Supplementary Information

Generative AI and interrupted peripheral participation:
evidence of structural closure from Stack Exchange

This Supplementary Information file collects descriptive exhibits, identification checks, and additional structure-to-function evidence referenced from the main text.

Supplementary Methods: detailed five-layer robustness suite

With $N_{\text{cluster}} = 7$, standard cluster-robust inference is unreliable, and the algorithmic treatment group holds only two communities. We therefore wrap the two-way fixed-effects estimates in a five-layer robustness suite. The layers do not change the point estimates; each instead supplies parallel inference under a different identifying assumption, and we report how well the layers agree as our main robustness verdict. The summary verdicts appear in the main text.

Parallel-trends test. We regress each outcome on a linear time trend interacted with treatment status over the pre-period (2016–2022). A non-significant interaction supports the parallel-trends assumption that the difference-in-differences identification relies on.

Wild cluster bootstrap. We compute Rademacher wild cluster bootstrap p-values for the treatment coefficients following Cameron, Gelbach, and Miller (2008), using $B = 4{,}999$ replications that draw $\{-1, +1\}$ weights per community.

Synthetic control. Because the algorithmic group has only two communities (AI.SE and Data Science SE), the fixed-effects estimate's external validity for that group rests on those two units. We build a synthetic AI.SE from a donor pool of the five non-algorithmic communities, fitting the standard synthetic control to the pre-period outcome path (Abadie, Diamond, & Hainmueller, 2010), and report the average post-period gap as an alternative identification.

Leave-one-community-out. We re-estimate the model seven times, each time dropping one community, to verify that no single community drives the result. A coefficient that remains sign-stable across all seven re-estimations indicates broad robustness.

Placebo treatment years. We re-estimate the model on the pre-2023 window only (2016–2022), treating each of 2020 and 2021 as a fake treatment year. If the main estimate captures a true GenAI-induced shift rather than a pre-existing trend, the placebo estimates should be non-significant.

Supplementary exhibits

Supplementary Table S1: Summary statistics of the seven Stack Exchange communities (2016–2025) with group-level codifiability proxies. Pre = 2018–2022, Post = 2023–2025.

Group	Community	Avg. Nodes	QA Events	Code density (Pre → Post)	Formula/1k chars (Pre → Post)
Algorithmic	AI.SE	1,312	11,488	0.268 → 0.321	1.11 → 0.89
	DataSci.SE	3,740	33,274		
Disciplinary	Stats.SE	12,816	117,801	0.078 → 0.093	4.12 → 3.88
	Physics.SE	12,579	217,293		
	Chem.SE	3,077	32,612		
Practice-based	Cooking.SE	2,256	22,169	0.004 → 0.001	0.01 → 0.01
	Travel.SE	4,532	44,095		

Supplementary Table S2: Pre- versus post-GenAI group-averaged structural indicators.

Dimension	Indicator	Group	Pre	Post	Δ
Bonding	Modularity	Algorithmic	0.602	0.706	$+0.104^{**}$
		Disciplinary	0.427	0.440	+0.013
		Practice-based	0.381	0.400	+0.019
Bridging	BC Gini	Algorithmic	0.896	0.894	−0.002
		Disciplinary	0.942	0.932	−0.010
		Practice-based	0.923	0.900	−0.022
	E-I Index	Algorithmic	−0.272	−0.497	-0.224^{***}
		Disciplinary	+0.131	+0.073	−0.058
		Practice-based	+0.161	+0.073	−0.088
	Avg Path (GCC)	Algorithmic	3.893	4.169	+0.276
		Disciplinary	3.380	3.361	−0.019
		Practice-based	3.261	3.243	−0.018
Concentration	Degree Gini	Algorithmic	0.572	0.512	−0.060
		Disciplinary	0.690	0.680	−0.010
		Practice-based	0.675	0.652	−0.023
Function	$\tau_{0.5}$ (h)	Algorithmic	11.2	16.6	+5.4
		Disciplinary	3.4	5.4	$+1.9^{**}$
		Practice-based	5.7	8.4	+2.7

Note. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Supplementary Table S3: Parallel-trends test for the DiD identification.

Indicator	**Interaction β**	**p-value**	**Verdict**
Modularity	+0.014	0.122	✓ Pass
Avg Path Length (GCC)	+0.014	0.684	✓ Pass
Top-20 Degree Share	−0.010	0.119	✓ Pass
Degree Gini	−0.001	0.653	✓ Pass
Active Nodes (ln)	+0.247	< 0.001	× Fail
Edges (ln)	+0.216	< 0.001	× Fail
Avg Clustering	−0.001	< 0.001	× Fail
Transitivity	−0.008	0.023	× Fail
BC Gini	+0.010	< 0.001	× Fail
E-I Index	−0.021	0.013	× Fail

Supplementary Table S4: Five-layer robustness suite for the DiD-identified indicators.

