

Assessing student engagement across Math Camp activities in Kenya via a mixed-methods evaluation of activity design

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The math camps initiative aims to pique interest in mathematics through short, activity-based sessions. The specific features of activity design that drive student engagement has not been evaluated, particularly in the African context. This project assessed student engagement across eight math camp activities delivered in Kenya, combining a quantitative survey with a qualitative review of open-ended student responses along with facilitator lesson plans. Immediately after each activity, students completed a short survey rating their engagement on a seven-item scale, along with two open-ended questions. Surveys were collected on paper and later transcribed using an artificial-intelligence-assisted process, checked against the original documents. Facilitator lesson plans were reviewed and six design features associated with effective discovery-based learning were extracted from them. Engagement was consistently moderate to high across all eight activities (composite scores of 3.5-4.1 out of 5), and nearly every activity shared the same core design features, particularly guided discovery and productive struggle, which limited the ability to isolate any single feature's effect using this dataset alone. Open-ended responses, however, provided independent qualitative evidence that students engaged meaningfully with each activity and their target mathematical idea. Students often referenced concepts such as parity, powers of two, and prime numbers. These findings suggest the camp's activities succeeded at their stated goal of building interest in mathematics.

Assessing impact of math camp active-learning activities on students' confidence and perceptions towards STEM

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Mathematics camps offer an alternative learning environment emphasizing collaboration, active participation, and inquiry-based learning. This project evaluates how active-learning mathematics camps affect students' mathematical confidence, attitudes toward mathematics, and interest in STEM, using a mixed-methods design combining archival analysis of student reflections, interviews with former camp volunteers, and questionnaires administered to current participants and alumni.

Since the first interim report, the 2026 camp ran from 10–14 August in Nyarongi, Homa Bay County, serving approximately 50 high-school and 60 pre-school/primary-school students, supported by roughly 15 volunteers. Entry and exit questionnaires were administered to student participants (33 and 42 responses respectively), and semi-structured interviews with former volunteers have been conducted. Baseline attitudes toward mathematics were already high before camp began, consistent with more than half of entry respondents having attended a previous Nyarongi camp; a preliminary comparison shows broadly stable self-reported attitudes with no large shifts, alongside evidence of ceiling effects to be examined further once qualitative data are integrated. Remaining work includes transcribing and coding the historical journal archive, coding volunteer interview transcripts, and distributing questionnaires to alumni and first-time volunteers.

Improving zero-shot coordination through test-time search over partner models

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Ad hoc teamwork requires an agent to cooperate with previously unseen partners whose strategies may differ from those encountered during training. I first investigated whether robustness could be learned through Partner-SAM, a training method that exposes an agent to locally adversarial variations of its training partners. Although these perturbations reached their intended behavioral distance and reduced training return as designed, they did not reliably improve coordination with held-out partners across Level-Based Foraging and Overcooked tasks.

I therefore developed a test-time planning method that evaluates each available action by simulating short future trajectories. The agent models its partner from the interaction history, tests candidate actions in the simulator, and overrides its original policy only when the predicted improvement exceeds a safety margin. In a controlled matching game, Bayesian inference over a partner library increased return from the reactive baseline of 2.000 to 7.287, approximately reaching the theoretical identification ceiling of 7.25. On a fully observed Overcooked task, library-based search improved the frozen policy by 28.3 points, with a 95% confidence interval of [26.5, 30.2]. Search using a fixed, non-adaptive partner model also improved performance, while online partner inference provided an additional 6.69-point gain. A conservative override margin substantially improved reliability by preventing changes based on noisy simulations.

The method remained vulnerable to partners outside its model class: confidently incorrect models could make planning harmful. These results indicate that test-time search can substantially improve coordination without retraining the underlying policy, but its success depends on accurately representing the partner. Current work expands the model class by combining learned policies with parameterized behavioral programs.

Andrews-Gordon identities and cylindric partitions

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Rogers-Ramanujan type identities are identities of q -series equating an infinite sum with an infinite product and have a variety of applications in integer partitions and many other fields of mathematics. Among them are Andrews-Gordon identities which are direct generalizations of the original two Rogers-Ramanujan identities, and they are of primary concern to this project. One proof of them relates the entire sum side to a generating function of cylindric partitions which are previously known to be the product side. In our work, we aim to refine this connection by interpreting each individual summand of the Andrews-Gordon identity in terms of a subset of cylindric partitions. Eventually, we hope this can be applied to give a proof of further generalizations of identities due to Huang-Jiang-Oblomkov.

Invariant measure of the half-space polynuclear growth model

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Polynuclear growth (PNG) is an integrable probability model that describes random surface growth behavior in space-time. Its state space is given by the set of upper semi-continuous height functions from $R \rightarrow Z \cup \{-\infty\}$. The dynamics consist of nucleation events governed by a space-time Poisson point process with rate 2 and deterministic growth of up and down jumps in the height function with rate 1. The invariant measures for full-space PNG are constructed by the superposition of two independent Poisson point processes with intensities ρ and ρ^{-1} . However, the invariant measures for the half-space model, with height functions on $R_{\geq 0}$, have not been identified. We prove that μ_ρ from Matetski, Quastel, and Remenik with $\rho = \lambda^{-1}$, where λ is the rate of nucleation at the origin, is invariant for half-space PNG.

Poisson coloring in the hyperbolic plane

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Consider a plane with a finite number of points and give each point a certain color. Let points fall in the plane according to a Poisson Point Process and give each point the color of the point in the plane that was closest to it. Aldous showed that in the case of the Euclidean plane, this process results in a random partition of the Euclidean plane into Lebesgue measurable sets. We investigate the process in the hyperbolic plane. We find that the hyperbolic geometry leads to stronger bounds for the distances between particles and their ancestors. We aim to show similar convergence in the plane and investigate any possible stronger properties.

The degree of the symplectic Stiefel manifold

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The symplectic Stiefel manifold is the set of linear maps preserving the canonical symplectic form. It has applications in physics, engineering, and robotics, specifically in the reduction of Hamiltonian systems and optimization under symplectic constraints. The symplectic Stiefel manifold can be realized as an algebraic variety cut out by quadratic relations arising from matrix equations which enforce the symplectic condition. The degree of the variety, a fundamental geometric invariant, is unknown and extremely expensive to compute symbolically even for individual cases. We use tools from commutative algebra, algebraic geometry, and representation theory to determine the degree of the symplectic Stiefel manifold in general.

Twisted CSS codes

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Calderbank–Shor–Steane (CSS) codes form the basis of many quantum low-density parity-check (qLDPC) code constructions. Despite significant progress in constructing qLDPC codes with favorable rate and distance scaling, fault-tolerant logical gate implementation has remained a challenge. In particular, several no-go theorems impose severe limitations on transversal gates, especially in the presence of geometric structure. Twisted CSS codes generalize ordinary CSS codes by decorating X-checks with diagonal phases, circumventing some of these logical gate implementation constraints. We construct a general algebraic framework for twisted CSS codes which characterizes twisted checks, the constraints imposed by their commutation relations, the codespace, and logical operators. Additionally, we propose an efficient two-stage decoder that first corrects X-errors and then addresses remaining diagonal errors, thereby mitigating the twist-dependent errors induced by measuring twisted X-checks in the presence of residual X-errors.