

Innovative Pedagogies for Geospatial Data Analysis with Python: Strategies for Engagement, Mastery Learning, and Career Readiness



Suborna Ahmed, PhD
Assistant Professor of Teaching

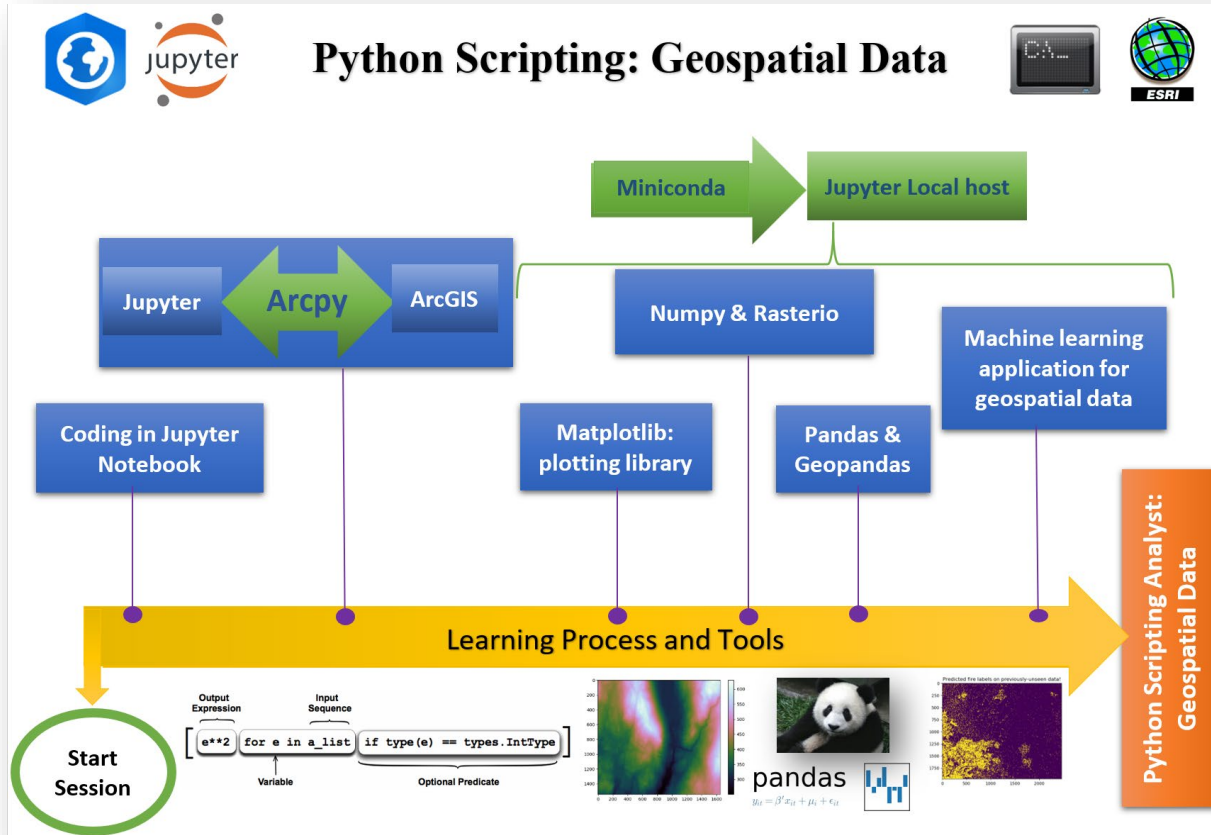
Department of Forest Resources Management
Faculty of Forestry, UBC Vancouver

SaGES 2025 Conference
June 17th 2025



THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Forestry

Geospatial Data Analytics Course Structure



Module Learning Structure

- Exploration and summarize geospatial data
- Select methods based on the objective
- Create a reproducible workflow
- Interpret

Why Geospatial Education Needs Innovation

- **Data Revolution:** Forest data is rapidly growing in volume and complexity due to:
 - Remote Sensing (LiDAR, satellite imagery)
 - Geospatial Technologies (GIS)
 - Artificial Intelligence (AI) and Machine Learning applications
- **The Diverse Learners and Educational gap:**
 - Effectively equip students and practitioners with competencies
 - Ensuring learning is accessible, current, and engaging

