# SHEDDING LIGHT ON CURIOSITY WINDOWS IN A MIDDLE-SCHOOL MATHEMATICS CLASSROOM

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*Curiosity is central to meaningful mathematics learning. This study examines the emergence of situational curiosity in middle-school students during mathematics lessons, using an emoji-based questionnaire (five time points, seven emotions) alongside analysis of classroom events and interactions. Across a lesson co-designed with the researcher, taught by a teacher in a Grade 7 class, we identified "curiosity windows": episodes where curiosity intensifies in relation to specific classroom events. In a lesson analysed, curiosity rose during open inquiry, peaked when students' propositions were tested and formalized into a canonical formulation of the Pythagorean theorem, and remained high when the theorem was framed historically. The study offers a new method for capturing curiosity in situ as a dynamic emotion.*

## INTRODUCTION

Curiosity is increasingly recognized as central to meaningful mathematics learning; yet, classroom practice often privileges procedure over exploration and collective sense-making (Leikin et al., 2026). Evans et al. (2023) demonstrate that explicit curiosity-supporting moves are rare, and Engel (2011) argues that school routines can marginalize students' "need to know". The challenge, then, is to specify at a fine-grained level when and how curiosity can be nurtured and sustained within the flow of mathematics lessons.

Existing research offers helpful conceptual and methodological resources; however, much of it still relies on global or retrospective characterisation of lessons (e.g., "engaging topic", "surprising moment") and rarely traces curiosity as it unfolds in real-time or links shifts in curiosity to fine-grained didactical moves during instruction. Responding to this gap, Leikin and Pitta-Pantazi (2025) call for studies that locate mathematical curiosity within tasks, didactical situations, and classroom interactions. The present study addresses this agenda by tracking students' curiosity as part of their in-lesson emotional trajectories and examining short local episodes, which we will define as *Curiosity Windows*, in which curiosity intensifies or is sustained in relation to task structure and the teacher's in-the-moment pedagogy. Accordingly, we ask: When and under what conditions does students' curiosity emerge within the broader emotional landscape of mathematics lessons, and how are these moments connected to didactical moves and real-time pedagogy?



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## THEORETICAL BACKGROUND

**Curiosity as an epistemic, dynamic emotion.** Following classic accounts, Berlyne (1954) describes curiosity as arising when cognitive disequilibrium is created by novelty or conflict, whereas Loewenstein (1994) frames curiosity as a response to a salient "knowledge gap" that invites exploration. In classroom settings, Engel (2011) similarly argues that curiosity is context-sensitive and pedagogically shaped rather than a stable trait. Accordingly, we conceptualise curiosity as an epistemic emotion that can emerge and recede within the unfolding lesson.

**Emotional trajectories and episode-based analysis.** From a dynamic emotions perspective, Muis et al. (2018) and Pekrun (2019) emphasise that students' emotions fluctuate over short time scales as task demands, appraisals, and interaction patterns change. In parallel, an episode-based approach in mathematics education proposed by Rotem and Ayalon (2022) segments lessons to identify moments where content, pedagogy, and interaction converge in consequential ways. We bring these strands together by aligning repeated in-lesson emotion reports with episode boundaries, and by treating *Curiosity Windows* as short instructional episodes in which self-reported curiosity is locally intensified or sustained at a high level.

**Real-Time pedagogical moves.** Work on classroom interaction suggests that moment-to-moment instructional moves can redirect the trajectory of a mathematics lesson by making students' thinking accessible and reorganising participation. Rotem and Ayalon (2022) demonstrate how pausing, revoicing, and foregrounding students' contributions can transform routine interactions into critical events, while Stein et al. (2008) describe how teachers anticipate, monitor, select, sequence, and connect student ideas to shape the mathematical storyline of whole-class discussions. Building on these perspectives, the present study examines how such in-the-moment moves, together with task framing that sustains sense-making rather than routine completion (Stein et al., 2000; Engel, 2011), are mirrored not only in the epistemic trajectory of the lesson but also in the class's emotional trajectory, as episodes that function as Curiosity Windows.

## METHODOLOGY

The study was conducted with five mathematics teachers in grades 7-10, each of whom taught one or two lessons co-planned with the first author, designed to create conditions for the in-situ emergence of students' curiosity. Participation was voluntary, with parental consent and institutional ethical approval. In this paper, we focus on a grade 7 lesson taught in an excellence-track class (an advanced mathematics-physics track with 8 weekly hours of mathematics instruction). This lesson was selected because its emotional trajectory and episode structure provided particularly rich instances of emergent curiosity for fine-grained, episode-level analysis. The class contained 30 students aged 12–13 years. The lesson was taught by an experienced teacher (15 years

of teaching; M.A.), who had a prior professional relationship with the first author through shared teacher-education coursework.

