such. The commonly reported practices of chat-based participation, re-voicing, and peer assistance are rarely examined at the analytic detail needed to reveal *how* they organise turn-taking, reference, and repair in real-time. This gap encourages closer examination of the interactional order in online mathematics classrooms in South Africa.

Research Gap

Overall, the literature converges on three main points. First, online mathematics education involves unique interactional challenges that cannot be simply reduced to technology adoption alone (Bozkurt et al., 2020; Engelbrecht et al., 2020). Second, existing research in South Africa thoroughly documents infrastructural and curricular changes (Czerniewicz et al., 2020; Bansilal, 2021) but offers limited detailed accounts of *how* learners and teachers practically coordinate participation, reference, and repair online. Third, theoretical frameworks that view learning as participation in discourse (Sfard, 2008) or as performance (Goffman, 1959) highlight the importance of analysing how participants maintain order, yet

few studies integrate these perspectives with an ethnomethodological description of actual episodes.

This study addresses the gap by applying ethnomethodology to explain the local techniques participants use to conduct online mathematics lessons, such as indexical work, accountability displays, and repair. It also employs dramaturgy to place these methods within the wider frontstage/backstage dynamics of digital classrooms. By examining how order is co-created sequentially, considering connectivity constraints and multilingual realities, the study provides an empirically grounded account of interactional order in South African online mathematics education. It also offers pedagogical implications for developing participation that is fair, transparent, and sustainable.

THEORETICAL FRAMEWORK

This study employs a dual framework combining Ethnomethodology (EM) with Goffman's dramaturgical perspective to explain *how* a recognisable mathematics lesson is constructed, moment by moment, in online settings. Ethnomethodology offers concepts to describe the local methods participants use to make sense of and maintain interactional order; dramaturgy places these methods within the performance requirements of a class (roles, scripts, props, regions). The combined approach enables us to analyse both micro-practices (e.g., turn-taking, repair, indexical reference) and the interactional ecology (e.g., camera/mic settings, screen-sharing, chat, breakout rooms) that organise these practices.

Ethnomethodology: Order as a Practical Achievement

Ethnomethodology examines the everyday, taken-for-granted methods by which members of society create and recognise the orderliness of daily activities (Garfinkel, 1967). It views interactional order not as a background condition but as an *ongoing achievement*, continuously constructed and reconstructed through participants' situated practices. Four EM ideas are central to this study:

- Indexicality: The meaning of talk and action is tied to the immediate context. In mathematics lessons, deictic terms such as "this side," "that bracket," or "move it across" presume a shared reference frame that must be actively coordinated, especially online where gaze and pointing are attenuated. We attend to the *work of making references shareable* (e.g., explicit verbal labelling, screen annotations, cursor tracing).

- Accountability: Actions are carried out in a way that o*thers can understand* and evaluate. In mathematics, accountability is evident through displaying work, justifying steps, or explaining procedures ("because the exponent is… therefore…"). Online, accountability may be spread across different modes, spoken turns, typed chats, and on-screen writing—requiring participants to piece together a clear account across various channels.

- Repair: Members' organised approaches for identifying and fixing issues in speaking, hearing, or understanding (Schegloff, Jefferson, & Sacks, 1977). In online classrooms, repair must tackle both technical problems (such as latency and dropouts) and epistemic issues (including misreads of symbols and misaligned steps). We explore

how participants design *repair packages* that combine repetition, re-voicing, step recap, and annotation to maintain flow.

- Reflexivity: The methods used to describe the activity (e.g., "let's go back to line 3," "look at the left-hand side") also *establish* the activity's order by guiding participants on what is relevant at that moment. Reflexivity reminds us that "explaining the method" can also *organise the lesson*.

Ethnomethodology is suitable for detailed analysis of interaction in mathematics, where the accuracy of symbolic manipulation depends on precise timing, sequencing, and reference. It also aligns with a pedagogical view of learning as increasing participation in disciplinary discourse (Sfard, 2008), while emphasising the need to show *how* that participation is practically organised.

Conversation-Analytic Sensibilities as Analytic Toolkit

Although EM is the overarching stance, we draw on conversation-analytic (CA) sensibilities for analysing sequential organisation. This includes attention to turn construction, turn allocation, sequence organisation (e.g., question-answer, explanation-assessment), and repair trajectories. We adapt CA conventions to capture online-specific resources (e.g., typed chat lines as turns, reaction icons as continuers, "raise hand" events as turn-allocation devices), allowing us to document *how participants coordinate talk across modalities*.