Instructional Design Framework

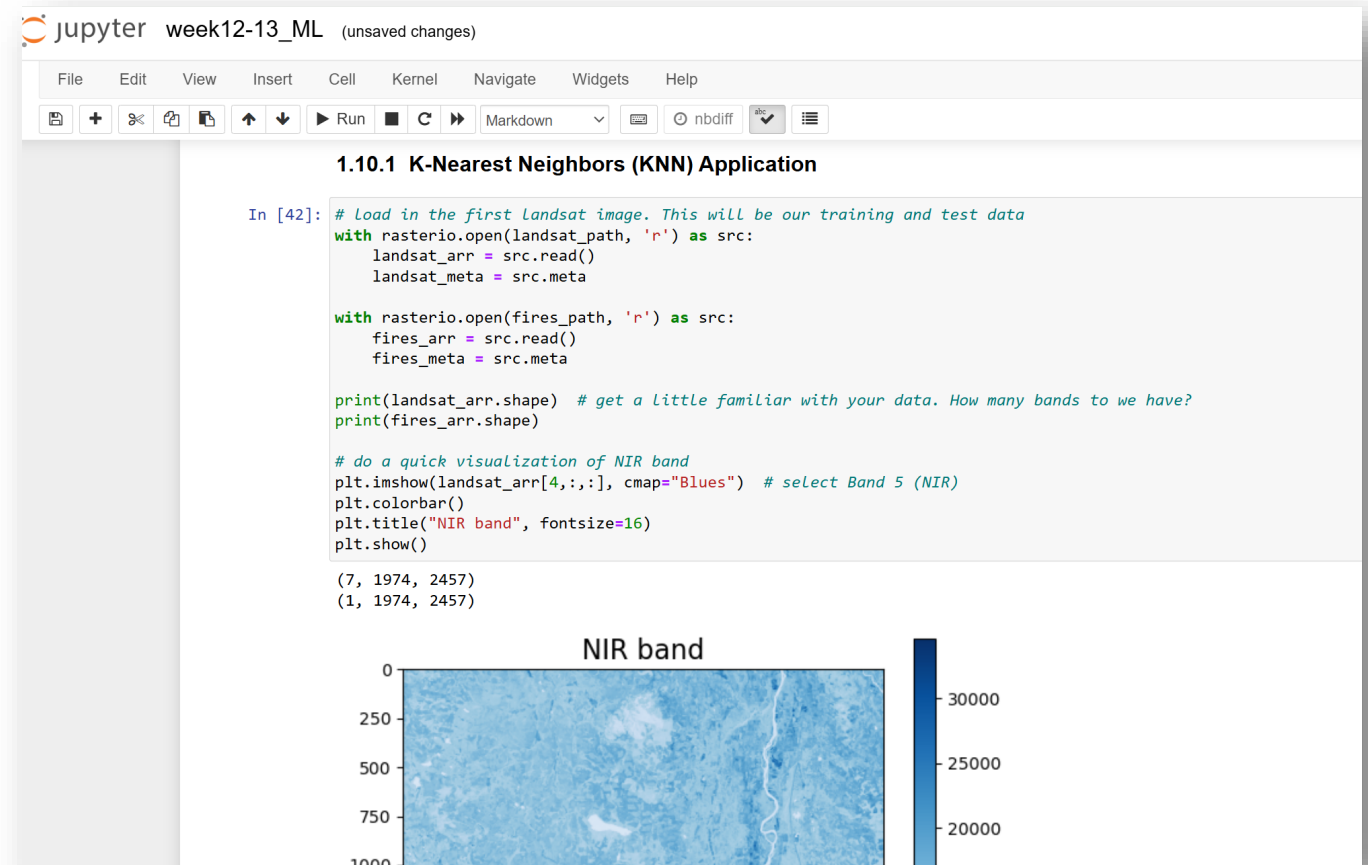
Integrated Pedagogical Strategies

- Active learning
- Mastery learning
- Open Education Resources (OER) integration