Data collection relied on two complementary sources. First, each lesson was video recorded, documenting the teacher's pedagogical moves and classroom discourse. These data were used to produce detailed lesson descriptions and to detect episode-level shifts. Second, students completed an anonymous online (via cell phones) emoji-based form at five points during each lesson (T1-T5), indicating the intensity (1-4) of one or more of seven emotions: surprise, curiosity, confusion, enjoyment, frustration, hesitation, and boredom (selected as a basic set following relevant emotion-in-learning literature; Muis et al., 2018; Pekrun, 2019). After brief training conducted prior to the lesson, the form could be completed in 10-15 seconds and was designed as a low-burden in-situ self-report tool. To create a class-level curiosity graph from individual reports, we aggregated students' responses at each time point (treating "not selected" as 0). T1 was administered immediately after the teacher opened the lesson by announcing that "today the lesson will be a bit different". T2-T4 were prompted by the researcher to coincide with visible shifts in task structure, representations, or interaction patterns, at approximately 10-minute intervals. T5 was administered at the end of the lesson.

For analysis, each lesson was decomposed into episodes anchored by consecutive emotion-form time points; for example, changes in emotions from T2 to T3 occurred during Episode 2. Central to this analysis is the concept of a Curiosity Window, which links affective and didactic occurrences. It is defined as an instructional episode in which class-level reported curiosity increases or remains high, and this affective footprint coincides with and can be explained by identifiable teacher moves and/or classroom interactions. Such episodes were identified through a three-step process that integrated quantitative screening with qualitative interpretation: (1) for each episode, we compared the aggregated class curiosity intensity at the opening and closing time points; (2) episodes were tagged as such when aggregated curiosity at T{k+1} was higher than at T{k}or remained at the same high level (e.g., more than 40% of students reported that they experienced curiosity at least at level 3); and (3) for each tagged episode, we analysed the corresponding video and transcript excerpts, drawing on Braun and Clarke's (2006) principles of qualitative analysis to describe the teacher's didactical moves, task features, and classroom discourse during each episode.

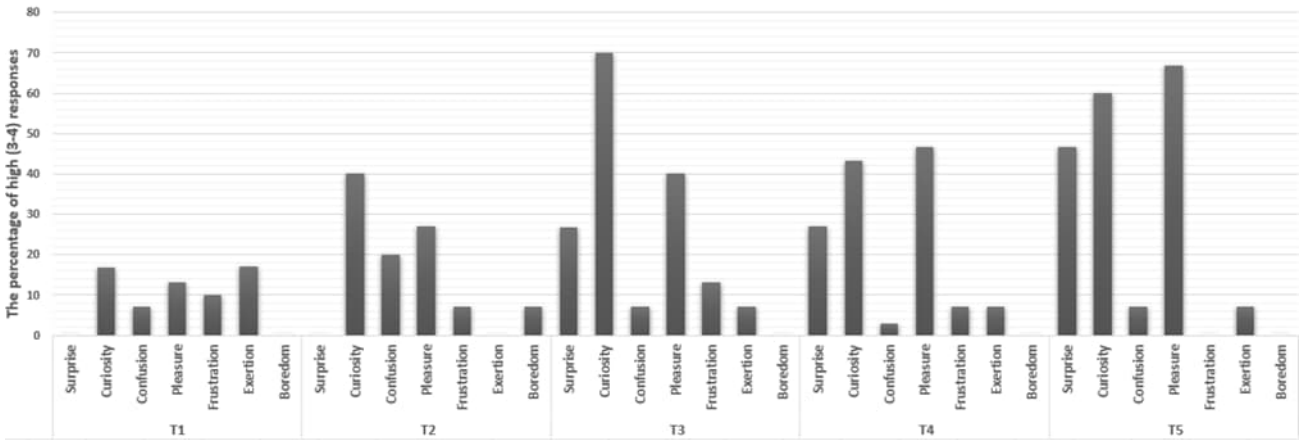
The Findings section presents the Grade 7 lesson as an episode-by-episode analysis in which all episodes identified as Curiosity Windows are reported in an expanded format. For each Curiosity Window, transcribed excerpts were condensed into an episode summary and then interpreted in conjunction with the adjacent emotion reports to justify why this episode was tagged as a Curiosity Window and to characterize the didactic moves, interactional features, and accompanying emotions associated with the arousal or sustainment of curiosity.

