Broadening STEM Curricula and Student Experiences through Multi-Instructor Team Taught Course

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Abstract

A course titled "Advanced Technologies in Agriculture and Environmental Sciences" has been developed by a team of faculty and staff at University of Maryland Eastern Shore (UMES). The course was conceived to develop a broader student base for the "Precision Agriculture" related activities that have been ongoing at UMES for the past few years with support from USDA and NASA. The course has been opened to all Science, Technology, Engineering and Mathematics (STEM) seniors and graduate students on campus. In an effort to diffuse the compartmentalization of knowledge and rigid disciplinary boundaries within academia, the course has been designed to be a multi-instructor team taught course. Faculty and staff from Agriculture, Natural Sciences, Engineering, Aviation Sciences and collaborators from USDA, NASA, and representatives from a local industry involved in "Precision Farming" have worked together to plan and deliver the course. The course content spans over fundamentals of global positioning systems (GPS), yield monitoring, soil testing, variable rate applicators, fundamentals of plant physiology and agronomy, Geographical Information Systems(GIS), statistics and data analysis, aerial imaging and remote sensing, nutrient and watershed management. Significant field work using various field sensors in conjunction with hand held GPS units is integrated with the course. USDA funding for project titled "Environmentally Conscious Precision Agriculture : A Platform for Active Learning and Community Engagement" have supported the course development efforts , as well as internship for selected students during summer and fall to continue experiential learning and research activities initiated during the course offering in spring.

Introduction

The course is an integral part of the USDA funded project at UMES titled " Environmentally Conscious Precision Agriculture : A Platform for Active Learning and Community Engagement". Experiential and active learning (Kolb, 1984) will play a key role in integrating classroom instruction with field work. The field of "Precision Agriculture" lends itself favorably to this learning paradigm and has been adopted in several 1862 Land Grant Institutions (Bates, et. al. 2002; Miles et. al., 2002). Precision Agriculture (Lu et. al., 1997; Pfister, 1998) is a knowledge-based system that enables farmers to apply precise amounts of fertilizers, pesticides, seeds, or other inputs to specific areas where and when they are needed for optimal crop growth. It integrates many advanced engineering technologies (Sudduth, 1999) including GPS receivers; GIS data bases; grid sampling/mapping techniques (Rao and Lee, 2002; Slater, 2000); yield monitors, variable-rate applications(Clark, 1996) and remote sensing imagery (Jurgens, 1997). Potentially, these advanced technologies can improve farm profitability, reduce chemical use, and reduce environmental degradation(Swinton and Lowenberg-De Boer, 1998). Environmental concerns and agricultural needs are of critical importance in the rural setting of UMES and its proximity to the Chesapeake Bay.

AGNR 488/688 & ENVS 488/ MEES 688 : Advanced Technologies in Agriculture and Environmental Sciences – Course Framework

AGNR 488a/688a (cross-listed as ENVS 488g/MEES 688g Advanced Technologies in Agriculture and Environmental Sciences (Credit, 3 Hours) (Lecture, 2 Hours + 2 hours of Lab) : Computer applications involving geospatial information technology in precision crop management. Plant nutrients, Soil Fertility and Soil Sampling, Yield Monitoring, and Yield Mapping, Remote Sensing, Variable Rate Application, Sensors and geolocated information gathering, Environmental Stewardship and environmental monitoring, Data Management, Analysis and Interpretation using appropriate statistics and GIS software Prerequisite : Senior or Graduate standing in any of the STEM disciplines or permission of instructor.

Textbook: Precision Agriculture, Terry Brase, Copyright © 2006 Thomson Delmar Learning
Supplemented by technical articles compiled by the instructors and internet resources.

References:
1. Mastering ArcGIS 2nd Edition, Maribeth Price, McGraw Hill
2. Mathematical Applications in Agriculture, Nina H. Mitchell, Thomson Delmar Learning

Lecture/ Lab: M W 12 noon – 1:50 P.M.

