Challenging Agricultural Governor's School Students with Advanced Geographic Computer Tools and Techniques

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Abstract

In 2001, a Governor's School of Agriculture was formed to bring 85 students to Virginia Tech for a 28-day residential program involving Agricultural Economics, Animal Science, Veterinary Medicine, Natural Resources, and Plant and Soil Science. The students were accustomed to highly technical home and teaching environments; 94% had home computers and 88% had modems. Eighty to 88% had used spreadsheets, databases, and slide show software and all had used the Internet at school. Nineteen percent had used satellite positioning systems and 25% computer-aided drawing programs. About 20 students elected to study geographic analysis (GIS) software. Ninety-three percent of those students reported that using GIS software made the agriculture subjects more interesting and 47% said it increased their interest in studying agriculture. Eighty-one percent said they would use their new knowledge at home, and 65% said it would help them in school. Thirty-one percent said they planned to take similar courses in college. Teaching agricultural subjects with sophisticated software and equipment appears to be a successful way to introduce the subject to non-traditional students in an exciting and challenging manner. This model is offered for others to consider when addressing high school students with the aim of recruiting them into collegiate agricultural programs.

Introduction

Today's students live in a highly technical world. At home, they are surrounded by sources of digital video and audio, the Internet, and video games that portray a three-dimensional virtual reality world of racing, fighting, sports, and adventure games. As students, they are exposed to videos, computer slide shows, instructional software, and the Internet in their classrooms. Their learning environment is more graphical and visually oriented than before, and the increase in visual information has raised the bar for teachers who want to capture their student's interests. Getting the attention of and impressing students accustomed to such a loud, bright, colorful, fast-moving world is an increasing challenge for teachers, especially for conventional science subject classes. Success can be gauged by how often the teacher hears slang expressions of excitement or interest form the students during lectures or field trips.

As the number of farming and ranching families declines nationwide (http://www.usda.gov/nass/), college agricultural teachers are faced with an increasing proportion of agriculture students with nontraditional backgrounds. Nontraditional students may need more background material than students who were raised on a farm or ranch. Background instruction must be provided in subjects such as crops, vegetation, soils, hydrology, animal science, economics, and land-use history to assist urban students to improve their image of agriculture, to gain an understanding of the agricultural environment, activities, and land-use choices, and to portray agriculture as a source of rewarding careers (Falvey and Matthews, 1999). Agriculture clubs and classes at the high-school level may provide this background but they are not available at many urban, private, or home schools.

New and innovative ways to appeal to potential students are needed to improve the image of the colleges of agriculture to facilitate attraction and retention of the best and brightest students from various backgrounds and schools (National Resource Council, 1996). Wildman and Torres (2002) reported that agricultural departments face a difficult challenge to recruit students who have not been exposed to prior agriculture experiences. The agricultural and environmental educators must contact high-achievement students in secondary schools, increase their knowledge and awareness level about employment opportunities in agriculture, and spark their interest in the subject. Those students who then find they have a high interest in the agriculture or environmental sciences and employment opportunities will become potential students to study those subjects in college. Contact with high-school students

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may be achieved in traditional ways through high school clubs (FFA, 4-H, Rodeo) and teachers or through nontraditional ways such as summer residential Governor's Schools.

Agricultural Governor's Schools

The first Governor's School was established in North Carolina in 1963, and as of 1996, there were 100 such schools. The National Conference of Governor's Schools (http://ncogs.org/) lists schools with Governor's School for the Agricultural Sciences at The Pennsylvania State University (Penn State) and Virginia Polytechnic Institute and State University (Virginia Tech). Each school is a two weeks to six week residential summer program for gifted and talented youths of high school ages, has highly selective criteria for student selection, and are supported entirely or in large part by their state legislatures and educational funding (http://ncogs.org/faqa.htm). Because recruitment is open to students from all backgrounds and public, private, and home schools, the schools offer new opportunities to expose students to new or innovative technology that may not be available to them and to introduce them to various agriculture sciences.

