

Conceptual Bridges in Machine Learning

Exploring the Effect of Analogies on Multilayer Perceptron Understanding

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1. Introduction & Background

- ML - new, abstract, core subject
- Multilayer Perceptrons (MLPs):
 - math → **abstract**
 - biology → **intimidating**
- Metaphors → used in **CS** to teach abstract concepts
- Why not** in ML too?
=> Metaphors can “Bridge the Gap”!

2. Research Question

To what extent do **conceptual metaphors** and **analogies** improve novice learners' ability to **understand MLPs**?

3. Methodology

1

Analogy Generation

2

Expert Evaluation

3

Student A/B Test

Concept Mappings

Metaphors

Best Analogies

Variant Group (Analogies)

Control Group (No Analogies)

Analyze Effect on Knowledge Gain and Motivation

4. Results

1

Definition: The learning rate determines the size of the steps the optimization algorithm takes when adjusting the weights of the model in response to the gradients.

Analogy: The learning rate is like the stride of a hiker climbing a mountain with a map (the gradient) to reach the summit (optimal model weights).

generates

+

MLP Concept	Metaphor/Analogy Element
Learning rate	The stride length of the hiker
Optimization algorithm	The hiker
Adjusting weights	Climbing or stepping toward the summit
Gradients	The map or compass that points the hiker in the right direction
Model	The hiker's route
Optimal model weights	The summit (goal of the hike)
Training	The hiking journey

Criteria:

2

- Score** - Average of:
 - Target Concept Coverage
 - Mapping Strength
 - Metaphoricity
- Agreement between experts:**
 - Based on Krippendorff's Alpha

Scatterplot: Average Score vs Agreement per Question

Best-rated Analogies:

- Learning Rate (M9)
- Overfitting/ Early Stopping (M8)
- Hidden Layers (M10)
- Bias (M5)

All expert-approved analogies:

<https://ml-teaching-analogies.github.io/>

3

Effect of Analogies on Knowledge Gain: Not Statistically Significant

Effect of CS Background on Knowledge Gain: Not Statistically Significant

Effect of Analogies on Motivation: Not Statistically Significant Positive Trend

5. Discussion

- Knowledge Gain:**
 - Results different from prior studies, possibly due to:
 - Complexity of ML concepts
 - Limited exposure during the experiment
- Student Motivation:**
 - Analogy group → **numerically higher scores** in all categories
 - Analogies** may:
 - Boost student **confidence**
 - Make **ML** feel more **approachable**
 - Create **engaging** learning environment
 - Trends **align** with prior research on subject

6. Limitations and Future Work

- Expert Evaluation Limitations:**
 - Low, inconsistent number of evaluations.
 - Future: More evaluators, diverse expert pool
- Study Design Limitations:**
 - Small sample size (23 participants).
 - Focus on four MLP topics
- Future Research Directions:**
 - Investigate long-term effects of analogies
 - Repeat experiments to improve consensus