## FINDINGS

A Grade 7 lesson investigated relationships among the sides of right triangles with the goal of deriving and formalising the Pythagorean theorem. Episode 1 (T1→T2) focused on students creating and measuring multiple right-angle triangles and searching for patterns without being given a formula or a verification task. In whole-class discussion, Episode 2 (T2→T3), students proposed several possible relationships, which were tested on additional examples; incorrect conjectures were rejected. The canonical squared-sides relationship emerged as a generalisable conjecture and was confirmed using the students' original triangles, leading to a shared formulation of the theorem. In Episode 3 (T3→T4), the teacher showed a short video of a visual proof, followed by a discussion on using the theorem to find missing side lengths. In Episode 4 (T4→T5), the teacher provided a brief historical account, explaining how the discovery of irrational numbers, triggered by √2, challenged the Pythagoreans' core beliefs.

Figure 1 illustrates the percentage distribution of high-intensity emotions (levels 3-4), highlighting moments most likely to influence participation and reasoning. This overview sets the stage for the subsequent episode-level analysis of how shifts in reported curiosity relate to changes in task structure and classroom discourse.

Figure 1. High-intensity emotional reports.




The graph shows that curiosity increased during Episodes 1, 2, and 4, hence they are potential Curiosity Windows. We now provide an analysis of the didactic moves and interactional features of these episodes to justify why they qualify as Curiosity Windows and describe the general emotional shifts that coincided with the arousal or sustainment of curiosity.

*Episode 1*. The teacher opened the lesson by framing it as "a bit different" and withholding the goal, "we'll discover later what we're learning today". Following the teacher's instructions, each student drew five right triangles, measured sides, and searched freely for relationships: "look for relationships… you can add, subtract,

multiply, divide, square, take a square root". She repeatedly stressed accuracy ("measure really, really accurately"; "mathematics is a precise subject… so you need to be accurate"). Students proposed several relationships, but none were found to be generally applicable. When a proportional idea appeared, she pressed, "Does this hold in every triangle? Does the rule always hold? We want to see whether there is something that characterises all of us". Students later described abandoning ideas ("I tried adding the three sides… but I realised quickly it won't work"). She normalised this, "even if you didn't end up finding any relationship, it's okay", and closed, noting that "nobody found any relationship yet".

Episode 1 was tagged as a Curiosity Window because the frequency of high curiosity (3-4) increased by 23.3% in conjunction with deliberate didactic moves that set the stage for an open, student-generated exploration of relationships under imperfect measurement, making the sought-after invariant feel both reachable and uncertain. Significant changes in other emotions include confusion (+13%), pleasure (+14%), and exertion (-10%), while boredom increased but remained at a low level (+7%).

*Episode 2.* After the exploratory phase, this episode marked a shift toward forming and testing a conjecture. The teacher highlighted uncertainty, "Will it always be like this? Because in the second triangle it doesn't increase together anymore", and reframed the work: "We are looking for a relationship… maybe the same relationship holds". A student proposed: "three squared plus four squared… equals the remaining number squared". The teacher pressed: "and why does it work?" and coordinated checking ("shall we check whether it works? You can use a calculator"). The episode ended with the teacher formulating the canonical statement: "one leg squared plus the other leg squared gives the hypotenuse squared".

Episode 2 was tagged as a Curiosity Window because the frequency of high curiosity increased by 30% in conjunction with didactic moves that shifted the activity from independent pattern-searching to collective checking of one of the student-generated conjectures, and naming/formalising the invariant relationship. Significant changes in other emotions include surprise (+26.7%), pleasure (+13%), confusion (-13%), and boredom (-7% to 0).

*Episode 4.* After proof and applications, the teacher shifted to a historical narrative and presented the Pythagoreans as a group that believed "everything in the world revolves around natural numbers", and that the $\sqrt{2}$ was a disruptive counterexample. Using the $1,1,\sqrt{2}$ triangle, she pressed: "Does $\sqrt{2}$ exist? Is it whole? Is it natural?" She highlighted the dilemma: "you developed a theory, …, and suddenly there is a point that collapses everything. What would you do? Ignore it? Create a new rule? Find a solution?" She then closed by emphasizing the epistemic stakes of the discovery, how a single counterexample can destabilize an established worldview, and by noting the Pythagoreans' reported attempt to suppress the result.

Episode 4 was tagged as a Curiosity Window because the frequency of high curiosity increased by 16.7%, coinciding with a clear shift to a historical-epistemic framing that recontextualized the theorem as consequential and worldview-challenging. Significant changes in other emotions include surprise (+19.7%) and pleasure (+20%), while confusion decreased (−3% to 0) and boredom remained at 0.

