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AI-INFUSED MICROLEARNING FOR MATHEMATICAL REASONING: AN INTERDISCIPLINARY CLASSROOM STUDY

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Abstract. This paper explores how microlearning can support mathematical reasoning in interdisciplinary secondary education. The intervention integrated two AI-infused microlearning activities into the 9th-grade Applied Digital Skills curriculum at a Bulgarian secondary school. The first module introduced statistical anomaly detection through Benford’s Law, while the second focused on logical classification using rhetorical reasoning (pathos, logos, ethos). Each unit was delivered as a short, focused episode with digital tools adapted to students’ prior skills.

The theoretical grounding draws on Mayer’s cognitive theory of multimedia learning and Thalheimer’s framework of spaced retrieval. Observations and reflections suggest that microlearning offers a complementary strategy for mathematics education, particularly when paired with AI-based tasks that foster critical thinking, algorithmic reasoning, and applied numeracy across disciplines.

Key Words: *microlearning, mathematical reasoning, AI in education, interdisciplinary pedagogy, secondary education.*

Introduction

Mathematical reasoning is a central competency in secondary education, yet its abstract nature often makes it difficult for students to engage meaningfully. When taught in isolation, mathematics can appear disconnected from real-life contexts, reducing motivation and limiting opportunities for transfer to other subjects.

Microlearning, understood as the delivery of short and targeted instructional units (Mayer, 2014), (Thalheimer, 2006), has gained attention as a strategy for addressing this challenge. Research shows that by segmenting content into manageable steps and combining them with digital tasks, microlearning supports both engagement and the application of abstract concepts in authentic scenarios (Silva et al., 2023), (Magbago et al., 2025).

This study investigates how microlearning can facilitate mathematical reasoning in interdisciplinary contexts. The intervention was implemented within an interdisciplinary subject called Applied Digital Skills, taught to 9th-grade students at a Bulgarian secondary school. Two AI-enhanced modules were tested: one exploring statistical anomaly detection through Benford’s Law, and another focusing on logical classification using rhetorical appeals. In both cases, mathematics was embedded in practical, cross-curricular tasks designed to make reasoning visible and transferable.

Theoretical Framework, Method and Implementation

This study draws on two complementary perspectives. Thalheimer (Thalheimer, 2006) defines microlearning as short, targeted instructional segments that reduce cognitive load, strengthen retention, and support just-in-time application. Mayer’s cognitive theory of multimedia learning (Mayer, 2014) similarly emphasizes the benefits of segmentation and dual coding, where information is presented through coordinated verbal and visual channels. Together, these models highlight the value of brief, focused tasks in supporting transfer of knowledge across domains.

In mathematics education, such principles are particularly relevant for abstract domains such as probability, classification, and data modeling. Short, interactive activities enable students to build conceptual understanding step by step, while also embedding mathematical reasoning into interdisciplinary contexts. This approach aligns with constructivist pedagogy (Frimaulia, 2022), where knowledge is actively built through authentic engagement.

The intervention took place at Ivan Vazov Language School in Plovdiv, Bulgaria, within the 9th-grade subject Applied Digital Skills. This interdisciplinary course integrates technology, civic education, and algorithmic thinking, with the aim of developing competencies such as computational thinking, critical digital literacy, teamwork, and applied problem-solving. Learning outcomes are framed around students’ ability to analyze data, structure arguments, and design digital solutions. By design, the course complements rather than replaces traditional disciplines, making it a suitable environment for experimenting with interdisciplinary microlearning tasks (Atanasov & Terzieva, 2024).

Approximately 190 students across seven classes participated during the 2024-2025 academic year, supported by four teachers. All classrooms were equipped with laptops, projectors, and access to browser-based platforms. Within the syllabus, the Benford's Law module was embedded in the section on data science foundations, while the Pathos-Logos-Ethos module was linked to units on digital communication and civic education. Both were delivered in parallel with conventional mathematics and language instruction, serving as interdisciplinary extensions rather than substitutes. Two microlearning modules were implemented:

- Benford's Law: Students explored statistical anomaly detection by analyzing digit distributions in real datasets. A pre-configured programming notebook allowed input of values and automatic visualization, emphasizing probability and applications such as fraud detection. The goal was to introduce students to probabilistic thinking and applied statistical reasoning through authentic examples.
- Pathos, Logos, Ethos: Students used a visual chatbot interface to classify persuasive statements by rhetorical appeal. The task required conditional logic and decision rules, bridging language studies and mathematics. While framed in civic education, the module highlighted transferable skills such as categorization, decision-making, and algorithmic structuring.

