Optimization Learning Journal

Week-by-Week Exploration Log

What We Tried • What We Learned • What Worked

6 Weeks of Iterative Learning
8 Functions • 48 Experiments • Breakthrough Discoveries

Total Weeks	**6**
Functions Optimized	**8**
Total Experiments	**48**
ML Models Used	**27**
Breakthrough Moments	**3**
Best Improvement	**39x (F5)**

Function 1 (2D) - The Mystery Function

Challenge: Finding signal in the noise

Week 1

Input: [0.10, 0.10] → **Output:** 0.000

What we tried: Initial exploration with small symmetric values

What we learned: Output is zero. No immediate signal.

Decision: Need to explore more

Week 2

Input: [0.12, 0.08] → **Output:** 0.000

What we tried: Asymmetry test - slightly different values

What we learned: Still zero. Asymmetry did not help.

Decision: Try larger values

Week 3

Input: [0.21, 0.11] → **Output:** 0.000

What we tried: Larger values to find any signal

What we learned: Still zero at doubled values.

Decision: Return to smaller range

Week 4

Input: [0.14, 0.14] → **Output:** 0.000

What we tried: Mid-range symmetric values

What we learned: Consistently zero regardless of input in [0.08-0.21] range.

Decision: Try very small values

Week 5

Input: [0.08, 0.08] → **Output:** 0.000

What we tried: Smaller values than Week 1

What we learned: All attempts [0.08-0.21] yield ~0. No pattern detected.

Decision: Try pattern from successful functions

Week 6

Input: [0.45, 0.45] → **Output:** 0.0128

What we tried: BREAKTHROUGH! Pattern transfer from F3/F5 (large values)

What we learned: ■ First non-zero output! Large values [0.45] found signal!

Decision: Continue local exploration around [0.45, 0.45]

Key Insight: Function has active region at larger values. Week 6 breakthrough after 5 weeks of zeros showed persistence pays off!

Week 7 Strategy: Local exploration around [0.45, 0.45] $\rightarrow$ [0.48, 0.48]

Function 2 (2D) - The Narrow Peak

Challenge: Finding and staying on ultra-narrow optimum

Week 1

Input: [0.10, 0.10] → **Output:** 0.0892

What we tried: Initial small symmetric values

What we learned: ✓ Best result! Established strong baseline.

Decision: Explore around this point

Week 2

Input: [0.12, 0.08] → **Output:** 0.0705

What we tried: Asymmetry test (Dim1 +0.02, Dim2 -0.02)

What we learned: ■ Asymmetry hurt (-21%). Peak prefers symmetry.

Decision: Return closer to [0.1, 0.1]

Week 3

Input: [0.21, 0.11] → **Output:** 0.0295

What we tried: Larger values (doubled)

What we learned: ■ Disaster (-67%). Moving away from [0.1, 0.1] is bad.

Decision: Stay near Week 1

Week 4

Input: [0.14, 0.14] → **Output:** 0.0150

What we tried: Mid-point between Week 1 and Week 3

What we learned: ■ Still terrible (-83%). Even 0.04 away hurts.

Decision: Micro-exploration only

Week 5

Input: [0.08, 0.08] → **Output:** 0.0463

What we tried: Below Week 1 (both dims -0.02)

What we learned: ■ Wrong direction (-48%). [0.1, 0.1] confirmed optimal region.

Decision: Use GP for precision

Week 6

Input: [0.111, 0.100] → **Output:** 0.1300

What we tried: ML Success! GP suggested [0.111, 0.100]

What we learned: ✓✓✓ NEW BEST! +46% improvement! Ultra-narrow peak found!

Decision: Continue GP-guided micro-exploration

Key Insight: Ultra-narrow peak! Moving 0.02 away loses 48%. Moving 0.04 away loses 83%. Precision matters!

Correlation: Both dims negative (-0.53, -0.65) → Lower is better

Week 7 Strategy: GP exploitation → [0.110, 0.099]

Function 3 (3D) - The Boundary Pusher

Challenge: Finding positive outputs while avoiding >1.0 penalty

Week 1

Input: [0.80, 0.80, 0.80] → **Output:** -0.1055

What we tried: Moderate-high initial values

What we learned: Negative output. Need to find path to zero/positive.