Team Taught: Abhijit Nagchaudhuri, Professor, Engineering and Aviation Science
Lurline Marsh, Professor, Department of Agriculture
Madhumi Mitra, Assistant Professor, Department of Natural Sciences
Tracie Earle, GIS Program Coordinator
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Guest Lecturers (USDA: Craig Daughtry, NASA: Geoff Bland, Farmsite : Scott Quinn)
Field Demonstration/Lecture: Earl Canter assisted by Hazel Russell and Tony Holden

Prerequisites: Senior or Graduate standing in STEM majors or permission of instructors

Course Objectives:

1. Provide students with an overview of the field of "Precision Agriculture" and its impact on yield enhancement and environmental stewardship.
2. Provide students with field demonstration of intelligent device implements used in precision agriculture, remote sensing and environmental stewardship.
3. Provide students with appropriate training in laboratory and field environment so that they are familiar and can use appropriate geospatial information technology, and computer software such as ArcGIS 9.0, Matlab Image Processing/ Matlab Mapping Toolbox, SMS advanced etc. to analyze and interpret vector and raster data that are generated with field studies in "Precision Agriculture and Environmental Stewardship"
4. Involve students in project based learning , teamwork, project report writing and presentation to promote experiential learning with particular emphasis in impacting their ability to work in teams, project planning and execution, and communication skills.

