Teaching Students to Apply Geographic Information Systems to Real-world Problems

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Scientia

TEACHING STUDENTS TO APPLY GEOGRAPHIC INFORMATION SYSTEMS TO REAL-WORLD PROBLEMS

Tools used to analyze agricultural systems, quantify natural resources, and identify sustainable agricultural processes and resource management solutions have evolved considerably in recent years. Many current tools utilize data gathered by geographic information systems, which collect and combine data from different disciplines. **Dr. Chastity Bradford**, Head of the Biology Department at Tuskegee University, has been involved in a project that introduces students to geographic information systems, teaching them how to apply such systems in multi-disciplinary research focusing on food, agriculture, health and natural resources.

Geographic Information Systems

Today, researchers working in different fields have access to a wide range of technologies and analytical tools, including machine learning algorithms, data visualization techniques, and predictive modelling methods. These innovative, advanced tools are designed to analyze pools of existing data to make reliable predictions, build visualizations and learn more about a particular topic of interest.

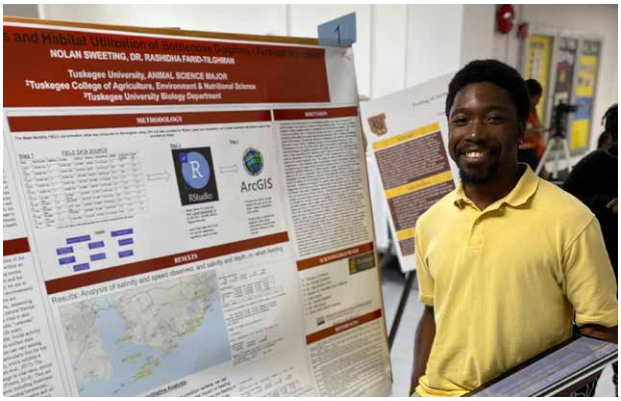
Among the fields that benefit from such technological advancements and data analysis methods are agriculture, food production, and natural resource management. In these contexts, new technologies are helping scientists to sustainably manage the natural resources available on Earth, and to improve agricultural processes so that they are less harmful to the environment.

Geographic information systems (GISs) are highly effective for conducting research focusing on agriculture, food, and natural resources. A GIS is essentially a computer system that can detect, capture, store, and display rich geographical information, such as mapping the layout of urban and natural environments. The most well-known GIS platform is arguably Google Maps, yet many other similar systems exist and are used by scientists every day.

Teaching Students How to Use GISs

The climate on Earth is changing rapidly and humanity now faces numerous challenges associated with natural disasters, food and water shortages, health risks, limited natural resources, and growing urbanization. GISs are proving to be highly valuable for tackling these challenges, as they allow scientists to better understand the spatial patterns underlying them, the geography of specific regions, and natural resources available.

As GIS platforms are now widely used in research settings worldwide, students graduating in agricultural, environmental, and human sciences could greatly benefit from knowing how to apply them to their studies. Dr. Chastity Bradford, Head of the Biology Department at Tuskegee University, has developed a program aimed at teaching students from underrepresented minority groups how GIS platforms can be used to conduct research focusing on food, agriculture, health, and natural resources.



The new program is called Discovering FACTs (Food and AgriCultural Tools), which Dr. Bradford created in collaboration with her colleague Olga Bolden-Tiller. A key objective of Discovering FACTs is to provide engaging, hands-on experiences for students at Tuskegee University, allowing them to familiarize themselves with GISs.

GISs are incorporated into every summer project proposed. Participants will be trained, certified, and eligible for a 12-month license after completion of the Discovering FACTS summer course and applied-research experience.

The GIS Training Course is led by GIS expert faculty, Dr. Souleymane Fall and Dr. John Meyers. Students learn GIS concepts, basic theoretical concepts, computer cartography, database systems, getting maps into digital form, and geocoding, while also becoming familiar with Arc-GIS software. Ultimately, by increasing the students' understanding of GISs and their possible applications in research settings, the team hopes to better prepare them for further post-graduate studies and workplace experiences.

The program is designed to improve the self-efficacy, grit, creativity, and professional resilience of STEM undergraduates or recent graduates. In addition, it aims to strengthen the students' sense of community, training them to collaborate with fellow scientists and with experts in other fields.

A 10-Week Research Program

Discovering FACTs is part of a series of projects known as Research and Extension Experiences for Undergraduates. These projects aim to create immersive experiences for undergraduate students, allowing them to take part in multi-disciplinary research studies and learn how to make the best use of modern technologies.

"Our team of investigators at Tuskegee University is composed of excellent faculty equipped and prepared to train the next generations of leaders," says Dr. Bradford. "Participants will join one of seven labs proposed to embark upon their GIS Applied-Research Experience. The Lab component of the training will allow students to use GIS software to explore, create, process, analyze spatial data and complete projects."

Some examples of student projects include "Precision Farming and Disease Management for Small-Scale Farmers", "Lemongrass-Infused Biodegradable Plastic" and "Epigenetic Modifications of G-Protein Coupled Estrogen Receptor Expression in Health".

"The goal of Discovering FACTs is to immerse students in investigation directed by a co-mentoring team comprised of energetic and productive faculty, who serve as minority science mentors," says Dr. Bradford. "To achieve this goal, we engage rising sophomores, juniors and seniors in a 10-week research and extension immersion in food, agriculture, natural resources and human sciences with GIS subthemes, with the goals of increasing the number of underrepresented individuals in this area in preparation for the workforce including positions that require a PhD."

The Discovering FACTs program offers students the opportunity to take part in 10 weeks of on-site research rooted in different disciplines, including agriculture, natural resource management, biology, and chemistry. During these 10 weeks, participants receive a stipend of $450 per week, as well as free accommodation. While conducting their studies, the students are taught how to use GIS technologies to integrate and analyze research data. In addition, they are offered the opportunity to participate in valuable career development activities.