Decision: Unclear pattern, continue exploration

Week 2

Input: [0.95, 0.95, 0.95] → **Output:** -0.0919

What we tried: Higher values (all dims → 0.95)

What we learned: ✓ Better! (-0.1055 → -0.0919). Higher values → closer to zero.

Decision: Push even higher

Week 3

Input: [0.98, 0.99, 0.87] → **Output:** -0.0856

What we tried: Near-boundary values with Dim 3 lower

What we learned: ✓ Continued improvement! Trend confirmed: higher → better.

Decision: Continue high values

Week 4

Input: [0.948885, 0.965632, 0.808397] → **Output:** -0.0786

What we tried: Linear regression suggested these values

What we learned: ✓ BEST SO FAR! Getting very close to zero! Pattern = high values.

Decision: Try pushing to 1.0

Week 5

Input: [1.01, 1.01, 0.82] → **Output:** -1.1543

What we tried: Crossed boundary (>1.0) to see if improvement continues

What we learned: ■ HUGE PENALTY! >1.0 causes massive drop (-1368%). Stay ≤1.0!

Decision: Stay under 1.0, try asymmetry

Week 6

Input: [0.928, 0.832, 0.004] → **Output:** -0.1161

What we tried: ML suggested Dim 3 → 0.004 (extreme low)

What we learned: ■ ML ERROR! Dim 3 low hurt performance. Ignored importance analysis.

Decision: Don't trust ML extremes

Key Insight: Clear trend: higher values → better. But >1.0 has sharp penalty. Dim 1 is 99.6% important!

Critical Mistake: Week 6 ML suggested Dim 3→0.004, ignored ARD showing Dim 3 barely matters

Week 7 Strategy: Push ALL dims to boundary [0.99, 0.99, 0.99]

Function 4 (4D) - The Sensitive Center

Challenge: Extremely sensitive to outliers and deviations

Week 1

Input: [0.5, 0.5, 0.5, 0.5] → **Output:** -3.986

What we tried: Center point as initial guess

What we learned: ✓ BEST RESULT (still holds 6 weeks later!). Center is good.

Decision: Explore around center

Week 2

Input: [0.3, 0.3, 0.3, 0.3] → **Output:** -4.306

What we tried: Lower symmetric values

What we learned: ■ Slightly worse. Center [0.5] better than [0.3].

Decision: Try asymmetry

Week 3

Input: [0.44, 0.29, 0.35, 1.25] → **Output:** -30.129

What we tried: Asymmetric with one extreme value (Dim 4 = 1.25)

What we learned: ■■■ CATASTROPHE! -656% drop! Outlier 1.25 destroyed performance!

Decision: NEVER use outliers again

Week 4

Input: [0.51, 0.60, 0.57, 0.01] → **Output:** -12.492

What we tried: High variance with Dim 4 near zero

What we learned: ■ Still terrible (-213%). Any extreme value kills performance.

Decision: Return to uniform values

Week 5

Input: [0.66, 0.30, 0.30, 0.36] → **Output:** -7.262

What we tried: Mixed approach (one high, three low)

What we learned: ■ Bad (-82%). Week 1 center still best after 5 weeks.

Decision: Micro-explore near [0.5, 0.5, 0.5, 0.5]

Week 6

Input: [0.2, 0.2, 0.95, 0.4] → **Output:** -19.009

What we tried: Corner exploration (Dim 3 high, others low)

What we learned: ■ DISASTER (-377%)! Corners fail. Center is truly optimal.

Decision: Confirm center is best, or explore middle ground

Key Insight: EXTREMELY sensitive! Outliers cause catastrophic failures (up to -656%). Center [0.5, 0.5, 0.5, 0.5] is optimal.

Lesson Learned: Week 3 outlier (1.25) taught us to avoid extremes. Week 6 corner confirmed center is best.

Week 7 Strategy: Explore unexplored middle ground [0.65, 0.65, 0.65, 0.65]

Function 5 (4D) - THE BREAKTHROUGH ■

Multi-modal function with 39x improvement discovery

Week 1

Input: [0.30, 0.30, 0.30, 0.30] → **Output:** 136.85

What we tried: Moderate uniform values

What we learned: Baseline ~137 established. Decent starting point.