Each module followed the same structure: a short video or slide introduction, an interactive digital task, and a brief reflection. Instructional time was limited to three 45-minute periods per module. Data were collected through classroom observations, short written reflections, and teacher interviews. Preliminary observations suggest that students developed competencies in probabilistic reasoning, logical classification, and digital problem-solving. While systematic evidence requires further evaluation, these early results indicate promising directions for skill development. Pre/post surveys and control group comparisons are planned for the next research phase.

Case Study, Module Design, Outcomes and Limitations

The study implemented two microlearning modules within the Applied Digital Skills curriculum, each designed to make mathematical reasoning explicit through short, interdisciplinary tasks. The first unit introduced Benford's Law, a statistical principle observing that in many naturally occurring datasets, lower digits-particularly 1-appear more frequently as leading digits than higher ones. While normally taught in higher education or data science contexts, the concept was simplified and adapted for 9th-grade students. The instructional sequence began with a short explainer video presenting examples from everyday data, such as city populations, sports statistics, and financial reports.

As shown in Figure 1 below students then used a pre-configured programming notebook where they could input datasets (provided or self-collected) and automatically generate digit-frequency graphs. All functions were pre-written; students only adjusted input values, ensuring the focus remained on interpreting results rather than coding syntax.

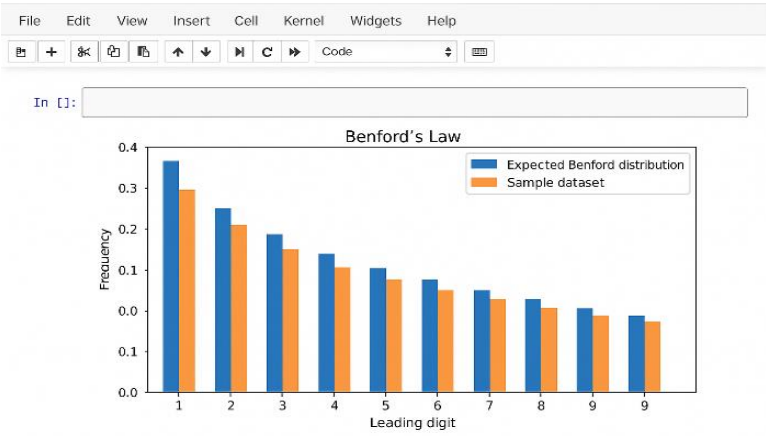

Figure 1. Student-generated visualization of digit frequencies (Benford's Law)

Despite initial unfamiliarity with statistical modeling, most students were able to describe expected digit distributions and identify when datasets appeared "non-conforming." One student reflected: "I didn't know numbers had a 'natural order.' Now I understand how patterns can reveal lies in data." Teachers noted high engagement, particularly among students usually reluctant to engage in mathematics. Some learners initially misinterpreted randomness as error, which led to short class discussions using metaphors such as coin tosses or dice rolls. The microlearning design allowed teachers to address misconceptions without disrupting lesson flow.

The second unit focused on rhetorical appeals-pathos (emotion), logos (reason), and ethos (credibility). While drawn from civic education and language studies, the activity was selected for its close alignment with classification logic, a transferable skill (Şahin & Kırmızıgül, 2023), (Gün-Şahin & Kırmızıgül, 2023) in both mathematics and computer science. Students first analyzed short persuasive statements taken from advertising, social media, and political speeches. These were introduced through a slide-based scenario that prompted discussion of emotional, logical, and credibility-based persuasion. The main task involved building a simple chatbot using a visual interface, as shown in Figure 2. Students labeled input statements, defined decision rules for classification, and tested the chatbot for consistency. This process required structured if-then reasoning and helped students translate intuitive judgments into logical frameworks.

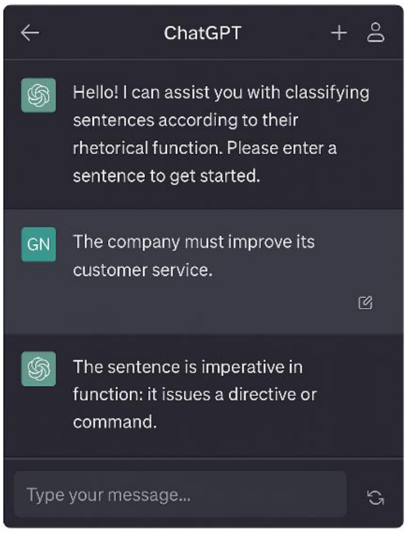

Figure 2. Screenshot of chatbot interface for rhetorical classification

Student reflections highlighted both cognitive and affective engagement. As one learner explained: "It's like teaching the bot how I would decide in my head." A teacher commented: "We talk about emotions in class, but this activity made it logical." Several unplanned discussions arose on how algorithms in digital platforms classify information, linking the exercise to broader questions of digital citizenship. Some students overgeneralized categories, applying personal interpretations inconsistent with logical rules, but peer examples and teacher guidance corrected these misunderstandings.