Instructional Design Framework

Active learning through Jupyter Notebook

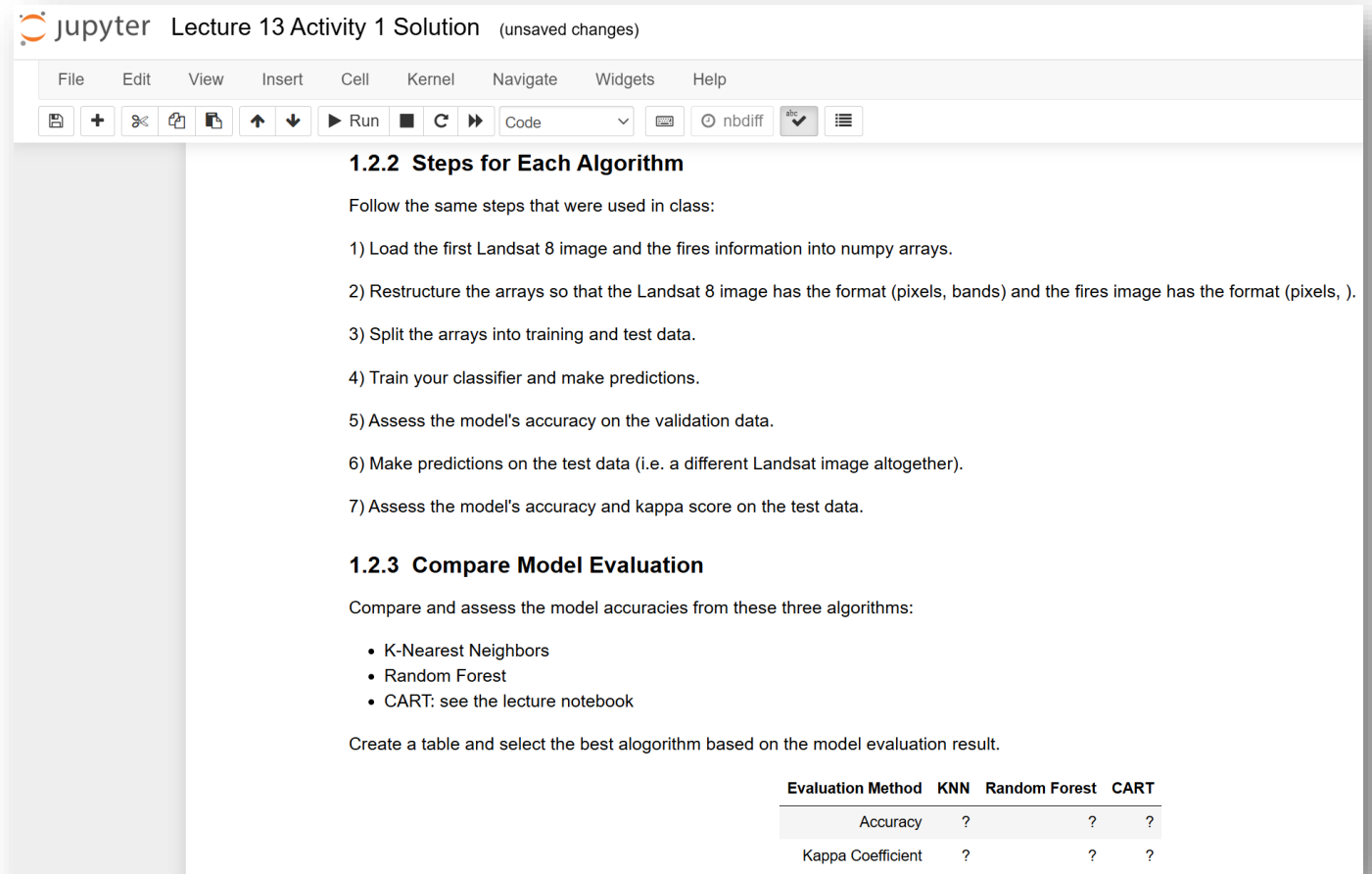
- Interactive Lecture and Exercises
- Bridging theory and practice



Instructional Design Framework

Active learning through Jupyter Notebook

- Interactive Lecture and Exercises
- Bridging theory and practice



The screenshot shows a Jupyter Notebook window titled "jupyter Lecture 13 Activity 1 Solution (unsaved changes)". The interface includes a menu bar (File, Edit, View, Insert, Cell, Kernel, Navigate, Widgets, Help) and a toolbar with icons for file operations, running, and code execution. The main content area displays the following text:

1.2.2 Steps for Each Algorithm

Follow the same steps that were used in class:

- 1) Load the first Landsat 8 image and the fires information into numpy arrays.
- 2) Restructure the arrays so that the Landsat 8 image has the format (pixels, bands) and the fires image has the format (pixels,).
- 3) Split the arrays into training and test data.
- 4) Train your classifier and make predictions.
- 5) Assess the model's accuracy on the validation data.
- 6) Make predictions on the test data (i.e. a different Landsat image altogether).
- 7) Assess the model's accuracy and kappa score on the test data.

