FLORIDA POLYTECHNIC UNIVERSITY

# Faculty Instruction Projects

## Grant Application Cover Page

PROPOSAL TITLE: **Advancing STEM Education through Geographic Information System (GIS)**


**FACULTY NAME**:

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DEPARTMENT: Environmental Engineering

**ADDITIONAL FACULTY TEAM MEMBERS**:

NAME: Sravani Vadlamani, PhD

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DEPARTMENT: Data Science & Business Analytics

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**PROJECT SUMMARY / ABSTRACT:** (limited to 300 words)

Existing research has shown the benefits of Geographic Information Systems (GIS) in improving the critical thinking and problem-solving abilities in both K-12 and undergraduate students. Much of the STEM research focuses on the design and implementation of programs and technologies but there is limited focus on the role of spatial thinking and inquiry based learning. This project aims to advance STEM education by utilizing GIS as an instructional tool in classes in Environmental Engineering and Data Science & Business Analytics (particularly Intelligent Mobility concentration) majors. Students are expected to enhance their analytical skills and improve their procedural knowledge including critical thinking, spatial reasoning, problem identification, model development, and proposing solutions. ArcGIS software will be introduced to both environmental engineering classes (i.e., ENV 3957 Environmental Sensing and ENV 4941/4943 Engineering Design Senior Capstone I and II) and business analytics classes (i.e., ESI 4513 Intelligent Mobility, ESI 4011 Data Analytics for Smart Cities & Transportation, and IDC 4942/IDC 4943 Data Analytics Capstone I & II). The GIS component will be introduced using the problem-based learning (PBL) approach that is guided by questions on data collection, quantitative analysis, and decision making. The students will be trained to design their projects, collect geospatial data, conduct spatial analysis, create maps and visualizations, and document and present results. In addition, freshmen and sophomore students (e.g., IDS 1380 Intro to STEM and EGN 1007 Concept & Methods courses) will be invited to the GIS-based project presentations to enhance awareness and motivate technology use. We will measure how the students benefitted from the software through assessments and feedback surveys and the results will be disseminated in the form of a final report. Students will gain invaluable experience of engaging in hands-on activities and exposure and familiarity to new software, aligning with the university's mission.

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# RESEARCH/PROJECT PLAN

Please refer to the separate attachment for a detailed project plan.

# Budget

## Budget Overview

| Category | Subtotal | Anticipated date needed |
|---|---|---|
| Supplies/ Equipment | $ 2000 | Fall 2021 |
| Payment for Services | $ | |
| Miscellaneous | $ | |

Total requested budget: $2000

## Supplies / Equipment

| Item | Amount | Anticipated date needed |
|---|---|---|
| ESRI ArcGIS Large Academic Bundle (1-100 users) for 2 years | $1000/year | Fall 2021 |
| | $ | |
| | $ | |

Supplies / Equipment subtotal: $2000

Provide a justification of the items listed above, including a statement of purpose and how the amount was determined .

ESRI offers a large academic bundle which allows concurrent use of the software for up to 100 users. This software costs $1000/year and we are requesting for a two-year subscription. The quote and relevant documentation obtained from ESRI is attached.

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Signature of all applicants below certifies the statements in the application are true, complete, and accurate to the best of her/his/their knowledge. All faculty applicants agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if a grant is awarded as a result of this application.

a) Faculty Applicants

Xiaofan Xu Xiaofan Xu Date 4/14/2021

Sravani Vadlamani Sravani.V Date 04/14/2021

Date

b) Department Chair or Division Director Signature

Mary B. Vollaro Date 4/15/2021

# Esri Academic Department License Pricing

Attachment: ESRI ArcGIS License Pricing (see Page 2 to find the price for Large Academic Department License)

The Esri Academic Department License provides affordable access to ArcGIS Online, ArcGIS Pro, ArcGIS Enterprise, and over a dozen mobile apps. ArcGIS is the mapping and analytics platform for gaining greater insights and making better decisions. Used by thousands of universities in hundreds of disciplines, ArcGIS provides a suite of apps for data collection,



## Small Academic Department License (up to 5 users)

- Visualize, analyze, and manage data for learning and research
- Combine your own data with ArcGIS Living Atlas of the World data
- Access self-paced e-Learning lessons on the Esri Training site

Hide description

The ArcGIS platform is used by thousands of organizations worldwide to make business decisions, deliver government services, protect natural resources, and keep people safe. Learning with ArcGIS gives graduates a competitive edge in many fields.