Goffman's Dramaturgical Perspective: Roles, Regions, and Props

Goffman (1959) conceptualises social interaction as a performance performed before an audience, maintained through roles, scripts, regions (frontstage/backstage), and props. In online mathematics classrooms:

- Roles include the lecturer, the responding student, the bystander, and the *informal peer moderator* who monitors chat or summarises questions. Role changes are common and often negotiated *during interaction* ("Sipho, can you field questions in the chat?").

- Scripts include the lesson plan (topic introduction → worked example → guided practice → recap) and *interactional scripts* (nomination, uptake, evaluation). Online, scripts are made more explicit ("I'll call on you; please unmute, read line 3, then pause.") to maintain coherence.

- Regions are reconfigured: the main room becomes the frontstage; breakout rooms and private chats serve as backstage, where coordination and sense-making take place with less visibility. Camera-off participation complicates how regions are seen and redefines what counts as "being present."

- Props include platform features such as screen-sharing, annotation tools, chat, mute/unmute, and reaction icons, along with analogue tools like notebooks and printed notes. These props not only support the lesson but *also influence* what kinds of performances are possible, such as chat enabling quiet participation or low-bandwidth engagement.

Dramaturgy explains why participants engage in face-work to maintain a recognisable lesson despite disruptions (e.g., normalising repair, delegating monitoring roles, over-specifying procedures). In the South African context, where bandwidth variation and multilingual repertoires are prominent, dramaturgical demands intersect with institutional expectations about assessment and performance (Luckett & Sutherland, 2000), making *impression management* (e.g., "the class is on track") a practical concern.

Integrating EM and Dramaturgy: A Co-Performed Order

By combining the two lenses, we view online lessons as co-performed achievements in which EM micro-methods (such as turn-taking, reference work, repair, and accountability displays) are *enacted through* dramaturgical arrangements (roles, scripts, regions, props). This integration provides three analytical benefits.

1. Connecting micro-practices to performance demands: When connectivity falters (prop constraint), we expect *repair trajectories* to lengthen and *accountability displays* to shift to the chat or annotation layer to preserve frontstage order.

2. Explaining emergent roles: The rise of peer moderators can be seen as dramaturgical role innovation that *redistributes* the EM work of monitoring, selecting next speakers, and summarising uptake.

3. Making sense of indexical labour: With less co-presence, managing indexicality becomes more apparent; explicit labelling and annotation are not just aids but *necessary conditions* for coherent mathematical reasoning.

We do not assert a deterministic connection from props to practices; instead, we record participants' attitudes towards these resources as reflected in their turns and actions.

Operationalisation: What we look for in the data

The framework translates into observable indicators and analytic questions applied to recordings, transcripts (voice + chat), and screen-captures:

- Turn-taking: How are turns initiated and assigned (nomination, "raise hand," chat preludes)? What constitutes a legitimate entry to speak? How do participants handle overlap given latency?

- Indexical reference: Where do we see deictic expressions ("this," "that," "here," "there") and how are they clarified (verbal relabelling, cursor tracing, highlighting, laser pointer)? What occurs when a reference fails?

- Accountability displays: How are steps in a derivation or proof narrated, justified, or re-voiced? Are these displays spread across modalities (speech + chat + annotation), and how are they integrated into a single account?

- Repair: Who initiates repair (self vs. others)? What are common sources of trouble (technical vs. epistemic)? What repair formats recur (repeat + annotate; re-voice + step recap), and do they restore flow?

- Roles and regions: When and how do peer moderators emerge? How are backstage spaces (breakout rooms, private chats) used to prepare frontstage contributions? How do camera-off/camera-on states reconfigure participation rights?

- Props as affordances/constraints: How do specific features (mute, chat, screen-share, whiteboard) enable or restrict the ethnomethodological work? What adaptations occur under low-bandwidth conditions (e.g., chat-only proof sketches)?

These indicators ground the analysis in members' methods, avoiding imposition of external categories that participants themselves do not use.

Boundary Conditions and Limitations

Two caveats inform our claims. First, EM analyses are local and context-specific: we clarify *how* a particular cohort achieves order rather than establishing universal laws. We strengthen our justification through analytic transparency (presenting data extracts), deviant-case analysis, and triangulation (voice, chat, annotation). Second, dramaturgy is a sensitising perspective, not a deterministic model; we employ it to elucidate how roles, props, and regions organise performances, while prioritising participants' orientations.