1.2.3 Compare Model Evaluation

Compare and assess the model accuracies from these three algorithms:

- K-Nearest Neighbors
- Random Forest
- CART: see the lecture notebook

Create a table and select the best algorithm based on the model evaluation result.

Evaluation Method	KNN	Random Forest	CART
Accuracy	?	?	?
Kappa Coefficient	?	?	?

Building a Rich Ecosystem of OER

Open Textbooks (Accessible on [GitHub](#)):

- Python Programming for Geospatial Data Analysis

Python Programming for Geospatial Data Analysis

Author: Dr. Suborna Ahmed

Python Scripting: Geospatial Data

Miniconda → Jupyter Local host

Jupyter ← Arcpy → ArcGIS

Numpy & Rasterio

Machine learning application for geospatial data

Matplotlib: plotting library

Pandas & Geopandas

Coding in Jupyter Notebook

Learning Process and Tools

Start Session

Python Scripting Analyst: Geospatial Data

Introduction

Fire labels on our training image

Actual fire labels

Predicted fire labels

```
# How does this model perform on data it has never seen before?
# Let's show it an image over the exact same area that was acquired on a different date (6 weeks later)
with rasterio.open(validation_path, 'r') as src:
    validation_arr = src.read()
    validation_meta = src.meta
```

```
# rearrange the array like we've done with the others
validation_arr = np.reshape(validation_arr, (bands, rows * cols))
validation_arr = np.swapaxes(validation_arr, 0, 1)
print(validation_arr.shape)
```

(4850118, 7)

Machine Learning Application in Geospatial Data

Learning Objectives:

1. What is Machine Learning?
2. Why Use ML in Remote Sensing/GIS?
3. scikit-learn
4. Setup the Environment
5. Types of Algorithms
6. Problem-Solving Framework

