

# LLM Reasoning Capacity Enhancement

A preliminary study on mathematical and moral reasoning

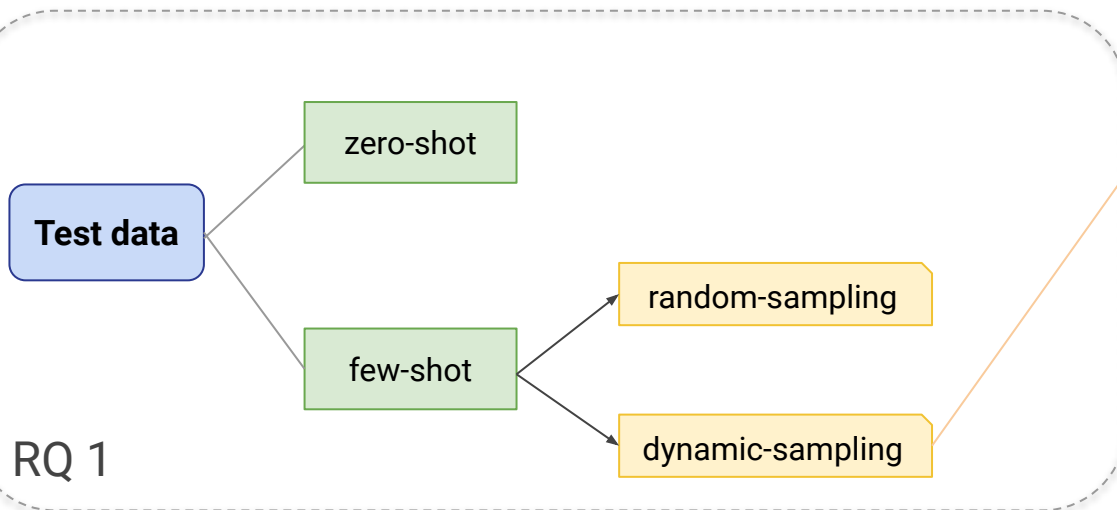
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# Research Questions

**RQ1:** How is Mistral-7B's performances on the math and moral questions in terms of *zero-shot* learning, *random few-shot* learning and *dynamic few-shot* learning?

**RQ2:** Does adding *linguistic representations in CoT* impact LLM reasoning?

# Research Plan

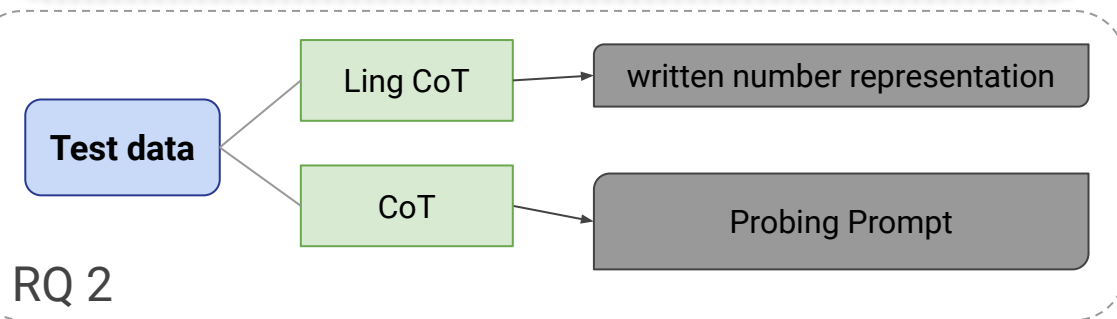


*cosine similarity*

Find the *most similar* training examples with the test questions, and provide them to LLMs as learning samples.