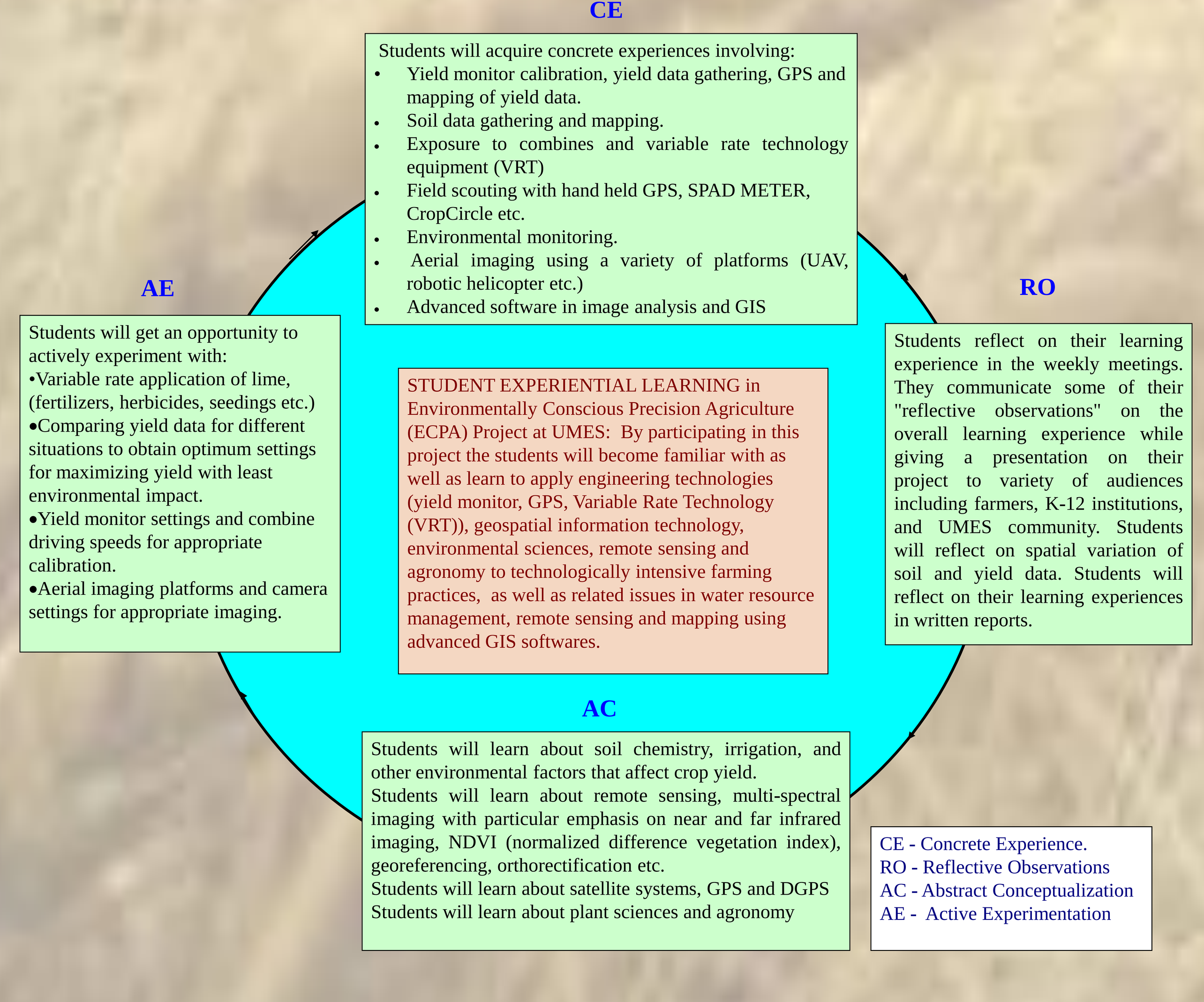


Figure 1: Kolb's Experiential Learning Cycle adapted for the Student Experiential Learning Activity in the ECPA Project

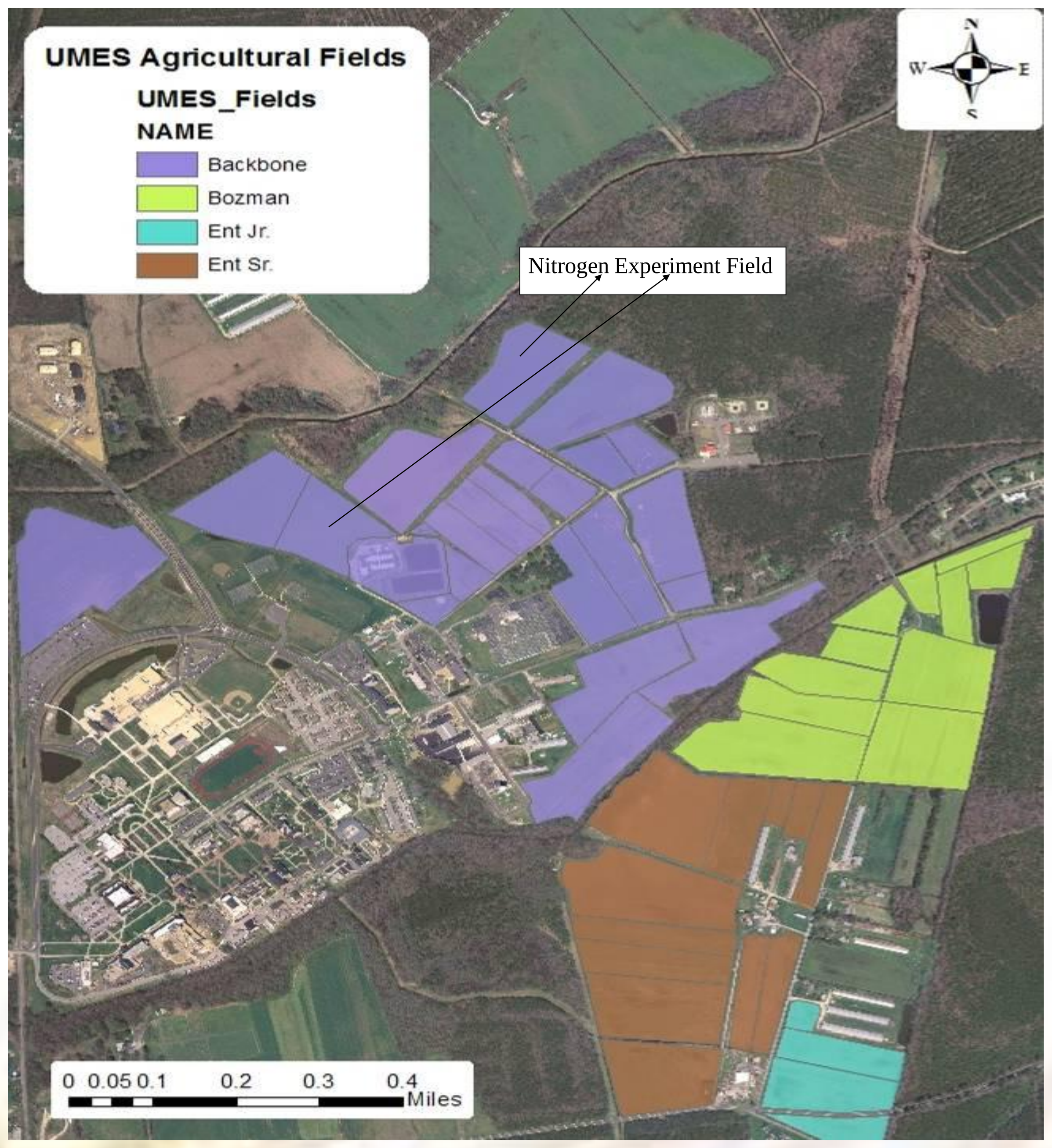
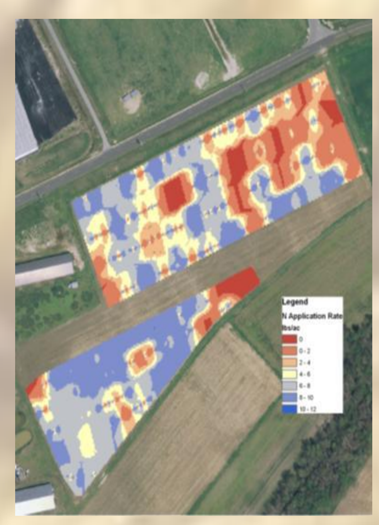