The program targets rising juniors, seniors and outstanding sophomores majoring in different STEM subjects, with grade point averages of above 3.0. Dr. Bradford and Dr. Bolden-Tiller hope that their project will also contribute to increasing diversity in STEM fields. When advertising the program, therefore, they particularly targeted women and students at minority-serving institutions, including Fort Valley State University, Alabama State University, Florida Agricultural and Mechanical University, Prairie View A&M University, and Alabama A&M University.

Immersive Laboratory Experiences

During the first week of the 10-week program, participating students receive research-specific training, to ensure that they are equipped with the skillset necessary to conduct their multi-disciplinary experiments. In the following eight weeks,

the students spend most of their days in research laboratories, collaborating with their mentors and other students in their research groups.

Every two weeks, the students complete a progress report explaining what they achieved so far, and these reports are then signed by their mentors. The program participants are also asked to attend a one-hour application course called "Introduction to GIS" one day of every week, as well as other seminars, social events, workshops, and group discussions.

During the research process, the students learn to use GIS systems to collect and analyze data related to the geographic distribution patterns of food, farms, natural resources, health hazards, and other factors. In addition to their hands-on research projects, participating students take part in an agricultural extension initiative aimed at educating farmers, agricultural professionals, and other stakeholders about sustainable practices and the use of GIS platforms.

Extension Training

The agricultural extension component of the Discovering FACTs program builds on an existing program offered at Tuskegee University, as part of the university's Cooperative Extension Program and work by the Carver Integrative Sustainability Centre. The goal of this component is to teach undergraduates about the importance of extension initiatives, which are aimed at disseminating valuable scientific information and practices among specific communities.

In the context of the Discovering FACTs program, students engage with different extension professionals working on community development, consumer science, youth development, environmental sustainability projects, or specialized in the management of small sustainable farms, forests, ranch settings, natural resources, or food systems. They also attend luncheons to engage with Extension Agents. This allows the students to learn more about opportunities in their field of study and how they can apply their new skillset in a real-world setting.

Preparing the STEM Workforce of Tomorrow

So far, the program devised by Dr. Bradford's team has proved to be a very promising and beneficial initiative. It has allowed several undergraduates and recent graduates, many of whom are from cultural backgrounds that are underrepresented in STEM fields, to become better acquainted with GIS platforms within real and multi-disciplinary laboratory settings.

In the future, the team plans to publish the results of their ongoing project evaluation, which assesses the benefits and limitations of their program more in-depth. Their project evaluation will entail the analysis of survey and interview data collected at the beginning, during, and at the end of the 10-week research and learning experience. These interviews and surveys allow the team to collect feedback from students, mentors, and program administrators on each of the components and learning experiences in the program. They also explore the impact that these experiences had on the students' skills, development, sense of community, and confidence.

In addition, Dr. Bradford and her colleagues plan to track the progress of all students who took part in the program, to learn whether it positively affected their professional skillset and career trajectories. This will be done through social media and online, by tracking the program participants' publications, presentations given, conferences attended, and other professional achievements.

Ultimately, programs like Discovering FACTs play a crucial role in ensuring that new generations of scientists are well-equipped to join the STEM workforce and to collaborate with others to tackle the complex climate, environmental, and public health-related challenges of our times. The work by Dr. Bradford and her colleagues could thus also serve as a valuable inspiration for other educators and academics worldwide, perhaps paving the way towards the development of similar hands-on training programs.

Meet the researchers

Dr. Chastity N. (Mc Rae) Bradford
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Dr. Chastity Bradford is Head of the Biology Department and an Associate Professor of Biology at Tuskegee University. She holds a PhD in Cellular and Molecular Physiology from University of Alabama at Birmingham and a BS in Biology from Spelman College. She was a Howard Hughes Faculty Fellow/Postdoctoral Associate in the department of Physiology and Functional Genomics at the University of Florida's College of Medicine. Dr. Bradford worked as a Visiting Professor at the Temple University Cardiovascular Research Center. She has been devising community-targeted health initiatives and academic projects aimed at increasing diversity in STEM. She focuses on discovering culture-tailored non-pharmacological intervention strategies that aid blood pressure control in rural Black Belt counties. She has trained PhD candidates, Master's students, undergraduates, and K-12 teachers. Over the course of her career, Dr. Bradford has carried out extensive research focusing on the role of the renin-angiotensin-system in cardiovascular remodeling and hypertension. She is now the Project Director of a program aimed at training students to use Geographical Information Systems to solve real-world challenges, funded by the USDA/NIFA.

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Dr. Olga U. Bolden-Tiller serves as Dean for the College of Agriculture, Environment and Nutrition Sciences at Tuskegee University. She holds a PhD degree in Animal Sciences from the University of Missouri-Columbia, where she matriculated as an USDA-National Needs Fellow. Dr. Bolden-Tiller continued her training at the University of Texas-MD Anderson Cancer Center as an NIH Fellow in Reproductive Biology. In 2005, she joined Tuskegee University as an Assistant Professor. Prior to obtaining her current position, Dr. Bolden-Tiller served as the Coordinator for the Animal, Poultry and Veterinary Sciences Program and Assistant Chair for the Department of Agricultural and Environmental Sciences. Dr. Bolden-Tiller has served as the Director for the NSF funded Integrative Biosciences Research Experiences for Undergraduates program at Tuskegee University and currently directs several summer pre-college programs, including AgriTREK, AgDiscovery, SciTREK, and DiscoveryTREK. In addition to her administrative and teaching duties, Dr. Bolden-Tiller maintains a small, but robust research program that entails elucidating the molecular mechanisms of testicular function in rodents and ruminants.

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