At Penn State, 64 of the state's top high school juniors and seniors spend five weeks learning about agricultural sciences. More than 700 students have attended the school since its inception in 1997. Nearly all of them have gone on to college, and many have chosen to attend Penn State's College of Agricultural Sciences (http://www.cas.psu.edu/docs/CASHOME/ACAPROG/Default.html).

The Virginia Summer Residential Governor's School for Agricultural (VGS) was established in 2001 and follows the format of the Pennsylvania School. According to the information presented to Virginia high school teachers and prospective students, the mission of the program was "to provide hands-on, cutting-edge scientific and academic instruction to the future leaders and scientists to develop their understanding of the scope, opportunities, challenges, and both academic and scientific rigor of the broad fields of agriculture and natural resources" (http://www.gsa.vt.edu/).

This paper presents a description of a one-week specialized course using global positioning systems (GPS) equipment and geographic information systems (GIS) software meant to capture the interest of students who grew up in an environment full of digital graphic images and electronic devices. The GPS and GIS training appear to be a unique offering among Governor's Schools. GPS devices are becoming more common for use by hikers and in automobile guidance systems. GIS software is a set of tools that relate different imagery, environmental, geographic, and demographic data at a common location (Independent Publishers Group, 1999).

Pedagogy for collegiate agricultural instruction using GIS is beginning to emerge in the literature. McCallister et al. (2001) report the successful development of a class combining land use planning and soil survey reports using GIS technology. Student response to this exercise was almost uniformly positive. Lee et al. (1999) produced a similar course introducing students to on-line county soil surveys and the STATSGO database using GIS. At the University of Arkansas, Scott and Smith (1995) are using GIS in a soil physics laboratory. In their evaluations, some students requested that additional time in the class be devoted to this area. These references all report a very positive student response to this new data management tool.

Many web-based articles and trade journal reports discuss the positive response of secondary education teachers and students to GIS technology (http://www.esri.com/industries/k-12/tocdetails.html#honorroll). The Thomas Jefferson High School for Science and Technology in Alexandria, Virginia is an example of secondary schools that offer a pre-collegiate program that stresses the geosciences, especially GIS (McGarigle, 1997). However, there are few publications that report the effect of colleges teaching GIS to high school students. The McMaster University GIS High School Outreach Program was created in December 1999 to teach, improve, strengthen, and promote GIS in high schools and, to date, has educated more than 1,750 high school students and teachers (Maynard and Vajoczki, 2002). This program sets an example of teaching GIS to secondary students but does not focus on agricultural sciences.

Because of the growing popularity of GIS instruction at the secondary level, the possibility of a devoting GIS instruction to agriculture just might be a way to attract this new generation of students to the agricultural and environmental science disciplines. Radhakrishna and Bruening (1994) reported that respondents to a survey on the role of computers in agriculture rated having good computer skills slightly more important to job success than having technical agriculture skills. Computer skills are important to both success in college and to success in agricultural careers (Andelt, et al., 1997). Recently, Environmental Sciences Research Institute, Inc (ESRI, Redlands, CA), the owner of GIS software such as ArcView™ and ArcGIS™, has devoted extensive resources towards publicizing on-line instruction and example projects for K-12 on their web site (http:// www.esri.com/industries/k-12/tocdetails.htm l#honorroll).

The objectives of this paper are to provide a model for energizing high-quality secondary students to encourage them to increase their interested in agriculture and geographic information systems (GIS) software by: (1) describing a challenging training session using GIS and incorporating crop, soil, and environmental sciences in land-use planning, and (2) presenting student backgrounds and their evaluation of the training.

