

# Higher Ed Guide to Esri E-Learning for Spatial Data Science



## Overview

Spatial data science allows analysts to extract deeper insight from data using a comprehensive set of analytical methods and spatial algorithms, including machine learning and deep learning techniques. Spatial data science topics may be included in a range of courses, including data science, business, and GIS.

This guide is an aid for instructors who want to use authoritative Esri web-based learning resources as part of college or university courses. This list is not a comprehensive curriculum, nor is it a course outline. It is intended to help instructors quickly identify and select those resources that best support their goals and students. Listed items are available as of September 2021 and are expected to be available through at least December 2021. **New listings are in orange.**

Full descriptions can be found at the links provided. All items listed are web courses unless otherwise noted. The complete Esri catalog can be found at [esri.com/training/catalog](https://esri.com/training/catalog). The information provided in this guide is subject to change without notice. Please email [GIStraining@esri.com](mailto:GIStraining@esri.com) or call (800) 447-9778, ext. 5757 with questions about courses.

You and your students may be eligible for unlimited access to the entire collection of self-paced e-Learning (web courses, training seminars, and more) if your institution has a qualifying product with a current maintenance subscription. To determine if this applies to you, contact your Esri software license administrator, [check online](#), or email [educationinfo@esri.com](mailto:educationinfo@esri.com).

This guide is organized into three main sections:

- **Learning Plans:** Esri-curated sets of e-Learning offerings with a suggested order.
- **Technology:** Individual e-Learning offerings that provide foundational concepts and skills to support spatial data science workflows.
- **Capabilities:** Individual offerings about specific spatial data science analysis techniques.

## LEARNING PLANS

A [learning plan](#) is a set of learning resources with a suggested order. You can use or assign one of the Esri-created learning plans listed here; make a copy and modify the plan before assigning it; or create your own learning plan from scratch. See the site [Help](#) (Category: Learning Plans) for more information about teaching with learning plans. The content in Esri-created learning plans is subject to change without notice as component items are added or retired.

### [Spatial Analysis and Data Science Fundamentals](#)

Courses and videos introduce the modern spatial analysis and data science capability of ArcGIS. Includes overviews to solving spatial problems, data engineering, data visualization, statistical and machine learning techniques using ArcGIS.

### [ArcGIS Technology for Spatial Data Science](#)

This comprehensive plan exposes learners to the ArcGIS tools that enable spatial data science, including ArcGIS Pro, ArcGIS Online, ArcGIS API for Python, R-ArcGIS Bridge, ArcPy for ArcGIS Pro, and ArcGIS Notebooks.

### [ArcGIS Notebooks Fundamentals](#)

This plan explores how to create, share, and use ArcGIS's integrated Python notebooks to perform advanced modeling, support machine learning, explore data, analyze locations, and more.

### [ArcGIS API for Python Fundamentals](#)

This plan collects the ArcGIS API for Python web courses into a single list. Learners will discover how to streamline analysis, manage content, and integrate Python with Jupyter Notebook to share scripts and reproducible research with others.

### [ArcPy Essentials](#)

This plan includes courses from beginning Python scripting to creating scripts to automate geoprocessing workflows and analyzing rasters. Introduces using ArcGIS Notebooks and teaches how to access over 1,400 geoprocessing tools using ArcPy.

### [R-ArcGIS Bridge Essentials](#)

This plan combines concepts and hands-on techniques for using the R-ArcGIS Bridge with several practical application tutorials.

### [Identifying Clusters Using ArcGIS](#)

This plan collects into a single list the web courses that cover statistical cluster analysis and space-time cluster analysis techniques.

### [Finding the Best Place](#)

This plan covers spatial tools and methods for suitability modeling.

### [Interpolating Surfaces Using ArcGIS](#)

This plan covers spatial interpolation concepts, techniques for interpolation and kriging in ArcGIS Pro, and tutorials where students apply interpolation in practical scenarios.

### [Image Classification Using ArcGIS](#)

This plan introduces image classification concepts and techniques using ArcGIS.

### [Deep Learning Using ArcGIS](#)

This plan teaches deep learning concepts, methods, algorithms, models, and techniques, using spatial data including 3D, imagery, and text, to derive geospatial information products.

## TECHNOLOGY

### Spatial data science

The following resources introduce spatial data concepts and techniques. (Get an overview of ArcGIS [Spatial Analysis & Data Science](#) capabilities.)

