Data Science Report

1. Fine-Tuning Setup

- **Base Model:** FLAN-T5 (small)
- **Method:** LoRA (Low-Rank Adaptation)
- **Dataset:** 39 lectures
- **Split:** 92/8 (train/validation)
- **Hardware:** Google Colab T4 GPU
- Config:
  - Epochs = 3 Batch size = 2 LR = 1e-4
  - Gradient accumulation = 4 FP16 = False
- **Params:** Base=247.6 M Fine-tuned=248.4 M
- Final train loss = 0.8776
- **Validation loss:** 0.8487 → 0.8466

Epoch	Training Loss	Validation Loss
1	No log	0.848744
2	No log	0.847209
3	No log	0.846583

```
TrainOutput(global_step=6, training_loss=0.8776093324025472, metrics={'train_runtime': 13.5337, 'train_samples_per_second': 3.547,
'train_steps_per_second': 0.443, 'total_flos': 32998812549120.0, 'train_loss': 0.8776093324025472, 'epoch': 3.0})
```

2. Dataset & Preprocessing

Cleaned and tokenized short Q&A pairs using the model tokenizer.
Each entry is limited to fixed token length.
Data was small and simple—limited diversity and complexity.

3. Results

Query	Base Summary	Fine-tuned Summary	ROUGE-1	ROUGE-L
Explain black holes	Nothing, not even light…	Same	1.0	1.0
What is Sun	The Sun is a G-type…	Same	1.0	1.0
Define planets	Pluto is a "dwarf planet"…	Same	1.0	1.0

	query	base_summary	fine_tuned_summary
0	Explain black holes	Nothing, not even light, can escape from them.	Nothing, not even light, can escape from them.
1	What is sun	The Sun is a G-type main-sequence star (G2V) l...	The Sun is a G-type main-sequence star (G2V) l...
2	Define planets	Pluto is a "dwarf planet" because it doesn't s...	Pluto is a "dwarf planet" because it doesn't s...

```
🧠 Topic: Explain black holes
ROUGE Scores (Fine-tuned vs Base):
  ROUGE-1: 1.0000
  ROUGE-L: 1.0000

🧠 Topic: What is sun
ROUGE Scores (Fine-tuned vs Base):
  ROUGE-1: 1.0000
  ROUGE-L: 1.0000

🧠 Topic: Define planets
ROUGE Scores (Fine-tuned vs Base):
  ROUGE-1: 1.0000
  ROUGE-L: 1.0000
```

Observation:

Outputs identical to base model → underfitting.

High ROUGE due to overlap, not real improvement.

4. Analysis

- Stable training (loss ≈ 0.84) but minimal learning.
- LoRA adapted few parameters, insufficient for major semantic change.
- Dataset too small and repetitive; only 3 epochs; limited compute.

5. Limitations & Future Work

Issue	Fix
Small dataset	Expand to 300-500 examples
Few epochs	Train longer (10–15 epochs)
Low variety	Include more complex queries
Limited metrics	Add BERTScore / human ratings

6. Conclusion

Fine-tuning with LoRA was successfully integrated but showed little improvement due to **small dataset, short training, and minimal parameter updates**.

Despite limited results, the experiment validated the **fine-tuning pipeline** and evaluation process.