Methods

Instruction Methods

In 2002, about 85 VGS students each year attended four weeks of classroom and outdoor training. Each student was asked to take six core courses, four of which were discipline-based, plus one computer application course, and one communications course. Students were assigned a major, with about 20 students per major. Within the major, students completed two specialized courses designed to provide major-specific instruction and to prepare them to work on a major-specific, small group research project. In 2002, about 20 VGS students chose to take the GIS session, which involved hands-on experience using GIS software, digital aerial photos and satellite imagery, digital cameras, GPS receivers, and field sampling. Training sessions lasted nearly two hours per day for one full week. The topics listed in Table 1 and the level of presentation were equivalent to that given to college students taking their first course in GIS, with more of an introductory level of instruction given for the environmental and soil science subject matter. The 2002 training was designed to introduce basic tools and concepts with an emphasis on allowing active student participation. In addition, the students were challenged with a conceptual land-use problem that gave them a purpose and goal for some of their activity.

Having successfully completed this course, students were expected to be able to:

1. Use GIS computer programs to overlay digital data to produce interpretive maps
2. Use Global Positioning System (GPS) receivers and digital cameras in the field and add that data to their GIS file
3. Use digital topographic and elevation data to view landscapes in 3-dimensional perspectives
4. Use GIS and interpretive guidelines to determine wise land-use management

Day 1 covered basic computer skills using Windows 2000™ operating system (Microsoft, Inc., Redmond, WA) and ArcView 3.2a™ GIS (Environmental Systems Research Institute, Inc., Redlands, CA), basic geography, digital data types, and data availability (Table 1). On Day 2, the students were introduced to various digital data and imagery sources commonly used in association with agriculture, environmental sciences, and natural resource application. Examples were chosen that the students could relate to easily, such as downloading imagery of their hometown or of the Virginia Tech campus. Day 3 focused on land-use planning and data interpretation with emphasis on soil and plant sciences. The students began compiling a GIS project that involved land-use on the Virginia Tech campus, and prepared for the field trip activity on Day 4.

On Day 4, the class went on a walk across the open fields on the west side of the campus in order to do some field-checking of the maps they used in their class project. For example, the class used digital cameras to collect site pictures and used GPS units to locate potential building corners and verify location and composition accuracy of the data layers they downloaded from the Internet. Maps with utility lines, soils, contour lines, parking lot and building outlines were drawn on top of aerial photos and were printed out for the students to take along on the trip. The location data to be collected with GPS receivers included the four corners of a proposed new building approximately 50 by 100 ft in size, and any important features such as power poles or utility lines that would affect construction but did not appear on the campus maps supplied. Students were asked to inspect the vegetation and look for plants that were indicators of wetlands, to verify the percent slope, to

Table 1. Syllabus for the 2002 Virginia Agricultural Governor's School GIS instruction.

	Subject area and specific topics
Day 1	**Introduction to computers and GIS**
	Basic computer OS, program, and file management
	What is GIS?
	Creating a GIS project
	Spatial vs. tabular data
	Raster versus vector data
	Point vs. line vs. polygon spatial data
	Common spatial data types - Grids, Images, Shapefiles, Coverages
	Scale
	Common projections and coordinates
	Finding and downloading data files
	Activating extensions
	Viewing and modifying tables
	Collecting and adding GPS data
	Adding data layers and creating new maps
	Editing the legend and labeling features
	Creating and printing maps
Day 2	**GIS information**
	Imagery - DOQQs, Landsat, satellite
	Digital Soil Survey - SSURGO
	Digital Vegetation Information - NLCD, GAP
	Digital Hydrology Information - DRGs, TIGER, NWI
	Topographic and transportation - DRGs, TIGER
	Elevation data - DEMs
	Accessory data - hyperlinked images and GPS event themes
Day 3	**Using digital data for land use planning**
	Measuring and analysis tools
	Basic geoprocessing and buffering
	Examples of Agricultural planning
	Examples of Environmental planning
	Examples of urban/suburban planning
Day 4	**Field trip**
Day 5	**Conclusion**
	Campus GIS demonstration with new GPS and images
	3-D projects, flyovers, and interactive GIS
	Questionnaire and wrap-up discussion

determine the direction of runoff and distance to stream or water inlet from the hypothetical building. In addition, students were asked to take a picture in all major directions from the center of the proposed building location, in order to determine the view after construction.