Figure 2 : UMES Agricultural Fields in which experimental plots for fieldwork integrated in the course has been identified

Highlights of Laboratory and Field Work Component of the Course

Use of Optical Sensors to Maximize Nitrogen Use Efficiency for Winter Wheat

To provide students with hands-on experience utilizing hand-held optical sensors and GPS unit and ArCGIS 9.3 software tools to determine NDVI for calculating optimal application of nitrogen during mid season for winter wheat. A field experiment was set-up on a winter wheat field at UMES to allow students to collect spatially located NDVI data and use the information to estimate net profit and amount and cost of N fertilizer applied to a winter wheat crop using four management methods listed below:
Method 1: No N application in mid-season.
Method 2 :N-rate applied uniformly across field based on yield goal for winter wheat.
Method 3: Variable rate using mean NDVI for the entire N-Rich strip.
Method 4: Variable rate using maximum NDVI for the entire N-Rich strip.
Some of the results obtained by the students using equations provided in (Raun, 2005) are outlined below.



N- Prescription Map (Method 3)

Optical Sensor - Crop Circle

N- Prescription Map (Method 4)

Method	Yield (bu/ac)	Total Yield (bu)	Gross Value ($)	Net Value ($)
No N (Ypo)	14.46	88.06	427.10	427.10
Flat Rate N	30.00	182.70	886.10	818.86
Ypn Max NDVI	30.87	188.00	911.79	886.24
Ypn Mean NDVI	21.88	133.25	646.26	636.50

Figure 3 : Results from student field project using optical sensors

Actual applications for variable rate nitrogen application at UMES in the future using prescription maps or on-the-go sensing and actuation will involve significant effort in developing information specific to eastern shore, however, the experience provided the students preliminary insight in this active field research area.

pH Mapping of Bozman

At the onset of the precision farming project in 2005 grid soil sampling was performed over the Bozman field and GIS maps developed for pH and other nutrient levels. The pH levels were found to be consistently low 4 – 5.5 and correlated fairly well with yield of the crops harvested with yield monitor and mapped using GIS software. Subsequently using a prescription map and variable rate applicator lime was applied to the field to bring up the soil pH to targeted levels varying between 6 and 7.5 at specific portions of the field. The field component of the course provided an opportunity for student teams to use a soil probe and collect soil samples with corresponding GPS readings using a GPS mobile mapper, and observe pH values using a pH meter using the same grid. The data was subsequently mapped using ArCGIS and spatially interpolated to obtain raster data. The raster map obtained will be correlated with future yields from the field.