Decision: Try variations

Week 2

Input: [0.28, 0.32, 0.30, 0.29] → **Output:** 137.29

What we tried: Slight asymmetry around 0.3

What we learned: Similar result (~137). Function appears stable near 0.3.

Decision: Continue around 0.3

Week 3

Input: [0.344822, 0.264687, 0.374156, 0.203902] → **Output:** 131.78

What we tried: GP suggested more asymmetry

What we learned: Slightly worse. Still in ~130-140 range. Plateau discovered.

Decision: Explore other regions

Week 4

Input: [0.196828, 0.320017, 0.300, 0.289958] → **Output:** 140.74

What we tried: Linear regression suggested these values

What we learned: Small improvement to 141. Still stuck in local optimum ~140.

Decision: Try drastically different region

Week 5

Input: [0.99, 0.90, 0.98, 0.93] → **Output:** 5549.45

What we tried: ■ LEAP OF FAITH! Jump to boundary [0.9-1.0]

What we learned: ■■■ MASSIVE 39x IMPROVEMENT! Global optimum found! Multi-modal!

Decision: Stay near this region!

Week 6

Input: [0.985, 0.905, 0.975, 0.925] → **Output:** 5398.58

What we tried: Micro-exploration (moved 0.005-0.015 from Week 5)

What we learned: ■ Regression (-151 points, -2.7%). Peak is SHARP! Small moves hurt.

Decision: Use GP local search

BREAKTHROUGH MOMENT: Week 5's jump from [0.3] region to [0.99] region found global optimum!

Key Discovery: Multi-modal! Local optimum at [0.2-0.3] → 140. Global at [0.9-1.0] → 5549!

Sharp Peak: Week 6 moved 0.005-0.015 and lost 151 points. Requires precision!

Dimension 3: 96.6% important! This dimension drives the function.

Week 7 Strategy: GP local search → [1.0, 0.853, 1.0, 0.977] (Predicted: 6001!)

Function 6 (5D) - The Steady Climber

Consistent progress toward zero with diverse mid-range values

Week 1

Input: [0.75, 0.75, 0.75, 0.75, 0.75] → **Output:** -1.521

What we tried: High uniform values

What we learned: Negative. High uniform values not ideal.

Decision: Try lower values

Week 2

Input: [0.30, 0.30, 0.30, 0.30, 0.30] → **Output:** -1.139

What we tried: Low uniform values

What we learned: ✓ Better! (+25%). Lower is better direction.

Decision: Try asymmetry

Week 3

Input: [0.49, 0.02, 0.45, 0.40, 0.32] → **Output:** -1.123

What we tried: Diverse mid-range with one very low (Dim 2 = 0.02)

What we learned: ✓ BEST! Diversity helps. Mix of low and mid values works.

Decision: Continue diverse patterns

Week 4

Input: [0.69, 0.001, 0.04, 0.001, 0.001] → **Output:** -2.067

What we tried: Binary extremes (one high, four near zero)

What we learned: ■ DISASTER (-84%)! Extremes fail. Need balance.

Decision: Return to balanced diversity

Week 5

Input: [0.26, 0.18, 0.50, 0.48, 0.41] → **Output:** -1.092

What we tried: Diverse mid-range (all different, 0.18-0.50)

What we learned: ✓ NEW BEST! Steady progress -1.52→-1.09. Diversity in [0.2-0.5] optimal.

Decision: Push trend further

Week 6

Input: [0.10, 0.10, 0.70, 0.70, 0.60] → **Output:** -1.231

What we tried: Pushed trend too aggressively (Dims 1,2→0.1, Dims 3,4→0.7)

What we learned: ■ Overshot (-13%). Changed too many dims at once.

Decision: Focus on Dim 5 (89% important)

Key Pattern: Steady improvement -1.521 → -1.139 → -1.092. Moving toward zero!

Strategy: Dims 1,2 LOW (negative correlation), Dims 3,4,5 MODERATE-HIGH (positive correlation)

Critical Discovery: Dim 5 is 89.2% important! Focus optimization there.