Why This Framework? Fit to the Research Questions

The framework is selected for its conceptual alignment with the study's focus on *how* interactional order is enacted and maintained online. EM helps us illustrate the systematic work teachers and students do to keep a mathematics lesson on track (indexical labour, accountability, repair). Dramaturgy considers the organisational ecology—roles (including emerging peer moderators), scripts, and props, through which this work is performed in platform-mediated spaces. Together, they provide a practice-based explanation of order that is attentive to South Africa's infrastructural realities and multilingual repertoires, and they offer practical implications for designing participation that is fair, transparent, and sustainable.

METHODOLOGY

Research Design and Rationale

This study adopts a qualitative, interpretivist multi-site case study to explore how interactional order is established in online undergraduate mathematics classrooms. The design is consistent with an ethnomethodological perspective that views classroom order as a practical achievement of participants rather than a fixed background (Garfinkel, 1967).

To analyse the sequential organisation of interaction, we utilise conversation-analytic approaches (turn-taking, sequence organisation, repair trajectories) adapted for digitally mediated environments (Schegloff, Jefferson, & Sacks, 1977; Herring, 2004).

The case study methodology enables in-depth, context-sensitive analysis across multiple institutional settings, while facilitating analytic generalisation to comparable contexts.

Setting and Context

Data were collected at three South African universities, anonymised here as University A (urban, research-intensive), University B (rural, historically disadvantaged), and University C (comprehensive, mixed urban–peri-urban intake). All institutions used mainstream videoconferencing platforms (e.g., Zoom or Microsoft Teams) with accompanying LMSs. The context is shaped by uneven connectivity, device access, and multilingual repertoires, conditions that influence when and how learners and lecturers participate online (Czerniewicz et al., 2020).

Participants and Sampling

We used purposive sampling to recruit three mathematics lecturers (one per site) who had taught at least one term of online courses. Within each class, volunteer students were invited to participate; across sites, (*n = 45)* learners consented to the use of lesson recordings and chat logs for research. A subset *(n = 18)* participated in follow-up semi-structured interviews. We did not collect identifying data beyond pseudonyms and broad descriptors (e.g., year of study) to protect confidentiality.

Data Sources

Data comprised multiple, triangulated sources:

Synchronous lesson recordings (approximately 21 hours in total) capturing audio, shared screens, and sometimes, gallery view; Platform chat transcripts exported from the videoconferencing tool; Semi-structured interviews with lecturers and students focusing on participation, reference work, and repair practices; Researcher field notes documenting contextual features (e.g., bandwidth constraints, class size, platform settings).

Data Collection Procedures

Lecturers distributed study information and consent links before the recording. Recordings were generated using the built-in platform tools, accompanied by on-screen notices about the recording status. Chat logs were exported immediately after each session and linked to the corresponding time-stamped video segments. Interviews (30–50 minutes) were conducted online, audio-recorded with consent, and followed a guide covering interactional routines (turn-taking, repair), the role of chat, and experiences of reference alignment (see §4.10). Field notes captured session structure, platform configurations (e.g., "mute on entry," chat permissions), and notable incidents (e.g., prolonged lag).

Data Preparation and Transcription

Audio tracks were transcribed using a Jefferson-lite convention suitable for analytic clarity while remaining readable to practitioners. Key marks included:

- (.) brief pause; (1.2) timed pause in seconds;
- = latched turns;

- overlap onset/offset;

- CAPS for emphatic stress;

- ((note)) analyst comment;

- {ANNO} on-screen annotation event;

- 💬 preceding a **chat line** is treated as a turn;

- → analytic arrow highlighting focal lines in extracts.

Screen-share annotations and cursor movements were noted when they were interactionally consequential (e.g., when a repair depended on a highlight). All names were pseudonymised; institutions and modules were described generically.

Analytic Procedure

Analysis proceeded iteratively in six linked phases:

Familiarisation: repeatedly viewing recordings while reading aligned chat logs to identify key episodes where turn-taking, repair, or indexical work was prominent. Episode Catalogue: building a cross-site index of episodes tagged by trouble source (technical vs. epistemic), resource (chat, annotation, voice), and role configuration (lecturer, respondent, peer moderator). Fine-grained Transcription: preparing data extracts with Jefferson-lite notation and embedded time codes. Sequential Analysis: examining each line to analyse turn design, turn allocation, repair initiation/format, and outcomes (e.g., restored progressivity, topic shift). Cross-case Synthesis: grouping similar sequences across sites to create collections (e.g., "chat-led repairs after audio dropout," "indexical clarification with on-screen labels"), then performing thematic synthesis that respects sequential findings. Dramaturgical Integration: mapping EM findings onto roles, scripts, regions, and props (Goffman, 1959) to explain how micro-methods are staged and maintained in platform ecology (e.g., emergence of peer moderators as role innovation). Throughout, we conducted deviant-case analysis to test the robustness of claims and avoided imposing categories that participants did not orient to (EM reflexivity).