- [Spatial Data Science: The New Frontier in Analytics \(MOOC; 6 weeks; October 27 – December 8, 2021\)](#) Explores the application of spatial data science to find patterns and improve predictive modeling. Shows how to integrate popular open data science packages into analyses.
- [ArcGIS Pro: Your Spatial Data Science Workstation](#) (Video, 56 mins.) Presents how to build workflows which draw from both the extensive Python data science ecosystem and rich ArcGIS Pro geoprocessing tools to access data. Covers using Notebooks for interactive analysis.

- [ArcGIS API for Python for Analysts and Data Scientists](#) (Video; 53 mins.) Explains how Python programmers can tap into geospatial analysis and workflows using ArcGIS API for Python. Presents an overview of using the API, the kinds of tools available, and the benefits of using them. Uses examples in Jupyter notebooks.
- [Machine Learning: An Introduction](#) (Video; 53 mins.) Provides an overview of data-driven algorithms and techniques in ArcGIS that automate data prediction, classification, and clustering. Covers a range of spatial machine learning tools and integration with external frameworks.
- [Real-Time and Big Data Analysis with ArcGIS Velocity](#) (Training Seminar; 44 mins.) Explains how to use ArcGIS Velocity to ingest, visualize, and analyze real-time data feeds; store data over time; and quickly summarize and perform data analysis.

### Related Learning Plans

- [ArcGIS Technology for Spatial Data Science](#)
- [Spatial Analysis and Data Science Fundamentals](#)

## ArcGIS foundation

The following web courses cover skills and concepts about GIS and ArcGIS Pro that data science students may find helpful.

- [GIS Basics](#) (2 hrs., 35 mins.) Presents fundamental components and capabilities of GIS and how ArcGIS can help organizations address business needs.
- [ArcGIS Pro Basics](#) (50 mins.) Introduces tools to integrate, visualize, analyze, and share data.
- [Basics of Geographic Coordinate Systems](#) (1 hr., 15 mins.) Teaches fundamental concepts of coordinate systems used to locate features on the earth.
- [Getting Started with Spatial Analysis](#) (1 hr., 10 mins.) Introduces the six categories of spatial analysis that can help you answer geographic questions.
- [Getting Started with Geoprocessing](#) (1 hr., 30 mins.) Presents key concepts and geoprocessing techniques used for analysis, including setting the geoprocessing environment.
- [Symbolizing Map Layers](#) (1 hr., 45 mins.) Teaches basic principles of map symbology.

## ArcGIS and Python scripting foundation

The following Learn Path is for instructors.

- [Teach with ArcGIS Notebooks](#) (Learn Plan; 1 hr., 15 mins.) Use ArcGIS Notebooks as a teaching tool, from delivering class assignments to presenting analysis in a slideshow.

The following resources introduce ArcGIS Python libraries, ArcGIS Notebooks, and context necessary to begin Python scripting with geospatial data. (Get an overview of [ArcGIS Python Libraries](#).)

- [Learn Python with ArcGIS Notebooks](#) (Learn Plan; 3 hrs., 45 mins.) Uses ArcGIS Online Notebooks to create Python code for data visualization, analysis, and management.
- [Python Libraries for Spatial Data Science](#) (Training Seminar; 1 hr., 12 mins.) Provides a guided tour of the most essential Python libraries for geospatial professionals and data science practitioners who want to include spatial data and techniques in their analytical workflows. Compares ArcPy and ArcGIS API for Python.
- [Get Started with ArcGIS Notebooks](#) (Training Seminar; 1 hr., 4 mins.) Introduces basic concepts of data science, machine learning, and artificial intelligence in the context of ArcGIS Notebooks, the Python scripting environment in ArcGIS Enterprise.
- [ArcGIS Notebooks Basics](#) (1 hr.) Introduces ArcGIS Notebooks in ArcGIS Pro. Presents the interface and functionality for creating Python notebooks to perform spatial data analysis.