Across both modules, students showed increased confidence in articulating logical steps, identifying patterns, and applying reasoning across contexts. Teachers valued the modular structure, reporting that the short digital tasks were easy to integrate without disrupting conventional instruction. Preliminary observations as depicted in Figure 3, suggest the development of probabilistic thinking, classification skills, and digital reasoning competencies.

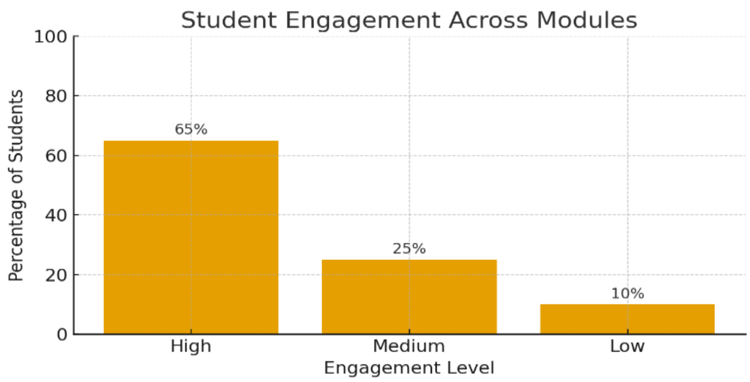

Figure 3. Distribution of observed student engagement levels across both modules

At the same time, the absence of formal assessments limits the strength of conclusions. Observations and reflections provide only indicative insights. Future research will employ pre/post surveys, statistical analysis, and control-group comparisons to validate learning outcomes.

Discussion

The two microlearning units examined in this study-Benford’s Law and Pathos, Logos, and Ethos-illustrate the pedagogical potential of short, focused learning episodes to foster mathematical reasoning in interdisciplinary contexts. Though different in content and tone, both modules supported the development of transferable cognitive skills: abstraction, classification, and pattern recognition. These skills, traditionally embedded in mathematics curricula, were made accessible through thematic relevance and digital interactivity. From a theoretical perspective, the results support Mayer’s principles of multimedia learning (Mayer, 2014), particularly the value of segmentation, dual coding (text and visuals), and learner-paced control. By isolating a single objective per session, the microlearning format reduced cognitive overload and allowed students to focus on conceptual understanding. Thalheimer’s emphasis on spaced retrieval and task relevance (Thalheimer, 2006) also proved applicable: both modules encouraged iterative learning and discussion, with students revisiting core ideas informally across subjects.

Importantly, teachers reported that the micro-units functioned as effective complements rather than substitutes for traditional instruction. For instance, the Benford module extended earlier work on percentages and probability, while the rhetorical appeals module reinforced argumentative structures from language classes. Teacher interviews highlighted increased participation, noting that “short tasks lowered barriers (Şahin & Kırmızıgül, 2023), (Magbago et al., 2025) for students who often avoid mathematics.” These qualitative impressions align with observed engagement levels, where the majority of students were active contributors.

The interdisciplinary design also enabled broader outcomes beyond mathematics. Students practiced ethical reasoning by recognizing manipulative rhetoric, developed data skepticism when analyzing irregular distributions, and reflected on algorithmic processes in digital platforms. Such outcomes demonstrate that microlearning can serve not only cognitive but also civic and digital purposes. This convergence reinforces the value of embedding microlearning into diverse curricular areas, particularly where logic and structure are shared across disciplines (Silva et al., 2023), (Magbago et al., 2025).

Conclusion and Future Work

This study examined how microlearning can integrate mathematical reasoning into interdisciplinary secondary education. Two classroom-tested modules-Benford’s Law and Pathos, Logos, and Ethos-demonstrated that short, structured activities can increase student engagement, lower barriers to abstract reasoning, and connect mathematics to real-world and civic contexts.

Observations indicated that students were able to recognize statistical patterns, apply conditional logic, and articulate reasoning steps, while teachers valued the ease of incorporating micro-units alongside existing lessons.

At the same time, limitations were clear. Without formal assessments, findings remain indicative rather than conclusive. Misconceptions in probability and classification also highlighted the need for scaffolding and further instructional support. Future research will therefore include pre- and post-testing, student surveys, and control-group comparisons to provide a more rigorous evaluation of learning outcomes. These steps will also allow for professional statistical analysis (Frimaulia, 2022) of diagnostic results, as suggested in related literature.

The next phase will expand the approach to additional modules, such as algorithmic bias (Suchanek et al., 2024), numerical misinformation, and digital decision-making. In this way, microlearning can serve as a flexible and scalable framework for fostering not only mathematical reasoning but also digital literacy and civic competencies. Progress will be gradual, building step by step toward systematic evidence and broader curricular integration.

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