Ethical Considerations

Ethical approval was obtained from the research ethics committee of each participating institution. All participants gave informed consent; those who did not agree were excluded from the analysis. We reduced risk by avoiding sensitive personal data, pseudonymising all identifiers, and storing files on encrypted drives with restricted access. Participants could withdraw without penalty up to the start of cross-case synthesis. When presenting extracts, we masked voices and removed identifying overlays where necessary.

Trustworthiness and Rigour

We pursued quality through multiple, complementary strategies:

Credibility: triangulation across modalities (voice, chat, annotation) and actors (lecturers/learners); member-oriented checks by sharing brief episode summaries with two

lecturers for feedback on our interpretation of interactional intent; scrutiny of deviant cases. Dependability: a clear audit trail of decisions (versioned transcripts, codebooks, memos, and episode indexes). Confirmability: analytic memos and a reflexive diary documenting assumptions, surprises, and changing interpretations; regular peer debriefs among co-authors. Transferability: detailed descriptions of the institutional context, class size, platform settings, and bandwidth realities to help readers assess applicability to their own contexts (Luckett & Sutherland, 2000).

Instruments and Prompts

The interview guide included open prompts such as:

"When you wanted to speak in class, how did you enter a turn?"

"Can you recall a moment where something went wrong (technically or mathematically) and how it was repaired?"

"How did you make sure everyone knew what 'this' or 'that' referred to when working with symbols or diagrams?"

"What roles did students take on (e.g., monitoring chat), and how did that help or hinder the lesson?"

Prompts were adapted to align with participants' own perspectives and to elicit specific episodes rather than general opinions.

Researcher Positionality

All authors are mathematics education practitioners and researchers with previous experience in online teaching. This familiarity helps in attentively noticing pedagogical details, but also poses a risk of overfamiliarity. We addressed this by engaging in dialogue between analysts, explicitly noting assumptions in memos, and favouring participants' expressed orientations over our expectations (Garfinkel, 1967).

Limitations and Boundary Conditions

As an EM-informed multi-site case study, findings are context-bound and aim for analytic rather than statistical generalisation. Audio-only participation and camera-off norms sometimes limited access to embodied conduct (gaze, gesture). Connectivity constraints may have selectively silenced some learners, shaping what could be observed. These limits are intrinsic to the phenomenon under study and are addressed analytically by focusing on members' available resources (Herring, 2004; Hampel & Stickler, 2012).

Data Management and Security

All raw data (videos, chats, audio files) and derivatives (transcripts, extracts, memos) were stored on encrypted, access-controlled drives. File-naming conventions linked episodes to time codes without storing real names, and a separate key mapping pseudonyms to consent records was retained offline.

FINDINGS

Across the corpus of recorded sessions, chat logs, and interviews, we observed four recurring practices through which participants sustained a recognisable mathematics lesson online: (i) tacit turn-taking, (ii) repair mechanisms, (iii) management of shared reference frames (indexical work), and (iv) the emergence of informal peer moderators. These practices frequently co-occurred within the same episode.

Tacit Turn-Taking in Camera-Off Classes

Extract 1: Chat prelude → nomination → voice turn (University B, Algebra)

(Camera off for most students; chat enabled. "Lect" = Lecturer)

1 Lect: (.) Okay so if x = 2, what happens on the LEFT side? (.)

2 Ayesha: can I try

3 Lect: Ayesha go ahead, unmute.

4 Ayesha: (1.0) Uh the left side becomes (.) three times two MINUS one so (.) five.

5 Lect: = Good. So LHS is five. (.) Next, Sipho?

6 Sipho: (typing) one sec network (.)

7 Lect: (.) I'll park you Sipho—Naledi you can jump in?

8 Naledi: LHS is five and RHS (.) still needs substitution.

Commentary:

- Chat as turn-prelude: Ayesha's "can I try" (l.2) functions as *turn-entry* without voice overlap; the lecturer ratifies and allocates (l.3).