Week 7 Strategy: Focus on Dim 5 → [0.15, 0.15, 0.50, 0.50, 0.70]

Function 7 (6D) - The Peer Learner

Learning from competitors and achieving +72% improvement

Week 1

Input: [1.0, 1.0, 1.0, 1.0, 1.0, 1.0] → **Output:** 0.000034

What we tried: All maximum values

What we learned: Nearly zero. High uniform is very bad.

Decision: Try opposite - low values

Week 2

Input: [0.2, 0.2, 0.2, 0.2, 0.2, 0.2] → **Output:** 0.408

What we tried: All low values

What we learned: ✓ MASSIVE improvement! Low values much better than high.

Decision: Try diversity

Week 3

Input: [0.21, 0.19, 0.21, 0.19, 0.17, 0.19] → **Output:** 0.347

What we tried: Small variations around 0.2

What we learned: ■ Regression. Too similar. Need MORE diversity.

Decision: Increase range

Week 4

Input: [0.08, 0.32, 0.15, 0.28, 0.41, 0.27] → **Output:** 0.568

What we tried: Wider diversity (0.08-0.41 range)

What we learned: ✓ Better! More diversity helps. Range = 0.33.

Decision: Push diversity further

Week 5

Input: [0.05, 0.50, 0.25, 0.20, 0.15, 0.85] → **Output:** 0.836

What we tried: Extreme diversity (0.05-0.85 range = 0.80)

What we learned: ✓ NEW BEST! Pattern confirmed: MORE diversity = BETTER.

Decision: Check peer performance

Week 6

Input: [0.06, 0.48, 0.25, 0.20, 0.40, 0.75] → **Output:** 1.435

What we tried: ■ Adapted peer pattern! Peer had [0.058, 0.492, ...] → 1.365

What we learned: ✓✓✓ +72% improvement! Beat peer (1.435 vs 1.365)! Dim 6 = 94% important!

Decision: Fine-tune winning pattern

Pattern Discovery: MORE diversity = BETTER. Progression: 0.00003 → 0.41 → 0.57 → 0.84 → 1.44

Peer Learning: Week 6 adapted competitor's pattern and BEAT them! (1.435 vs 1.365)

Key Dimension: Dim 6 is 94% important. Optimization focuses there.

Week 7 Strategy: Fine-tune → [0.038, 0.462, 0.239, 0.171, 0.378, 0.734]

Function 8 (8D) - The Complex Balancer

High-dimensional optimization requiring balance, not extremes

Week 1

Input: [0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1] → **Output:** 9.542

What we tried: Uniform low values (all 0.1)

What we learned: Good baseline ~9.54. Low uniform values work.

Decision: Try slight variations

Week 2

Input: [0.12, 0.09, 0.11, 0.10, 0.08, 0.13, 0.11, 0.09] → **Output:** 9.554

What we tried: Small asymmetry around 0.1

What we learned: ✓ Tiny improvement (+0.01). Some diversity helps slightly.

Decision: Try larger values

Week 3

Input: [0.29, 0.25, 0.02, 0.29, 0.14, 0.22, 0.25, 0.30] → **Output:** 9.548

What we tried: Mixed values (0.02-0.30 range)

What we learned: Similar to Week 1. Function stable in low-mid range.

Decision: Test extremes

Week 4

Input: [1.0, 0.001, 1.0, 0.001, 0.001, 1.0, 1.0, 0.001] → **Output:** 4.180

What we tried: Binary extremes (half at 1.0, half at 0.001)

What we learned: ■■■ CATASTROPHIC! Lost 5.4 points! Extremes destroy performance!

Decision: NEVER use extremes again

Week 5

Input: [0.05, 0.25, 0.25, 0.25, 0.25, 0.25, 0.05, 0.05] → **Output:** 9.643

What we tried: Return to low-mid range with diversity

What we learned: ✓ NEW BEST! Recovered from disaster. Balanced values [0.05-0.25] work.

Decision: Continue balanced approach

Week 6

Input: [0.18, 0.15, 0.20, 0.15, 0.25, 0.15, 0.15, 0.18] → **Output:** 9.676

What we tried: Fine-tuning in [0.15-0.25] range

What we learned: ✓ NEW BEST! Small incremental gains. Dim 3 most important (71%).

Decision: Focus on Dim 3

Critical Lesson: Week 4 binary extremes lost 5.4 points. NEVER use extremes on F8!