Robustness layer	**Modularity**		**Avg Path (GCC)**	
	Estimate	Verdict	Estimate	Verdict
Main TWFE	+0.085	sig. ($p < 0.01$)	+0.294	sig. ($p < 0.01$)
Parallel trends	+0.014	✓ Pass	+0.014	✓ Pass
Wild cluster bootstrap	+0.085	✓ $p < 0.001$	+0.294	✓ $p < 0.001$
Synthetic control (AI.SE alone)	+0.158	✓ same sign	+0.510	✓ same sign
Leave-one-community-out	$\in [+0.055, +0.114]$	✓ Stable	$\in [+0.199, +0.389]$	✓ Stable
Placebo 2020	+0.027	✓ $p = 0.296$	−0.079	✓ $p = 0.426$
Placebo 2021	+0.053	‡ $p = 0.003$	−0.028	✓ $p = 0.277$

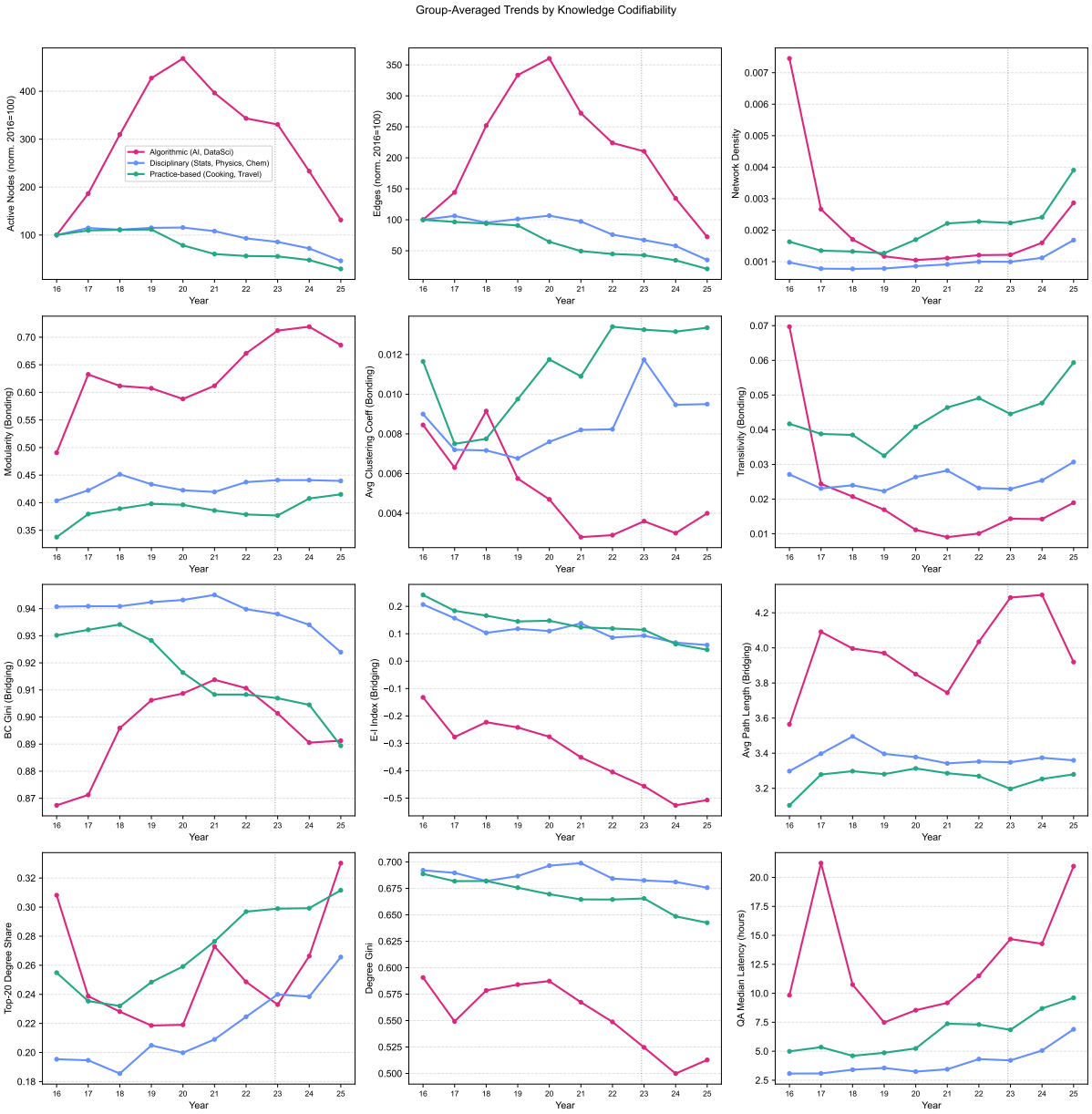
‡A milder 2021 placebo effect is detected for modularity ($\beta = +0.053$, smaller than the main estimate of +0.085). This is consistent with early GPT-3/Codex effects rather than a violation of the 2023 identification window; average path length shows no comparable 2021 effect.

Supplementary Fig. S1 plots the year-by-year group-averaged trajectories of all structural indicators, complementing the pre–post structural summary in the main text. Supplementary Table S5 reports the first-difference correlations between year-over-year structural change and year-over-year QA-latency change, corroborating the panel fixed-effects regressions in the main text.

Supplementary Table S5: First-difference correlations between structural indicators and QA latency.

ΔStructure	**Pearson r**	p	**Direction**
ΔModularity	$+0.512^{***}$	< 0.001	↑ Mod → ↑ Latency
ΔAvg Clustering	−0.200	0.117	n.s.
ΔTransitivity	-0.437^{***}	< 0.001	Complex
ΔBC Gini	-0.419^{***}	< 0.001	Complex
ΔE-I Index	-0.320^{**}	0.010	↓ E-I → ↑ Latency
ΔAvg Path (GCC)	$+0.420^{***}$	< 0.001	↑ Path → ↑ Latency
ΔTop-20 Degree Share	-0.264^{**}	0.037	Complex
ΔDegree Gini	-0.518^{***}	< 0.001	Complex

Note. $^{***}p < 0.01$, $^{**}p < 0.05$.



Supplementary Fig. S1: Group-averaged structural indicators (2016–2025).