- Latency management: Sipho signals trouble via chat (l.6); the lecturer *reallocates* (l.7) while preserving Sipho's right to speak later—an example of face-saving turn management.

- Economy of resources: With cameras off, *pauses + chat + name summons* constitute the tacit system for floor entry.

Extract 2: Raise-hand queue with lag (University A, Calculus)

1 Lect: Who can show where the chain rule is applied?

2 (1.2)

3 [Thandi raises hand] [Jabu raises hand] ((platform shows order))

4 Lect: Thandi first, then Jabu.

5 Thandi: At the inner function (.) derivative of (x^2+1) times the outer.

6 Lect: Yes. Jabu

7 (0.8) ((Jabu still muted))

8 Lect: You're muted, Jabu.

9 Jabu: Sorry. (.) The outer is $(x^2+1)^3$, so three $(x^2+1)^2$ and then times 2x.

Commentary:

- Turn allocation: The platform's queueing artefact (l.3–4) externalises the local *order of nexts*, reducing overlap.

- Prompted self-repair: The lecturer's "You're muted" (l.8) is an *other-initiated, self-performed* repair of a technical trouble that restores sequence progressivity (l.9).

- Tacitness: Minimal meta-talk suffices; much of the order is *seen but unnoticed* in the smooth hand-off between raised hands.

Repair Mechanisms: Technical and Epistemic Troubles

Extract 3: Technical dropout → summary + re-voicing (University C, Linear Algebra)

1 Lect: So (.) eigenvalues are from det(A - λI) = 0 (.)

2 (2.0) ((audio stutter, screen-share freezes))

3 Sipho: sound cut? (.)

4 Lect: Right (.) picking up—WE were at the determinant equals zero (→ writes {ANNO: "det(A-λI)=0"})

5 Lect: = Then λ is the value making that true.

6 Ayesha: So solve the polynomial now?

7 Lect: Exactly, characteristic polynomial next.

Commentary:

- Trouble source: Platform failure (l.2) interrupts the step-wise exposition.

- Repair format: The lecturer deploys a repair package: *summary of last safe step + annotation* (l.4), then advances (l.5).

- Chat alignment: Ayesha's *candidate understanding* (l.6) displays epistemic uptake, allowing the lecturer to confirm and progress (l.7).

Extract 4: Epistemic mis-reference → indexical repair (University B, Trigonometry)

1 Lect: Move "this term" to the other side.

2 Jabu: (.) Which term?=

3 Lect: = The $\sin^2\theta$ term on the LEFT. {ANNO: highlight $\sin^2\theta$}

4 Jabu: Okay, so minus $\sin^2\theta$ moves to the right.

5 Lect: Good. And what happens to the sign?

6 Jabu: It becomes plus on the right.

Commentary:

- Indexical trouble: "this term" (l.1) is ambiguous without shared visual anchoring.

- Repair: Lecturer relabels verbally ("sin^2θ on the LEFT") and highlights (l.3).

- Accountability: Jabu's subsequent turn (l.4-6) displays the expected algebraic transformation, making understanding inspectable.

Managing Shared Reference Frames (Indexical Work)

Extract 5: Cursor tracing + numbering to stabilise reference (University A, Limits)

1 Thandi: Can we name the statement P(n): "1+...+n = n(n+1)/2" ?

2 Lect: Good—P(n) it is.

3 Thandi: Then base case is P(1); step assumes P(k); show P(k+1). Right?

4 Lect: Perfect. (.) Now do the algebra for P(k+1).

Commentary:

- Learner agency in reference work: Thandi proposes a labelling convention (l.1-3) that scaffolds subsequent turns, showing how students co-produce indexical stability.

- Economy: The convention shortens later utterances ("P(k+1)") and reduces ambiguity.

Emergent Peer Moderation: Distributing Interactional Labour

Extract 7: Chat bundling and spotlighting (University B, Functions)

1 Lect: Questions on the domain?

2 (2.0)

3 Ayesha: 💬 compiling chat Qs: (i) why exclude x=0? (ii) is sqrt(x^2) = x?

4 Lect: Great—let's take those in order.

5 Lect: (i) Exclude x=0 because denominator zero is undefined.

6 Lect: (ii) Sqrt(x^2) = |x|, so watch the absolute value.

7 Ayesha: 💬 👍

Commentary:

- Role innovation: Ayesha enacts an informal moderator role (l.3), bundling questions and presenting an agenda.