- [Data Science Workflows Using ArcGIS Notebooks](#) (2 hrs.) Introduces the process for performing data engineering tasks using ArcGIS Notebooks in ArcGIS Pro.
- [Python for Everyone](#) (3 hrs., 30 mins.) Introduces basic Python concepts and the Python scripting environment in ArcGIS.
- [Spatial Data Science with Notebooks in ArcGIS Pro](#) (Video, 62 mins.) Focus on using notebooks to support spatial data science workflows. Shows how to employ existing notebook samples and how prototyping in notebook cells helps analysis and automation workflows.
- [Introduction to ArcGIS API for Python](#) (Video; 32 mins.) Introduces spatial capabilities in ArcGIS API for Python. Describes the organization of modules and objects in the API.

### Related Learning Plan

- [ArcGIS Notebooks Fundamentals](#)

## Scripting with ArcGIS and Python

The following courses and tutorials guide students through creation of Python scripts for common spatial data workflows. The descriptions indicate which solution is used: ArcGIS Pro/ArcPy, ArcGIS API for Python, or both.

- [ArcGIS API for Python: An Introduction to the Modules](#) (Video; 43 mins.) Covers working with feature and imagery layers, geocoding, directions analysis, geoenrichment, and more.
- [ArcGIS API for Python for Analysts and Data Scientists](#) (Video; 53 mins.) Explains how to tap into the geospatial component of big data to analyze and visualize spatial patterns to solve problems.
- [Scripting for Geoprocessing Workflows](#) (3 hrs., 30 mins.) Create Python scripts using desktop GIS and ArcPy. Teaches a common scripting workflow and how to set geoprocessing environments, access data for automation, choose a cursor, get parameter values, and create a tool.
- [Creating Python Scripts for Raster Analysis](#) (1 hr.) Uses the Python window in ArcGIS Pro and the ArcPy raster object class to solve a spatial problem.
- [Update Real Time Data with Python](#) (Tutorial; 1 hr., 50 mins.) Shows how to create a Python feed routine in ArcGIS Pro to automate GIS data layer updates. Uses ArcGIS API for Python to update an online feature service.
- [Performing Analysis Using ArcGIS API for Python](#) (1 hr., 35 mins.) Introduces analysis capabilities available in the API and demonstrates the process for integrating them into apps.
- [Accessing Data in a Portal Using ArcGIS API for Python](#) (1 hr.) Teaches accessing data from a portal using the API so that you can integrate spatial data into your Python apps.

### Related Learning Plans

- [ArcPy Essentials](#)
- [ArcGIS API for Python Fundamentals](#)

## R-ArcGIS Bridge

ArcGIS provides a set of statistical cluster analysis tools that allow you to specify each parameter in your analysis. The following courses present concepts and skills needed to use the various tools. (Get an overview of [R-ArcGIS Bridge](#).)

- [Using the R-ArcGIS Bridge](#) (2 hrs.) Shows how to load spatial data into an R workspace to perform statistical analysis using the R-ArcGIS bridge.
- [Integrating R Scripts into ArcGIS Geoprocessing Tools](#) (1 hr.) Teaches how to apply a workflow to create a geoprocessing script tool that uses the capabilities of R.

- [Analyze Crime Using Statistics and the R-ArcGIS Bridge](#) (Tutorial; 2 hrs.) Uses ArcGIS Pro to explore temporal trends and hot spots, plus functions in R to perform statistical analysis.

**Related Learning Plan**

- [R-ArcGIS Bridge Essentials](#)

## CAPABILITIES

### Pattern detection

ArcGIS provides a set of statistical cluster analysis tools that allow you to analyze where clusters exist. The following courses present concepts and skills needed to use these tools.

- [Mapping Clusters: Introduction to Statistical Cluster Analysis](#) (50 mins.) Provides foundational skills and concepts required to begin cluster analysis and interpret results. Uses the Hot Spot and Cluster And Outlier Analysis tools.
- [Mapping Clusters: Optimized Hot Spot and Optimized Outlier Analysis](#) (2 hrs.) Teaches two tools that use your data to define analysis parameters and allow you to refine analysis decisions.
- [Mapping Clusters: Hot Spot and Cluster and Outlier Analysis](#) (1 hr., 20 mins.) Introduces the Hot Spot Analysis (Getis-Ord  $G_i^*$ ) tool and the Cluster And Outlier Analysis (Anselin Local Moran's I) tool and explains how they help you control your analysis.
- [Machine Learning Explained: Finding Clusters](#) (Video; 53 mins.) Illustrates how clustering algorithms work, how to interpret results, and how and when to apply these methods.