Further Resources

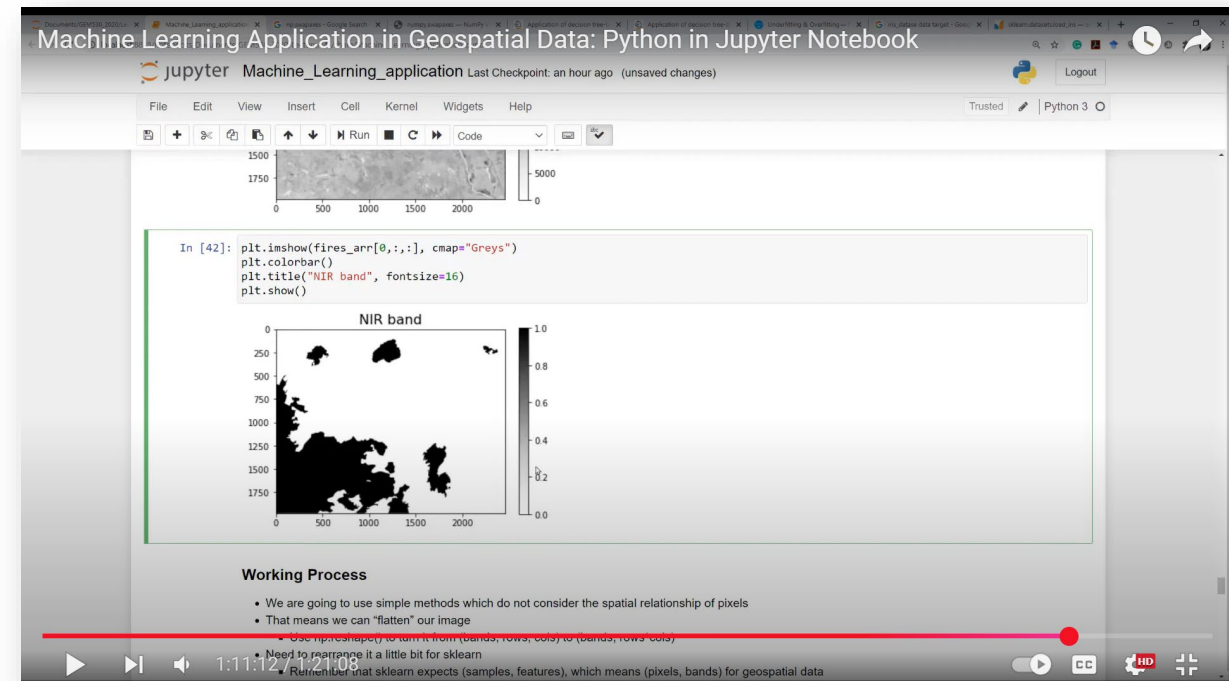
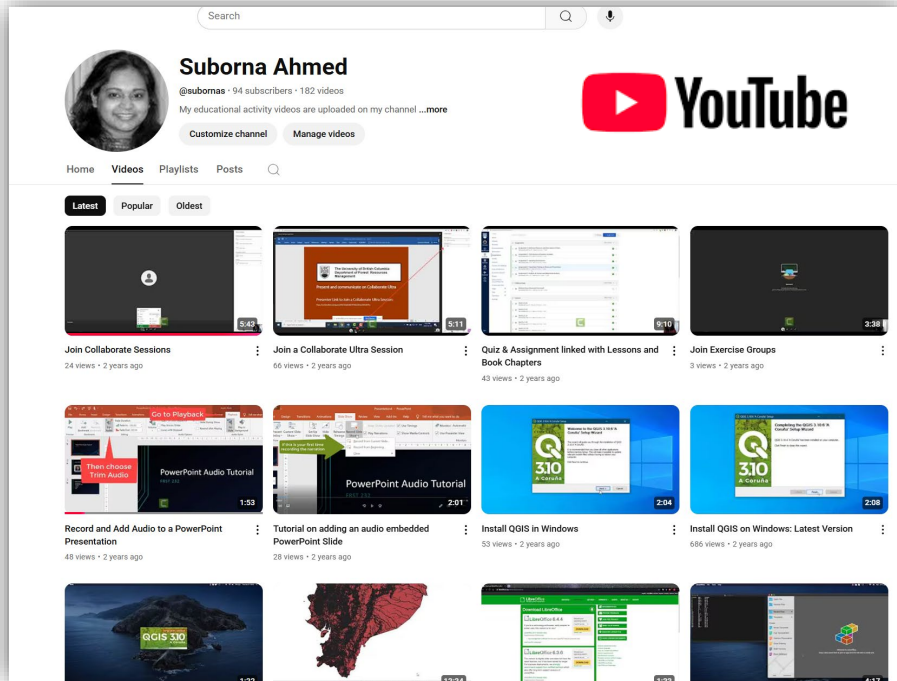
Solution

- K-Nearest Neighbors (KNN)
- Application
- Random Forest
- Compare Model Evaluation:

Building a Rich Ecosystem of OER

Instructional Videos

- YouTube Channel: 119+ open educational videos
- Global Reach: Over 65,401 views from Canada, USA, UK, India, Spain, Vietnam, Indonesia, and more



Integration of Open-Source Software

Integration of Open-Source Software:

- Core Tools: Python (Jupyter Notebooks, ArcPy)