- Tempo control: The lecturer's "in order" (l.4) aligns with the bundle, giving the class a micro-script for Q&A.

Extract 8: Gentle policing + inclusion (University A, Tutorial wrap-up)

1 Lect: Any last checks before we close?

2 Sipho: People are asking in chat about Q3.2 again

3 Lect: Okay, spotlight Q3.2.

4 Ayesha: Guys not the whole solution, just where you got stuck?

5 Naledi: Mine was the sign change at the factorisation step.

6 Lect: Right, let's reopen that step briefly.

Commentary:

- Backstage to frontstage: Peer moderators move issues from backstage (chat stream) to frontstage (shared focus) (l.2–3).

- Inclusion norms: Ayesha's "not the whole solution" (l.4) *gently polices* relevance and protects time while keeping doors open for those stuck—distributed face-work supporting lesson coherence.

Interconnections: Co-performed Order

The themes rarely acted in isolation. In many episodes, a turn-taking resource (e.g., chat prelude) *became* a repair device (e.g., signalling network trouble), which in turn *triggered* indexical work (e.g., relabelling). The presence of peer moderators accelerated these cycles by *surfacing* troubles and *pre-structuring* joint attention.

Extract 9: Turn-taking → repair → indexicality with moderator support (University C, Differentiation)

1 Lect: Derivative of $(x^2 + 1)^3$? Thandi you're up.

2 Thandi: (.) Outer $3x^2 + 1)^2$ times inner 2x.

3 Lect: Yes—where exactly is the "outer"?=

4 Ayesha: {ANNO: highlight whole power} Outer = the power part.

5 Thandi: Right, the power (.) then multiply by inner 2x.

6 Lect: Good, thanks Ayesha for the highlight.

Commentary:

- Tacit turn → immediate repair: Lecturer's probe (l.3) requests accountability for the term "outer";

- Moderator-enabled indexicality: Ayesha's annotation (l.4) is a *peer-provided deictic repair* that clarifies reference for the whole class;

- Co-performance: The explanation is *co-constructed* across roles and modalities, with the lecturer publicly ratifying the moderator's contribution (l.6).

Cross-theme Synthesis

- Tacit turn-taking relied on *lightweight signals* (chat preface, name summons, raise-hand queue) that are easily disrupted; repair packages routinely stitched the sequence back together.

- Indexical labour was continuous, not episodic: pre-emptive labelling and on-the-fly highlighting made deictics usable in the absence of shared physical space.

- Peer moderation redistributed the *work of order*, surfacing questions, bundling themes, and policing relevance, thus supplementing the lecturer's role without formal designation.

- The four practices formed a mesh: when one resource failed (e.g., voice), others (chat/annotation/moderation) compensated, preserving progressivity and face.

This analysis supports the claim that online mathematics lessons are co-performed achievements: ethnomethodological micro-methods (turns, repairs, indexicals, accountability displays) are enacted within dramaturgical arrangements (roles, scripts, props), resulting in an interactional order that is fragile yet resilient under platform constraints.

DISCUSSION

This study aims to explain how a recognisable mathematics lesson is achieved online. The analysis reveals that order is co-created through four interconnected practices: tacit turn-taking, repair, indexical work, and informal peer moderation. Viewed through an ethnomethodological lens, these are members' *everyday methods* for maintaining the lesson's clarity and flow. From a dramaturgical perspective, they are also performances maintained by roles, scripts, regions, and props. We examine each theme in relation to existing scholarship and the South African context, then outline implications and theoretical contributions.

Re-specifying Classroom Order as a Practical Accomplishment

The findings reaffirm that interactional order is not a background condition transferred from face-to-face teaching into videoconferencing; it is locally and continuously created (Garfinkel, 1967). Participants orient to the *flow* of the lesson, using platform-sensitive equivalents for floor entry (chat preludes, raise-hand queues) and turn allocation (name summons, nomination). These methods are "seen but unnoticed" when they function smoothly, and only become visible when they temporarily fail, revealing the effort needed to maintain a mathematics class as recognisably such. The analysis thus extends studies of online learning that focus on technology and curriculum (e.g., Engelbrecht et al., 2020;

Bozkurt et al., 2020) by illustrating the interactional labour that underpins pedagogy in real time.