**Related Learning Plan**

- [Identifying Clusters Using ArcGIS](#)

### Space-time analytics

The following offerings teach methods to extend statistical cluster analysis to find patterns across both space and time.

- [Introduction to Space-Time Analysis](#) (25 mins.) Describes space-time analysis and its capabilities.
- [Creating a Space Time Cube](#) (40 mins.) Describes components of a space-time cube, which is the foundation of space-time analysis, and teaches how to create one.
- [Space-Time Analysis: Finding Temporal Trends](#) (2 hrs., 10 mins.) Explains how to perform emerging hot spot analysis to pinpoint trends and visualize them using space and time.
- [Space-Time Analysis: Time-Series Clustering](#) (1 hr.) Explores ways to analyze temporal data by clustering locations based on the similarity in the characteristics of their time series.
- [Analyzing Traffic Accidents in Space and Time](#) (Story Map) Presents a workflow that uses spatial statistics to analyze crashes in space and time along a road network. Includes link to tutorial.
- [Identifying Popular Places with Spatiotemporal Data Science](#) (Tutorial; 1 hr., 45 mins.) Includes how to aggregate data, detect spatial and temporal clusters, and create a space-time cube. Analyze emerging hot spots to identify where to locate a new business.

**Related Learning Plan**

- [Identifying Clusters Using ArcGIS](#)

## Predictive analytics

The following offerings teach ArcGIS Pro interpolation workflows to create prediction surfaces.

- [Introduction to Regression Analysis Using ArcGIS Pro](#) (3 hrs.) Introduces regression analysis concepts and teaches how to create a properly specified regression model.
- [Spatial Interpolation with ArcGIS Pro](#) (Training Seminar; 1 hr.) Discusses uncertainty related to predicted values. Explains how to use the Geostatistical Wizard and apply kriging techniques.
- [Geostatistical Interpolation: Introduction](#) (1 hr., 40 mins.) Explains key geostatistical interpolation concepts. Shows how to use ArcGIS Pro to evaluate associated data assumptions.
- [Geostatistical Interpolation: Using Empirical Bayesian Kriging and EBK Regression Prediction](#) (3 hrs., 45 mins.) Explains how ArcGIS Pro automates the most difficult aspects of building a valid kriging model. Shows how to perform exploratory spatial data analysis. Teaches how to create prediction surfaces and cross-validate the results.
- [Geostatistical Interpolation: Reaggregating Data Using Areal Interpolation](#) (3 hrs., 45 mins.) Teaches the two main use cases of areal interpolation, which applies kriging theory to data averaged or aggregated within polygons: downscaling a source polygon dataset and using the prediction surface to fill in missing polygon data.
- [Geostatistical Interpolation: Creating a 3D Prediction Surface](#) (3 hrs., 20 mins.) Teaches how to interpolate 3D point datasets using Empirical Bayesian kriging 3D (EBK 3D).
- [Downscale Climate Data with Machine Learning](#) (Tutorial; 4 hrs.) Set up a Conda environment; build a regression model; use Jupyter Notebook and Python to automate temperature estimation; and create a time series mosaic and use R to analyze data.
- [Model Water Quality Using Interpolation](#) (Tutorial; 1 hr., 20 mins.) Explore data using histograms and line charts, interpolate data in ArcGIS Pro, and assess interpolation results.

### Related Learning Plan

- [Interpolating Surfaces Using ArcGIS](#)

## Suitability modeling

These offerings teach spatial tools and methods that can be used to solve suitability problems such as finding the best location, allocating resources effectively or minimizing costs.

- [Suitability Modeling: Introduction](#) (2 hrs., 40 mins.) Teaches how to define a problem in terms of an analysis goal and suitability criteria, plus how to prepare data for a suitability model.
- [Suitability Modeling: Creating a Weighted Suitability Model](#) (4 hrs., 15 mins.) Learn to create a weighted suitability model. Learn to use sensitivity and error analysis to evaluate results.
- [Suitability Modeling: Creating a Simple Suitability Model](#) (2 hrs., 35 mins.) Learn to create a suitability model that produces an easy-to-interpret binary result.
- [Shade equity - Determine tree planting locations with suitability analysis](#) (Tutorial, 1 hr., 30 mins.) Follows a scenario-driven workflow to explore data, prepare data for analysis, and model tree planting priorities. Uses ArcGIS Pro, Spatial Analyst extension, and Business Analyst Desktop.