On Day 5, the students were shown how to incorporate their GPS and imagery data files into the GIS project. As a treat, the students were shown how to import digital elevation data and allowed to create hillshades, contour and drainage maps, and 3-D flyovers of the Blacksburg area.

Four students volunteered to do a GIS land-planning project to plan the location of a nature trail that winds by a pond, running creek, wetlands, native tree stand, crops, pastures, and grazing animals. The trail was required to be parallel to concrete walks and asphalt drives and parking lots, but must be placed to avoid car and bicycle traffic. The trail was to wind through areas with pleasant views, must avoid dense vegetation and be open for safety reasons, and be wide and level enough for major portions to be accessible to handicapped persons and wheelchairs. The trail could cross existing creeks with bridges but must be on non-flooded soils suitable for trails and picnic areas. The project students were also asked to suggest a location for a Visitor's Center on suitable soil that was not flooded, not too near a creek, and not on slopes susceptible to severe erosion during construction. The trail was intended to be adjacent to no-till strip cropping planted on the contour, forest plots, and active animal pastures that met best management practices (BMPs).

The four special project students were given free access to very high-resolution (0.33-m pixel) natural color images flown at low altitude in the late 1990s. The images had been rectified to within 0.33m. The four students were assisted with downloading and overlaying data from the campus web site that included: contour lines, utility lines, building and parking lot outlines, roads, streams, trees and shrubs, and sidewalks. Other layers of data such as soils, wetlands, and hydrology were downloaded and added to the project. Soil interpretation guides were provided along with strategies for proper site selection that incorporated interpretation of vegetation and hydrology data. The students were expected to compile all of the layers together and then make one new map showing the suggested location of the nature trail and Visitor's Center. Students were assisted with incorporation of digital pictures and GPS data points into the GIS project layers.

The four project students spent open class time to develop a report, electronic slide presentation, a poster, and brochures to explain their project and results. The faculty mentor and GIS lab specialist guided the students when requested. The posters and slide presentations were conducted in an auditorium in front of peer groups, parents, staff, and faculty in a competition format resembling a speech contest. Superior presentations were awarded special recognition.

Results and Discussion

Student Background

A standard (generic) course evaluation was handed out at the end of the 2001 and 2002 instruction that is similar to standard evaluations used by another Agricultural Governor's School (posted at http://ncogs.org/evalproj/ag/ag01.htm). However, in 2002 survey experts at Virginia Tech developed an additional questionnaire that went beyond the normal questions to determine the student background in highly technical instructional and home environment. All answers were either “yes” or “no”. The students who were accepted to the VGS were exceptional and did not represent the overall student population. However, they did represent the body of students who are being actively sought after by colleges and are most likely to attend college.

The students who attended the 2002 VGS came from homes where highly technical digital electronics and were readily available (Table 1). For example, 94% had a computer at home and almost as many (88%) had an Internet connection by modem. One-fourth of the home connections were cable-internet connections. Most used the computers for entertainment purposes and applications such as digital audio (music CDs and MP3 files), digital video and imagery, and playing 3-D video games. This observation is supported by the work of Johnson et al. (2002). Students enrolled in a freshman Orientation class were surveyed to determine their computer experiences, self-efficacy and knowledge. Three quarters of the students had completed one or more computer courses in high school and owned a computer. The students actively used computer programs to communicate with others. Over 80% use America Online Instant Messenger™ (AIM) (AOL Time Warner, New York, NY) to chat interactively with friends on the computer. Three-fourths have sent digital pictures as email attachments, and most have learned how to edit the digital pictures they send. Three-fourths have made a web page, and one-fourth have added moving graphics or video clips to them. All students have used the Internet at school

Four-fifths said some of their teachers use electronic slideshow programs in class. One-third of the students said that lectures without slideshows are not as interesting as those with slideshows, and one-half said that their teachers use other computer programs and equipment to make their lectures more interesting. One-fourth of the students have seen or used a GIS/CAD program, and over three-fourths have used a spreadsheet or database program at school. These results substantiate the work of Johnson et al. (2002) and indicate that computer graphics and images have become part of the high school teaching environment, and that students have an increasing exposure to electronic graphics, images, and tabular data before they reach college or the workforce.