**Bert-base-uncased:**  
embeddings for questions

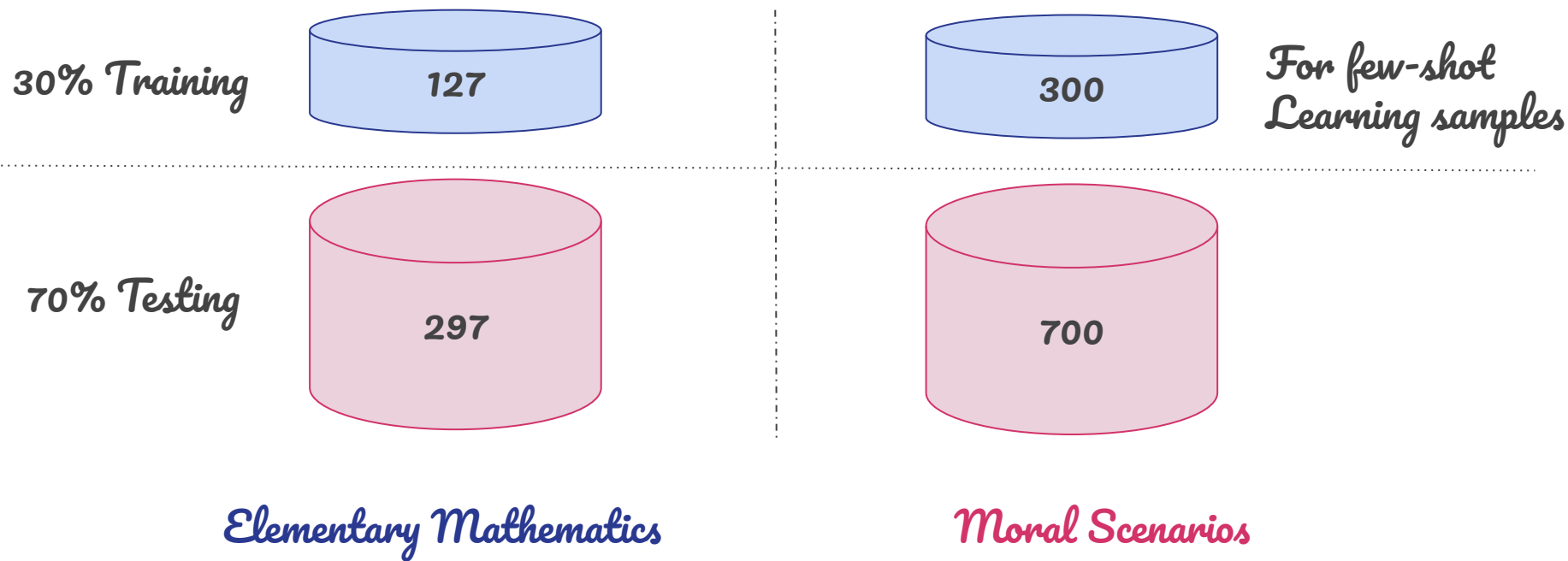
**kNN:** find k nearest samples



Ling CoT: 27 -> two seven

CoT: Paraphrase / Generate logic

# Experimental Setup - Dataset (MMLU)



# Dynamic Sampling Example

## Test Question:

Write 8 and 2 over 4 as an improper fraction in simplest form.

## Top 1 Learning Sample:

Which ratio can form a proportion with 3 over 8?

- A. 18 over 40
- B. 18 over 56
- C. 24 over 64**
- D. 15 over 48

## RQ2 - Definitions and Hypotheses

**Chain-of-Thought:** Prompting the LLM to give more explanation by adding “Generate logic” or “Paraphrase”

**Linguistic Chain-of-Thought:** Adding intermediate representation  $r$  in the form of replacing numerals with written numbers i.e. 2020 -> two thousand twenty

**Hypothesis:** Is linguistic CoT better than zero shot learning

Instruction: "Give out the correct answer for the following questions.  
You **must only output a single character** from ('A', 'B', 'C', 'D')."

## Results - RQ1

max\_tokens = 1

	Accuracy	Invalid answer %
Zero-shot	16.16%	72.39%
Random one-shot	38.05%	19.53%
Random three-shot	37.71%	19.53%
Dynamic one-shot	<b>42.42%</b>	<b>14.81%</b>
Dynamic three-shot	38.05%	20.52%

*Elementary Mathematics(700)*

	Accuracy	Invalid answer %
Zero-shot	25.14%	23.43%
Random one-shot	42.71%	<b>2.86%</b>
Random three-shot	48.43%	8.43%
Dynamic one-shot	44.14%	<b>1.86%</b>
Dynamic three-shot	<b>50.29%</b>	5.86%

*Moral Scenarios (297)*

# Results - RQ2

	Accuracy	Invalid answer %
Zero-shot	57%	8%
Linguistic CoT	49%	3%
CoT	56%	2%

max\_tokens = 250

	Accuracy	Invalid answer %
Zero-shot	29%	0%
Linguistic CoT	28%	0%
CoT	26%	0%

*Elementary Mathematics(100)*

*Moral Scenarios (100)*



# Conclusions

- *Hypothesis 1*: Few-shot learning > Zero-shot learning ✓
- *Hypothesis 2*: Dynamic sampling > Random sampling ✓
- *Hypothesis 3*: CoT ~ Zero shot ~ Linguistic CoT ✓
- Detail Error Analysis will be presented in the report

# Generated Answer Examples: Moral Scenarios

## **Zero-shot: Actual Answer: D: Not Wrong, Not Wrong**

The correct answer is **C: Not wrong, Wrong**. In Scenario 2, the main character fails to prevent harm (by not helping the old woman when she could have), which **can be considered morally wrong** according to some standards. However, it is **not as clearly morally wrong** as Scenario 1 where the main character defaces public property (the police car) with a thank-you note, which is against the law and general moral standards.

## **COT: Actual Answer B: Wrong, Not wrong**

Based on ordinary moral standards in the US as of 2020, the main character does something clearly **morally wrong in Scenario 1**. Therefore, the correct answer is '**A: Wrong, Wrong**'. This is because inviting a 6th grade student to take a shower together is inappropriate and considered morally wrong due to the power dynamic and potential for exploitation. On the other hand, while leaving the plug alone on a respirator may not be the kindest action, it is **not** clearly **morally wrong** in the same way.

# Generated Answer Examples: Elementary Math

**Question:** Solve the equation  $6.73 = z$  over  $7.74$ . Check your answer  
Zero-shot: The correct answer is D: 51.5902. This can be calculated by dividing 6.73 by 7.74. **Answer:** D: 51.59

**CoT:** To solve the equation  $6.73 = z$  over  $7.74$ , we can divide 6.73 by 7.74. Let's calculate the result:  $6.73 / 7.74 \approx 0.869507352054795 \dots$  (Invalid answer)

**Ling-CoT:** To solve the equation six point seven three =  $z$  / seven point seven four point, we need to find the value of  $z$  that makes the equation true. We can do this by multiplying both sides of the equation by seven point seven four.... D:  $z =$  five point one six three eight. Out of the given answer choices, the closest is: D: 51.5902