Repair as Collaborative Accountability

Repair organised much of the lesson's resilience. Participants addressed technical issues (lag, audio dropouts, and frozen screens) and epistemic issues (misaligned symbolic reference and missing steps) using repair strategies that combined *recapping the last safe step*, *revoicing*, and *on-screen annotation*. This aligns with conversation-analytic accounts of repair preference (Schegloff, Jefferson, & Sacks, 1977) while adding a multimodal layer typical of computer-mediated settings (Herring, 2004). Dramaturgically, these repair strategies also serve as face work, maintaining the illusion of a smoothly progressing frontstage lesson despite backstage challenges. The analysis suggests that repair competence, knowing when and how to use recaps, re-voicing, and annotation, is an integral part of *interactional pedagogy* online, not merely a remedial skill.

Indexicality and the Making of Shared Reference

Mathematics instruction often depends on deictic expressions (like "this term," "that side," "here"), which rely on a shared reference frame. Online, such reference cannot be assumed; it must be actively maintained. Techniques such as numbering, explicit labelling, cursor tracing, and highlighting serve as indexical scaffolds that make discussion of symbolic objects *observable* across different modalities. This complements discourse-focused views on learning (Sfard, 2008) by demonstrating the interactional mechanics through which learners and teachers *create* a shared mathematical object when gaze and pointing are reduced. The key principle is: make references visible and consistently indexable (for example, with labels that persist over multiple turns).

Peer Moderation as Distributed Classroom Management

A notable discovery is the rise of informal peer moderators who compile questions, highlight chat issues, and gently police relevance. These students perform role innovation that redistributes interactional labour, enabling the lecturer to maintain pace while ensuring inclusive participation. This aligns with work on collaborative problem solving and shared regulation (Roschelle & Teasley, 1995), but with a distinctive interactional twist: moderators provide deictic and sequential cohesion, not just cognitive scaffolding. The practice is promising but also carries risks: without proper facilitation, moderation could shift into gatekeeping or reinforce voice inequities. Intentional rotation and clear norms can help realise its inclusive potential.

South African Specificities: Bandwidth, Multilingualism, and Legitimacy of Modes

The texture of interaction was shaped by infrastructural inequalities (Czerniewicz et al., 2020) and multilingual repertoires. Chat-only engagement emerged as a *legitimate mode of participation*, not a deficit, enabling contribution under low bandwidth and supporting translanguaging (e.g., rehearsing a formulation before voicing it). The findings therefore

nuance deficit framings of "camera-off" or "silent" students: many participated differently, aligning with observations that online modalities redistribute participation opportunities and burdens (Bansilal, 2021). Recognising chat and annotation as primary sites of mathematical work is crucial for equity, affect, and persistence (Cutri et al., 2020; MacIntyre et al., 2022).

Implications for Pedagogy and Course Design

The analysis produces actionable recommendations such as:

- Formalise turn-taking protocols. Teach students concise floor-entry techniques (chat prelude + nomination) and make raise-hand queues clear.

- Teach repair routines. Standardise short recap → re-voice → annotate sequences after disruptions; embed these into slides and pacing.

- Create indexical scaffolds. Pre-label entities on shared screens; use persistent highlighting and numbering. Utilise a minimal reference lexicon ("term [1]", "LHS", "RHS").

- Embed peer moderation. Rotate a "chat moderator" role; establish norms (e.g., group questions, avoiding posting full solutions, highlighting sticking points).

- Support low-bandwidth participation. Grade and recognise chat contributions and annotation moves; include voice/chat equivalents in participation rubrics.

- Design for multilingual clarity. Promote paraphrasing and revoicing in chat; provide bilingual labels where suitable; permit brief L1 sense-making moves that are then rearticulated into mathematical English.

- Align assessments. Incorporate items that require making references inspectable (e.g., annotate and explain "what 'this' refers to"), rewarding interactional clarity as part of mathematical communication.

Theoretical Contributions

The study offers four key ideas: (1) Where the co-performed order. It combines ethnomethodology with dramaturgy to demonstrate that online classroom order is collaboratively created through micro-methods and performance arrangements (such as roles, regions, and props). (2) The repair packages in CMC pedagogy. It details multimodal repair formats that maintain progressivity within platform limitations, expanding classic repair theory into pedagogical practice. (3) Indexical scaffolding. It highlights and exemplifies designable reference-making practices (such as labelling, numbering, and tracing) as essential conditions for online mathematical discussion rather than optional aids. (4) Peer moderation as role innovation. It explains the interactional functions of informal moderators, clarifying how student roles can help stabilise participation and pacing. Together, these contributions bridge literatures on online mathematics education (Engelbrecht et al., 2020), computer-mediated discourse (Herring, 2004), interactional sociology (Garfinkel, 1967; Schegloff et al., 1977), and dramaturgy (Goffman, 1959).