The Small Academic Department License enables research teams to collaborate in the field or in the lab. With both cloud-based and on-premises solutions, scholars can work on any device anytime, anywhere, to map, analyze, and publish information.

View system requirements
View supported languages

What's Included

- ArcGIS Online with the GIS Professional Advanced user type
- The most popular ArcGIS Pro extensions
- ArcGIS Enterprise Advanced
- Apps for the field and for the office:
  - ArcGIS Collector, ArcGIS Survey123, ArcGIS StoryMaps, ArcGIS Maps for Office, ArcGIS Maps for SharePoint, and many more
- Premium apps for focused workflows, including the following:
  - ArcGIS Business Analyst, ArcGIS Community Analyst, and ArcGIS Insights
- 5 user licenses

Qty − 1 + $250/yr

Add to cart

## Medium Academic Department License (up to 50 users)

- Visualize, analyze, and manage data for learning and research
- Combine your own data with ArcGIS Living Atlas of the World data
- Access self-paced e-Learning lessons on the Esri Training site

Hide description

The ArcGIS platform is used by thousands of organizations worldwide to make business decisions, deliver government services, protect natural resources, and keep people safe. Learning with ArcGIS gives graduates a competitive edge in many fields.

The Medium Academic Department License supports up to 50 users for learning and research, and it can be used in a campus computer lab or on faculty's and students' own devices. With both cloud-based and on-premises solutions, scholars and students can work on any device anytime, anywhere, to map, analyze, and publish information.

View system requirements
View supported languages

What's included

- ArcGIS Online with the GIS Professional Advanced user type
- The most popular ArcGIS Pro extensions
- ArcGIS Enterprise Advanced
- Apps for the field and for the office:
  - ArcGIS Collector, ArcGIS Survey123, ArcGIS StoryMaps, ArcGIS Maps for Office, ArcGIS Maps for SharePoint, and many more
- Premium apps for focused workflows, including the following:
  - ArcGIS Business Analyst, ArcGIS Community Analyst, and ArcGIS Insights
- 50 user licenses

Qty − 1 + $500/yr

Add to cart

**Large Academic Department License (up to 100 users)** <----

- Visualize, analyze, and manage data for learning and research
- Combine your own data with ArcGIS Living Atlas of the World data
- Access self-paced e-Learning lessons on the Esri Training site

Hide description

The ArcGIS platform is used by thousands of organizations worldwide to make business decisions, deliver government services, protect natural resources, and keep people safe. Learning with ArcGIS gives graduates a competitive edge in many fields.

The Large Academic Department License supports up to 100 users for learning and research and can be used in a campus computer lab or on faculty's and students' own devices. With both cloud-based and on-premises solutions, scholars and students can work on any device anytime, anywhere, to map, analyze, and publish information.

View system requirements
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What's Included

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- Premium apps for focused workflows, including the following:
  - ArcGIS Business Analyst, ArcGIS Community Analyst, and ArcGIS Insights
- 100 user licenses

Qty − 1 + $1,000/yr

Add to cart

# Frequently asked questions

Show All

What resources are available to help me get started with ArcGIS Online?