Optimal Strategy: Balanced values in [0.05-0.25] range. Slow, steady improvement.

Dimension Focus: Dim 3 is 71.4% important. Dims 2,4,5 positive correlation, Dims 1,3,6,7 negative.

Week 7 Strategy: Balanced EI → [0.177, 0.194, 0.170, 0.194, 0.294, 0.143, 0.109, 0.208]

Cross-Function Insights & Lessons

1. Multi-Modal Functions Exist (F5)

F5 had local optimum at [0.2-0.3] → 140 and global optimum at [0.9-1.0] → 5549. Sometimes radical exploration (leaps, not steps) finds breakthrough regions. Weeks 1-4 optimized local peak. Week 5 leap found global peak (39x improvement).

2. Outlier Sensitivity Varies Drastically (F4 vs F6)

F4 catastrophic with outliers: single value 1.25 caused -656% drop. F6 tolerant: binary extremes only caused -84% drop. F8 middle ground: extremes lost 56%. Lesson: Test sensitivity early, then adjust exploration strategy accordingly.

3. Narrow Peaks Require Precision (F2 vs F7)

F2 ultra-narrow: moving 0.02 away loses 48%. Required micro-exploration (±0.005). F7 very tolerant: wide diversity beneficial (range 0.80 better than 0.33). Different functions need different precision levels. F2 needs GP, F7 needs simple patterns.

4. Dimension Importance Often Extreme (F3, F5, F6, F7)

F3 Dim 1: 99.6% important. F5 Dim 3: 96.6%. F6 Dim 5: 89.2%. F7 Dim 6: 94%. Many functions have ONE dominant dimension. Focus optimization there! ARD kernel analysis reveals this automatically from data.

5. Peer Learning Works (F7 Success)

F7 Week 6: Adapted competitor's pattern [0.058, 0.492, ...] → 1.365. Our version: [0.060, 0.480, ...] → 1.435. Beat them by 5%! Cross-validate peer insights with our analysis. When aligned, use it!

6. ML Trust Calibration Critical

✓ Trust ML when: Small perturbations (F2: [0.111, 0.100]), validated by importance analysis. ✗ Don't trust ML when: Extremes (F3 Dim3→0.004), contradicts patterns (F5 [1,1,1,1] predicted worse). Week 6 F3 mistake: ML suggested extreme, ignored ARD showing Dim 3 barely matters.

Summary Statistics

Metric	Value
Total Experiments	48 (6 weeks × 8 functions)
ML Models Used	27 instances
Gaussian Processes	21 instances (78%)
Linear Regression	6 instances (Week 4)
Pattern-Based	9 instances
Neural Networks	1 (tested, rejected)
Breakthrough Moments	3
F5 Week 5	+3900% (39x improvement)
F7 Week 6	+72% (peer pattern)
F1 Week 6	First signal after 5 zeros
Catastrophic Failures	3
F4 Week 3	-656% (outlier 1.25)
F8 Week 4	-56% (binary extremes)
F3 Week 5	-1368% (>1.0 penalty)

Top 10 Lessons Learned

• 1. **Explore Radically When Stuck** - F5's jump from [0.3] to [0.99] found 39x improvement

• 2. **Test Outlier Sensitivity Early** - F4's 1.25 outlier caused -656% drop

• 3. **Use Multi-Method Validation** - ARD + Correlation + Gradients provide robust insights

• 4. **Precision Matters on Narrow Peaks** - F2 lost 48% from moving 0.02 away

• 5. **Don't Trust ML Blindly** - F3 Week 6: ML suggested extreme, ignored importance

• 6. **Learn from Competitors** - F7 peer pattern led to +72% improvement

• 7. **Dominant Dimensions Exist** - Many functions have one dimension >85% important

• 8. **Extremes Usually Fail** - F4, F8 both destroyed by extreme values

• 9. **Persistence Pays Off** - F1 found signal in Week 6 after 5 weeks of zeros

• 10. **GP > Linear for Non-Linear** - Gaussian Processes vastly superior for complex landscapes

This journal documents 6 weeks of systematic exploration, 3 breakthrough moments, multiple catastrophic failures, and the iterative learning process that led to effective optimization strategies for each function.