Overall lesson trajectory: Curiosity rose modestly during open exploration (Episode 1), intensified when conjecture was tested and formalized (Episode 2), decreased during the proof (Episode 3, not presented here due to the space constraints), and remained high, with a peak of surprise, during the historical framing (Episode 4). Three of these episodes (1, 2, and 4) met the Curiosity Window criterion, each aligned with a reconfiguration of the didactic situation.

## DISCUSSION

Our episode-based analysis supports Muis et al. (2018) and Pekrun's (2019) dynamic approach to mathematical curiosity: rather than a diffuse, trait-like disposition, curiosity functioned as an epistemic emotion that fluctuated in tight synchrony with didactical moves and in-the-moment pedagogy. In Episode 1, curiosity rose as the teacher deliberately opened an under-specified problem space, asking students to generate, measure, and compare their own right triangles while withholding the rule, so that a potentially general relationship could be sensed but not yet settled. This design created a productive tension between novelty and uncertainty, consistent with Berlyne's (1954) view of curiosity as sparked by cognitive conflict and with Loewenstein's (1994) account of curiosity as emerging when a knowledge gap becomes salient yet remains temporarily unclosed. At the same time, curiosity co-occurred with increased confusion, suggesting that uncertainty does not necessarily generate curiosity, perhaps due to the too open nature of the student exploration. This pattern aligns with Engel (2011), who argues that classroom curiosity is pedagogically shaped by how students' "need to know" is structured and supported.

Episode 2 highlights a single condition for curiosity intensification: the transition from exploratory work to collectively owned, well-structured conjecture and public verification. Here, the teacher's orchestration, pressing for explanation, coordinating checking, and stabilising a shared formulation, reflected what Stein et al. (2000) described as sustaining cognitive demand through sense-making rather than extended technical execution, and it also resonates with the discussion practices outlined by Stein et al. (2008) for building a coherent whole-class mathematical storyline from student ideas. Notably, curiosity increased while confusion and boredom decreased, suggesting that curiosity was amplified when students recognised the relationship they helped to generate, and that could be a subject to shared scrutiny.

Episode 4 suggests an additional mechanism for generating curiosity: the historical-epistemic reframing of the discovered relationship, even when the teacher played a central role in the classroom interactions. By positioning $\sqrt{2}$ as a worldview-

challenging consequence, the teacher shifted the lesson from conjecture generating and testing to universal historical-epistemic stakes. From a dynamic emotions perspective, Pekrun (2019) and Muis et al. (2018) emphasize that short-term emotional shifts are sensitive to changing appraisals of value and meaning; in this episode, the narrative plausibly increased the perceived significance of the mathematics, coinciding with sustained curiosity alongside increased surprise and enjoyment. From an episode-based perspective, this pivot resembles what Rotem and Ayalon (2022) describe as a critical event in which participation, discourse, and mathematical meaning are reorganised.

Taken together, the study specifies three conditions under which curiosity emerged or was sustained: open exploration that renders a nontrivial knowledge gap perceptible; teacher moves that redirect activity toward conjecturing and collective verification, and historical-epistemic framing that makes mathematical ideas consequential. Methodologically, this approach responds to the call by Leikin and Pitta-Pantazi (2025) to situate mathematical curiosity in task and interaction-specific terms rather than global, retrospective labels.

Building on this position, the novelty of our study lies in offering a method for capturing curiosity and exploring the conditions that facilitate its appearance. The construct of Curiosity Window operationalizes curiosity as a bounded, episode-level phenomenon, allowing us to link specific didactical shifts to a local affective footprint rather than relying on global labels such as ‘an engaging lesson’. In doing so, it becomes possible to distinguish between potential curiosity-provoking situations and episodes in which curiosity is empirically demonstrated as intensified or sustained, thereby clarifying exactly what teachers do when curiosity arises.

Limitations of this study include its sample size and reliance on rapid in-lesson self-reports aggregated at the class level, which may not fully reflect students’ nuanced and changing emotional experiences at the individual level. Future research will examine more diverse classes, integrate micro-analytic measures of discourse alongside individual emotional trajectories, and test whether sequences of teacher moves prospectively predict the emergence and sustainment of curiosity across lessons.

## Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the author utilized ChatGPT to assist with translation and enhance readability and language. All content generated with AI assistance was subsequently reviewed and edited by the author, who takes full responsibility for the final version of the manuscript.

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