PROPOSAL TITLE: Advancing STEM Education through Geographic Information System (GIS)

APPLICANTS: Xiaofan Xu, Sravani Vadlamani

## RESEARCH/PROJECT PLAN

### Introduction

Research has indicated consensus among academia and industry practitioners for the need of a broader strategy for science, technology, engineering, and mathematics (STEM) education. This strategy is specifically expected to coordinate all the STEM disciplines and promote diverse education that includes deep technical and problem-solving skills (Bybee, 2010). To date, most research on STEM participation focuses on the design, implementation, and evaluation of programs or technologies. In the U.S., higher education in STEM lacks a cohesive understanding in regards to system-level analysis and spatial-dimensional thinking (Kelly and Knowles, 2016). The role of geography in the education of spatial thinking, inquiry-based learning, environmental education, and civic engagement was found to be significantly necessitating the need to incorporate geographical approaches and geospatial thinking into STEM education (Oyana et al., 2015).

Geographic Information System (GIS) is a framework for gathering, managing, and analyzing data based on the science of geography. GIS reveals deeper insights into data, such as patterns, relationships, and situations, engaging critical elements and helping scientists and engineers make smarter decisions. GIS technology has been widely adopted in the studies of environmental impacts, engineering economy, climate change, geospatial modeling, system-level design, software development, etc. For instance, as the intelligent mobility options and smart city transformations continue to evolve, advanced geospatial technologies are required and GIS is crucial to paving the way for autonomous vehicles. GIS is considered an excellent solution to promote the spatial thinking ability and big picture vision of STEM students.

This project aims to advance STEM education by utilizing GIS as an instructional tool. We will incorporate GIS technology in environmental engineering and data science and business analytics (particularly intelligent mobility concentration) classes as case studies. Students are expected to enhance their analytical skills and improve their procedural knowledge including critical thinking, spatial reasoning, problem identification, model development, and proposing solutions. The GIS component will be introduced using the problem-based learning (PBL) approach that is guided by questions on data collection, quantitative analysis, and decision making. The junior/senior students in environmental engineering and business analytics will be trained to utilize ArcGIS software to visualize analyses in their class projects. The outcomes from the class include both formal project reports and presentations. These project presentations will be open to freshman and sophomore students and serve as a source of inspiration to the

future leaders in the STEM community. In addition, a post-event survey will be conducted to the GIS class students to collect their responses to GIS benefits and challenges.

## Literature Review

Existing research has indicated the positive impact of GIS in STEM education. Baker (2014) demonstrated the benefits of GIS in STEM learning through the field studies of GIS in architecture design, trail and park exploration, community street light planning, air quality modeling, sound mapping, stream monitoring. He suggested great GIS opportunities for STEM college students in terms of data analysis, spatial thinking, project-based learning, and STEM skills. Shiau et al. (2018) investigated the factors influencing the innovation diffusion of GIS-based OpenStreetMap (OSM) in STEM education by defining an analytic framework based on innovation diffusion theory and the technology acceptance model. The study highlights the ease of use, observability, and compatibility of OSM, which influence STEM students' perception of the usefulness of the technology, their perceived attitude towards it, and their intention to continue the use of GIS.

Jant et al. (2020) studied the use of GIS for problem-solving by comparing the 53 high school seniors in AP Physics and AP History. The results show an improvement in spatial thinking and problem solving in the AP Physics class across the school year in contrast to comparison group (i.e., AP History class), suggesting that GIS-based instruction can enhance students' use of spatial reasoning when solving STEM-relevant problems.Ercan et al. (2016) conducted qualitative research evaluating a sample of junior science teacher candidates in a STEM educational setting using GIS. It is found that a four-week long teaching intervention had a positive effect on the science teacher candidates' views of implementing STEM as well as improving their views on and awareness of GIS.

All the previous studies have confirmed the positive impact of GIS in STEM education. However, more relevant data on the impact and wider STEM disciplines for GIS involvement are needed, which could be the contribution from this project.

## Methodology

This project requests funding for ArcGIS software licensing that will be primarily used for classroom instruction. ArcGIS software will be introduced to both environmental engineering classes (i.e., ENV 3957 Environmental Sensing and ENV 4941/4943 Engineering Design Senior Capstone I and II) and business analytics classes (i.e., ESI 4513 Intelligent Mobility, ESI 4011 Data Analytics for Smart Cities & Transportation, and IDC 4942/IDC 4943 Data Analytics Capstone I & II). The students will be trained to design their projects, collect geospatial data, conduct spatial analysis, create maps and visualizations, and document and present results. In addition, freshmen and sophomore students (e.g., IDS 1380 Intro to STEM and EGN 1007

Concept & Methods courses) will be invited to the GIS-based project presentations to enhance awareness and motivate technology use.