### Related Learning Plan

- [Finding the Best Place](#)

You might be interested in the [Spatial Statistics Resources](#) page from the Esri Spatial Statistics team.

## Multidimensional data

These offerings teach voxels, a data type that Esri introduced with ArcGIS Pro 2.6. Voxels are used to visualize multidimensional data, with application in atmospheric, oceanic, and geological sciences.

- [Displaying Raster Data in ArcGIS](#) (3 hrs., 15 mins.) Covers techniques to display and symbolize rasters and imagery, modify raster properties, and apply appearance functions.
- [Creating and Visualizing Voxel Layers in ArcGIS](#) (Video; 35 mins.) Discusses workflows to create voxels, the use of voxel data in ArcGIS Pro, and shows examples of applications.
- [Explore and Animate Geological Data with Voxels](#) (Tutorial; 1 hr.) Introduces the voxel layer's visual analytics capabilities, specifically for discrete data, using soils voxels for the Netherlands.
- [Visualize Ecological Marine Units with Voxels](#) (Tutorial; 1 hr.) Teaches how to create a NetCDF file from a global EMU point feature class and visualize it in 3D as a voxel layer in ArcGIS Pro.
- [Working with NetCDF Data in ArcGIS Pro](#) (2 hrs.) Teaches how to incorporate NetCDF format scientific data and models into common GIS workflows.

## Deep learning (AI with imagery)

Deep learning functionality in ArcGIS enables you to easily create map layers extracted from imagery. These offerings teach why and how to use different tool options. (Get overviews of ArcGIS [Machine Learning and AI](#) and [Analysis with AI](#) capabilities. You may be interested in the [Higher Ed Guide to Esri E-Learning for Imagery and Remote Sensing](#).)

- **[Imagery in Action \(MOOC; 6 weeks; Check website for class dates\)](#)** Explores cutting-edge imagery applications and workflows using ArcGIS Pro, ArcGIS Online, and ArcGIS Image Analyst.
- [Introduction to Image Classification](#) (1 hr., 15 mins.) Introduces options for creating thematic classified rasters in ArcGIS.
- [ArcGIS Deep Learning Tools for Imagery](#) (Training Seminar; 1 hr.) Explores the deep learning capabilities of ArcGIS. Shows a workflow to create a land-cover map using ArcGIS Notebooks.
- [Performing Supervised Pixel-Based Image Classification](#) (1 hr., 20 mins.) Introduces the supervised pixel-based image classification technique for creating thematic classified rasters.
- [Performing Unsupervised Pixel-Based Image Classification](#) (55 mins.) Teaches how to identify computer-created pixel clusters to create thematic classified rasters in ArcGIS.
- [Performing Supervised Object-Based Image Classification](#) (1 hr., 15 mins.) Introduces how to classify images based on user-identified objects or segments, paired with machine learning.
- [Performing Accuracy Assessment for Image Classification](#) (50 mins.) Shows how to test raster data products using statistical analysis to understand how well they represent the study area.
- [Unlocking Information from Imagery in ArcGIS](#) (Story Map) Shows how to use imagery workflows and deep learning for efficient, action-oriented problem solving.
- [Using Deep Learning with Imagery in ArcGIS](#) (Video; 42 mins.) Explores using ArcGIS Pro to extract information from remotely sensed imagery and introduces ArcGIS Image Server.
- [Deep Dive into Deep Learning](#) (Video; 45 mins.) Features demos that explore deep learning, how it can be applied to GIS, and types of geospatial deep learning models.

### Related Learning Plans

- [Image Classification Using ArcGIS](#)
- [Deep Learning Using ArcGIS](#)

### Notes

- You can view lists of new training, training pending retirement, and retired training on the [New and Retired Training Options](#) page. You will receive a message when retirements are announced. (Click View Messages while signed in to Training.)
- If you plan to assign a MOOC to a group of students or to an entire class, please review the following resources:
  - For students: [Get Ready for an Excellent MOOC Experience](#)
  - For instructors: [Assigning an Esri MOOC to Students](#)
- To request a transfer of training history from an institutional account to another account, students should contact Esri Customer Service at [service@esri.com](mailto:service@esri.com) or (888) 377-4575.