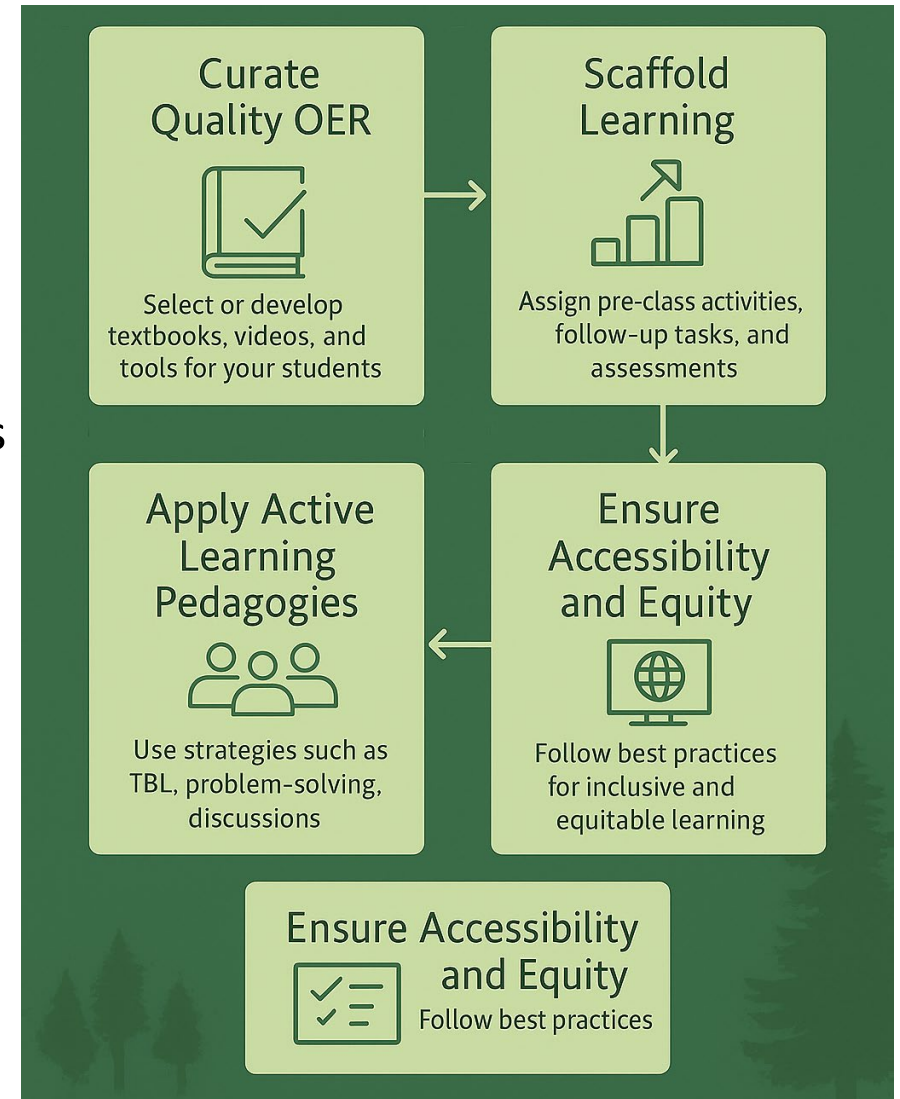
The image displays two overlapping Jupyter Notebook interfaces. The background notebook, titled "Data_Wrangling_Tutorials.ipynb", features a table of contents on the left with sections like "Data Wrangling in Python", "Introduction and Dataset Background", "Install and load required packages", "Download data", and "Data Wrangling". The main content area shows a map of Canada with a red dot indicating a location near Toronto. The foreground notebook, titled "Machine_Learning_application", shows a code cell with the following Python code:

```
In [20]: # do a quick visualization of NIR band
plt.imshow(landsat_arr[4,:,:], cmap="Greys") # select B
plt.colorbar()
plt.title("NIR band", fontsize=16)
plt.show()
```

Below the code, a visualization of the NIR band is shown as a grayscale image with a color bar on the right. The color bar ranges from 0 to 30,000, with major ticks at 0, 25,000, and 30,000. The image shows a landscape with a river and some vegetation.

Effective Strategies for OER Integration Stages

- **Curate Quality OER**
 - Select materials aligned with course outcomes
 - Prioritize open licensing and adaptability
 - Involve students in resource
- **Scaffold Learning**
 - Design structured learning sequences with OER
 - Incorporate pre-class videos, quizzes, and guided readings
 - Use formative assessments to guide instruction
- **Apply Active Learning Pedagogies**
 - Facilitate team-based problem-solving using OER
 - Incorporate think-pair-share, and coding demos
 - Leverage OER for real-world application tasks
- **Ensure Accessibility and Equity**
 - Use inclusive examples and multiple learning formats
 - Provide feedback loops and inclusive engagement strategies



Mastery learning: Self-Assessment Pathway

Achieving a High Level of Proficiency



Learn the
Materials

Apply the
learning
concept

Reflect on results:
identify strengths
and areas for
improvement

Create an
action plan

Reach out for
additional
support

Achieve the
learning goal



Mastery learning: Self-Assessment Pathway

- **Key Observations and Outcomes:**
 - Engagement and participation
 - Identification of learning gaps
 - Impact on learning outcome
 - Quality of reflection

Assignment Comments

Section 1

Q1: We got the right output, our second line of code is the same as the answer key, but we had an unnecessary extra line before it: `featureclasses = arcpy.ListFeatureClasses()`.