Two types of data will be gathered to validate the effectiveness of GIS in STEM education from the students' performance and response. First, the overall course performance of the students in the school year of their GIS-involved classes will be compared to the students' performance in the past years to evaluate if GIS can improve learning in general STEM classes. Second, a post-event survey will be conducted to collect students' subjective responses of their favorability of GIS, benefits from GIS learning, and willingness to continue learning GIS. The survey data will be statistically analyzed to determine the effectiveness of the software use. A report of the findings from this project will be submitted.

**Project Evaluation/Assessment Plan**

The proposed instructional activities will create an educational environment by providing exposure to a new technology tool and its application methods. The learning outcomes accosciated with this project listed in the table below are intended to fill the gap of incorporating geospatial thinking and approaches into STEM education.

| **Project Learning Outcome** | **Learning Level** | **Program Learning Outcome** |
|---|---|---|
| a. Students will understand the mechanism and application of GIS. | **Knowledge** – ability to recall previously learned material<br>**ABET Assessment** – homework, group project | ABET 1 – an ability to identify formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. |
| b. Students will learn how to apply GIS method to solve problems and deliver results. | **Application** – ability to use learned material in new situations.<br>**ABET Assessment** – homework, group project | ABET 1 – an ability to identify formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.<br>ABET 6 - an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. |
| c. Students will identify, formulate, and solve problems in groups and present the solutions formally. | **Comprehension** – ability to grasp meaning, explain, and restate ideas<br>**ABET Assessment** – group project | ABET 5 - an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives. |

We will measure how the students benefitted from the tool through several methods:

1. Evaluation: The class project reports and presentations will be assessed by the course instructors for all the courses included in this project. These projects will focus on the incorporation of geospatial analytical tools and techniques to aid in informed decision making. This evaluation will be done based on a rubric developed for this purpose and the desired level of achievement is 70% or higher.
2. Feedback survey: We will solicit feedback from the students about their learning experience, attitudes towards GIS, benefits, and willingness to continue learning and applying GIS in future courses and projects. These attitudinal survey questions will be on a 1-10 Likert scale and will also include open-ended questions to gauge the effectiveness and assess improvements for the future.

The assessments will be conducted for every course that uses GIS in the duration of the project and at least 70% of the student body are expected to be benefitted from this project.

**Timeline for the Project**

| Task | Timeline |
|---|---|
| Activities design and planning | July – August 2021 |
| Instructional software use | Fall 2021/2022, Spring 2022/2023 |
| Data analysis and assessment | Summer 2022/2023 |
| Final report deliverable | Summer 2023 |

**Broader Impacts**

The project aligns well with the departments' and university's mission of project-based learning. This project will expose students to problem-solving and analysis approaches using geographic information systems. Students will gain invaluable experience of engaging in various hands-on activities using the spatial software. Although the projects will be focused on environmental engineering and intelligent mobility applications, the approaches are scalable and adaptable to other domains and disciplines.

**Project Team**

Dr. Xiaofan Xu is an Assistant Professor in Environmental Engineering at Florida Polytechnic University. He obtained his PhD in Environmental Engineering from the University of South Florida and MS in Environmental and Urban Geosciences from the University of Missouri-Kansas City. He is the PI for this project and has prior experience with the use of GIS in research and teaching.

Dr. Sravani Vadlamani is an Assistant Professor in Data Science & Business Analytics at Florida Polytechnic University. She obtained her PhD in Civil Engineering and two Master's in Civil Engineering and Geographic Information Systems (GIS) from Arizona State University. She is the Co-PI for this project and has prior experience with the use of GIS in teaching.

## References


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