Figure 3 : pH meter, GPS Mobile Mapper and Soil Probe

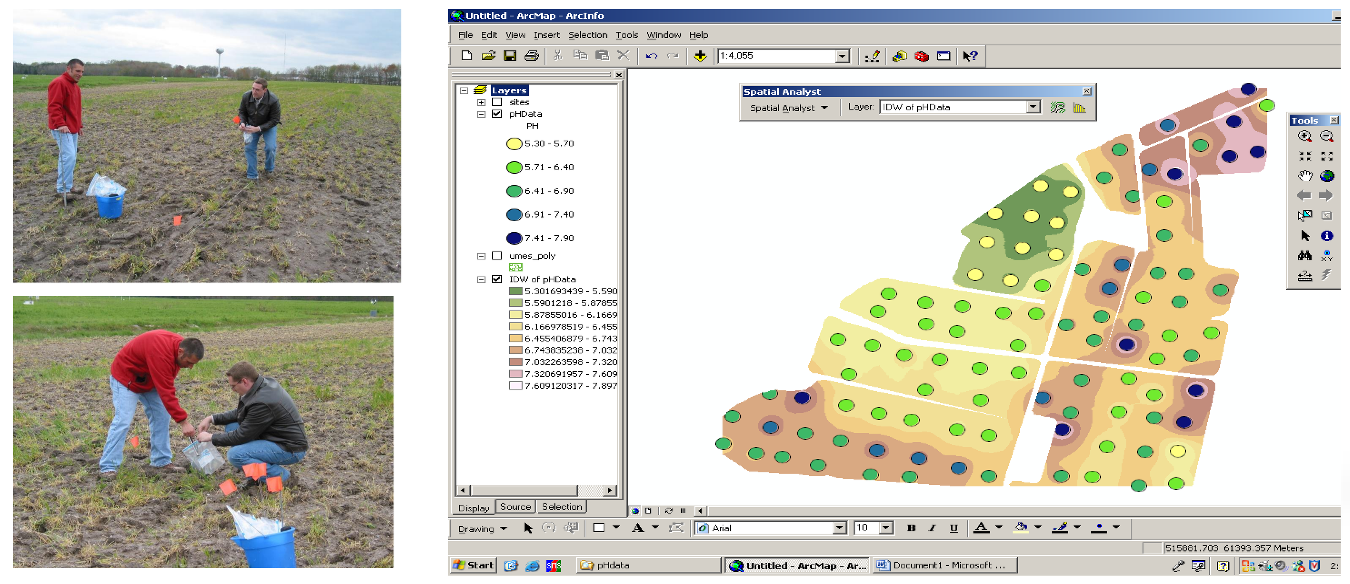


Figure 4 : Soil Sampling for pH reading and spatially interpolated pH map of Bozman

Variable Rate Nitrogen Experiment

To provide students with experiential knowledge of use of spatially located data and their use in field studies pertaining to " Precision Agriculture" , an experiment was set-up in a portion of the Backbone field. 30 ft. wide strips at nitrogen levels varying from 0 -200% of the recommended level were applied to the field in early spring (March). Field data was collected using Chlorophyll meter (SPAD), Leaf Area Index (LAI) meter, and a linear scale to observe the variation of chlorophyll content, LAI and height over time by spatially locating each measurement with a GPS unit. Aerial imaging was also performed and ground-truthed with field data.

Figure 5 : SPAD meter, LAI meter, linear scale, CIR/RGB camera mounted on Cessna 172

Figure 6 : Schematic layout of variable level nitrogen experiment and georeferenced RGB and mosaicked and georeferenced NDVI image obtained from color infrared imagery

Conclusion

The non-traditonal course structure has been well received by the students. Summer internship following the conclusion of the spring semester course have provided additional in-depth experiential learning and field research experience to the students themes directly related to project efforts undertaken in the course. Exposure to USDA Beltsville and NASA Wallops facilities have been integrated to enrich internship experience of the students during the summer. Some of the participating students have been inspired to pursue graduate research in the aspects of precision agriculture following the course. The project leaders are pursuing additional funding support through NASA, USDA, and DOE to continue to grow the project efforts and integrate education, research and extension in multidisciplinary teams.

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