Q2: We got the same answer and it worked.

Q3: We defined our output name outside of the for loop. The code within our for-loop is also much simpler than the answer key, but I think we get the same result.

Q4: We got the same answer however, we added `featureclasses = arcpy.ListFeatureClasses()`. We got less outputs but I think that has to do with our data set not the actual code itself.

Section 2

Q1: Our code is almost the same as the key. Our only difference is that we did not assign the AAB roads shapefile a name in order to make a cleaner line of code in the 'rows=' line, we just included the shp in "".

Q2: We tried to use the `acrp.py.management.CalculateField()` function instead but it didn't work. However Evan looked at our code and said it should have run and that the error had to do with jupyter not our actual code. However I do see that a for loop would be more efficient.

Q3: Our where clause is correct, but where they key uses `arcpy.SearchCursor(shp3, whereClause, "", "")` we have `arcpy.SearchCursor("AAB_roads_national.shp", whereClause)` I'm not sure what the "" does in the code. Our for loop also is different. The print command in the key says `print("len_mi is ", row.getValue("len_mi"))` where ours is `print("Length in mi for FIS:", row.FID, row.len_mi)`

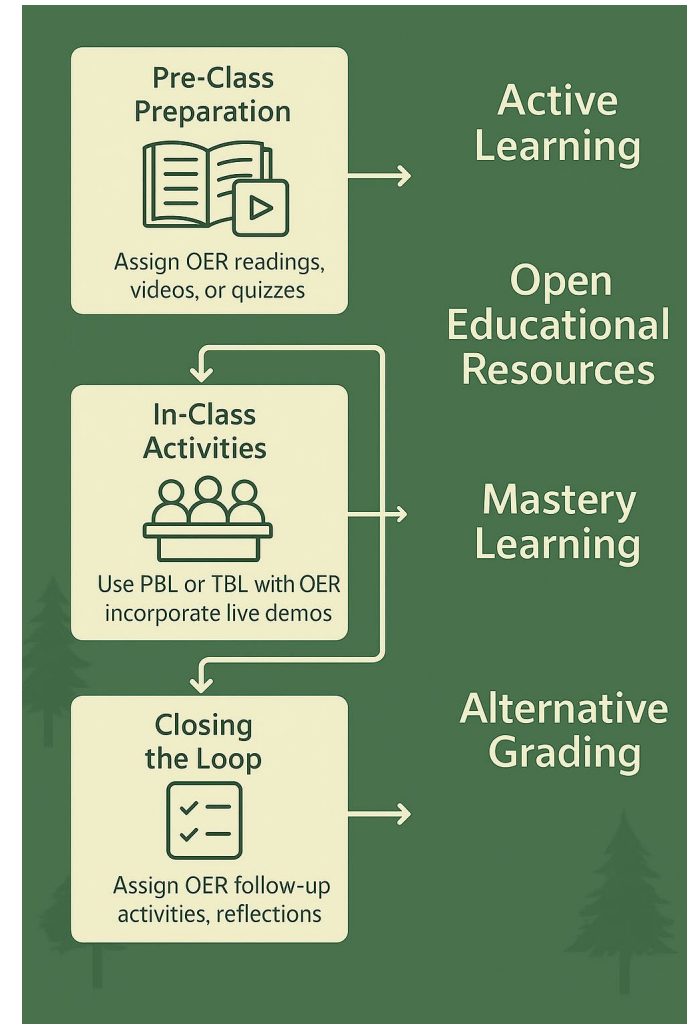
Pedagogical Techniques Tailored to Modules

Active Learning → Hands-on, coding-based engagement

OER → Freely accessible, adaptable resources

Mastery Learning → Iterative practice with feedback

Alternative Grading → Competency-based evaluation over high-stakes testing



Discussion and Future Directions

- **Scalability & Transferability :**

- How can these pedagogical models be adapted or scaled effectively in different institutional contexts or other quantitative disciplines?

- **Long-Term Impact:**

- What are effective methodologies for tracking the long-term impact of these approaches on student career trajectories and problem-solving capabilities in the field

Thank You!