Student Perceptions

At the end of the training, students were asked "yes" or "no" questions about their learning experiences (Table 3). Eighty-eight percent of the students said that the field trip added to their learning experience (Table 3). Responses indicate that almost all of them found using GIS fun and interesting, and most intended to use part of their new knowledge at home. For example, several students intended to download digital imagery of their hometown and neighborhood. Two-thirds said they learned something from the class that would help them in school the next year. One-third said they plan to take a GIS class in college. This is higher than the percentage of students in the College of Agricultural and Life Sciences at Virginia Tech who take these courses (currently about 1-2% of the student population). The GIS courses are becoming more populated with Agriculture and Natural Resources students because the skills are highly regarded by potential employers and the courses are being now a required part of the curriculum in many departments. Half of the students said that combining agriculture with GIS has increased their interest in learning more about agriculture, environmental sciences, and natural resources. This feedback provided reasurement that we had reached our goal of making the course interesting in both the computer software and subject matter areas.

Table 4 shows the results of the generic teacher and course evaluations for 2001 and 2002. The rating choices ranged from 1 to 4, with 1 for "Poor," 2 for "Fair," 3 for "Good," and 4 for "Excellent." We received evaluations from 34 students with average ratings of 3.1 to 3.4, indicating strong agreement with all questions about their satisfaction with the training. In addition, 17 of 21 students that answered said their expectations had been met by the course. Finally, the instructor made a very good impression on the students and they responded well to her teaching style. Evaluation comments will be used to improve the course in following years.

A few students provided additional comments to specific short answer questions about what they enjoyed most about the course (Table 5). The responses were varied between enjoyment of the training, the use of digital data, and the use of computers. Student comments varied about how the course changed their interest. Only 4 of the 17 students answered, and the answers did not add specific information to the feedback we had already received. Four students commented on how they would use the information from the course. Two students were interested in recreational uses, and two uses mentioned that were more academic in nature. The students commented that they would change the class by making the presentation slower and more explicit. This reaction was expected considering that the training dealt with highly technical subject material that required tedious attention to detail and sequential steps. Students who fell

Table 2. Questionnaire of background exposure of the 2002 Virginia Agricultural Governor's School students in the GIS instruction class to high-technology equipment and software. All answers were either "yes" or "no".

Question:		Yes	No	% Yes
1.	Do you have/use a computer at home?	15	1	94
2.	Do you have/use digital audio on your computer?	12	2	86
3.	Do you have/use digital video or digital pictures on your computer?	12	4	75
4.	Do you use your computer for 3-D games?	10	5	67
5.	Do you have/use any other 3-D video game equipment at home?	5	11	31
6.	Do you send digital pictures as email attachments?	12	4	75
7.	Do you edit digital pictures?	11	5	69
8.	Have you made a simple web page without images or graphics?	12	4	75
9.	Have you made a web page with moving images or video clip links embedded?	4	11	27
10.	Do you use AOL IM to chat with friends?	13	3	81
11.	Do you have a modem Internet connection at home?	14	2	88
12.	Do you have a cable Internet connection at home?	4	13	24
13.	Do you use the Internet at school?	17	0	100
14.	Have you used a GPS unit before at school?	3	13	19
15.	Do you have/use a Palm Pilot or other handheld at school?	1	15	6
16.	Do your teachers use PowerPoint or other digital slideshows?	13	3	81
17.	Do your teachers use computer programs and equipment in ways that make their lectures more interesting?	9	7	56
18.	Do you find other lectures less interesting if they do not use computer programs and equipment?	5	11	31
19.	Have you taken a class in CAD or GIS or learned to use CAD software?	4	12	25
20.	Have you used database or spreadsheet programs (Access or Excel, for example) at school?	12	3	80

Table 3. Questionnaire about the 2002 Virginia Agricultural Governor's School GIS instruction class content. All answers were either "yes" or "no".