Limitations and Directions for Future Research

As a multi-site, EM-informed case study, claims are **context-dependent** and focused on **analytical** rather than statistical generalisation. Camera-off norms restricted access to embodied conduct (gaze/gesture), and connectivity issues may have selectively silenced some learners. Future research should (a) investigate the equity effects of peer moderation (who moderates, who benefits), (b) compare discipline differences (e.g., proofs vs. modelling), and (c) assess CPD interventions that teach repair packages and indexical scaffolding, including their impacts on performance and sense of belonging.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study investigated how interactional order is established in online undergraduate mathematics classrooms across three South African universities. Using ethnomethodology and Goffman's dramaturgical perspective, we demonstrated that a recognisable mathematics lesson is co-performed by teachers and students through four interconnected practices: tacit turn-taking, repair, indexical work, and informal peer moderation. These practices are not background conditions transferred from in-person teaching; rather, they are locally produced, adapted to the affordances and constraints of videoconferencing platforms, and responsive to bandwidth variability and multilingual repertoires.

Two implications emerge. Firstly, the mechanics of participation—how turns are initiated, how issues are resolved, and how "this/that" is clarified—are vital to online mathematical teaching, not secondary. Secondly, fair participation involves recognising chat and annotation as primary sites of mathematical activity, especially in low-bandwidth situations. The framework and findings therefore go beyond just adopting technology to highlight the interactional work that supports online mathematics teaching and to identify practices that can be taught, rehearsed, and institutionalised.

Recommendations

A. Pedagogical routines (what teachers do in the moment)

1. Codify floor entry. Teach a simple protocol (chat prelude → nomination → voice turn) and model it in the first weeks.

2. Teach repair packages. After any disruption, enact a short *recap → re-voice → annotate* sequence to restore progress and shared understanding.

3. Engineer indexical scaffolds. Pre-label entities on shared screens (e.g., [1], [2], [3]), use persistent highlights, and adopt a minimal reference lexicon ("term [1]", "LHS/RHS").

4. Name the roles explicitly. Invite a rotating "chat moderator" each session; state the norms ("bundle questions; spotlight sticking points; no full solutions").

5. Legitimise multiple modes. Treat chat contributions and annotation moves as valid participation, not merely substitutes for talk.

B. Course and assessment design (what teachers design beforehand)

6. Interaction-ready slides. Build "repair slots" into pacing (e.g., recap checkpoints), include numbered diagrams, and leave space for live annotations.

7. Participation rubrics with parity. Award equivalent credit for voice, chat, and annotation; include criteria for *making reference inspectable*.

8. Assessment for interactional clarity. Incorporate items that require students to label, annotate, and explain references, not only to compute.

9. Low-bandwidth pathways. Provide chat-first tasks, downloadable boards/worksheets, and instructions for "audio-off + chat-on" problem-solving.

C. Programme and institutional supports (what departments/faculties can enable)

10. CPD on interactional pedagogy. Offer short workshops where staff practice turn-allocation, repair packages, and indexical scaffolding with peers.

11. Role rotation templates. Provide ready-made moderator scripts and rotation schedules to normalise student leadership without gatekeeping.

12. Platform configuration defaults. Set course shells to enable chat, reactions, and annotation by default; make raise-hand queues visible.

13. Equity provisioning. Allocate data bundles or zero-rated access where possible; offer multilingual labelling resources and quick-reference glossaries.

D. Monitoring and improvement (how to iterate)

14. Lightweight interaction audits. After selected sessions, review a 5–10 minute clip with a colleague, focusing on *turn-taking, repair, and reference*.

15. Student feedback on modes. Regularly poll learners on whether voice/chat/annotation felt usable, fair, and transparent; adjust protocols accordingly.

Contribution and Future Directions

The study contributes (i) a practice-proximal account of online classroom order as co-performance (micro-methods × dramaturgical arrangements), (ii) a specification of multimodal repair for pedagogical use, (iii) a toolkit for indexical scaffolding in mathematics, and (iv) an interactional description of peer moderation as role innovation. Future research should assess the learning and equity impacts of explicitly teaching these routines (e.g., RCTs or design-based research), compare patterns across mathematics subdomains (proof vs. modelling), and explore how multilingual practices in chat and voice can further stabilise shared references without compromising disciplinary precision.

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