Question:		Yes	No	% Yes
1.	Did using GIS software to make maps make it easier to get interested in the subject matter?	13	1	93
2.	Is using GIS fun at times?	16	0	100
3.	Now that you know how to find and get a free digital photo of your house or town, do you think you will try it at home?	13	3	81
4.	Do you think you will use anything you learned in this class to help you in school next year?	11	6	65
5.	Do you think that land use planning can be done better with data combined in a GIS than by looking a several maps and tables?	17	0	100
6.	Does seeing a landscape or object in 3-D make it more fun to learn?	17	0	100
7.	Do you plan to take any GIS courses in college?	4	9	31
8.	Did using GIS in this class increase your interest in learning more about agriculture, the environment, or natural resources? (Y/N)	7	8	47
9.	Did the field trip add to the learning experience?	14	2	88

behind easily or failed to execute the computer programs typically found the experience frustrating. Only 2 of the 17 students brought up this comment, but the feeling was occasionally expressed during the training.

Table 4. Summary of the generic 2001 and 2002 course evaluations for the Virginia Agricultural Governor's School GIS instruction. The rating choices ranged from 1 to 4, with 1 for "Poor", 2 for "Fair", 3 for "Good", and 4 for "Excellent".

Question	Mean Rating
Degree to which subject matter was made stimulating or relevant	3.2
Administration of the class and organization of materials	3.3
Adequacy of handouts and materials	3.4
Educational value of out-of-class assignments/field trips	3.3
Rate your gains in this course compared with similar courses you have taken.	3.1
Overall rating of course (1 to 4 scale, 1 low, 4 high)	3.2
Total students responding	34

Table 5. Course questionnaire and comments by the 2002 Virginia Agricultural Governor's School GIS instruction students. All questions were short answer.

Question:
1. What did you enjoy the most about this course?
Using computers to draw maps
Finding homes, putting together maps
Seeing a recognizable place via satellite image
Learning to coordinate themes
2. How has this course changed your interest towards this subject? Has it increased, decreased, or stayed the same?
Use GPS/GIS systems when hiking, learned how to use GIS system
No change or interest
Fun, but frustrating
Increased interest; fascinated by technology
3. How can you use the information from this course in your future?
Can't unless it becomes a hobby
Camping, hiking, making plot points
Better understanding of computers
In many environmental fields
4. What changes, if any, would you recommend making for this course?
Get assistants, professor did not wait for everyone when lost or confused
None
Slow down instructions, type them out
Use labs that don't delete work
5. Additional Comments:
Class was fun
Overall, it was great
Exceeded expectations
Very interesting

Summary

The VGS has followed in the pattern of the Pennsylvania Agricultural Governor's School to excite and introduce agriculture to exceptional, highly-motivated secondary students. These students came from backgrounds with exposure to highly technical equipment and software. The GPS and GIS training outlined in this paper was designed to challenge them and peak their interest in agriculture, land-use planning, and advanced graphical software. While these students were exceptional and probably did not represent the average background of the general student population, they do represent the body of students who are being actively recruited by colleges and are most likely to attend college. Several students who became involved in an extra-curricular project had the opportunity to become acquainted with the staff and facilities of the Crop and Soil Environmental Sciences Department at Virginia Tech and became more familiar with several types of computer software and media for presentations. The training has been conducted for two years, and has already been greeted with overwhelming approval by the students and serves as a model for other similar ventures in the teaching environment.

The goal of assessing the educational and home environment background of the students was achieved and used to tailor the instruction of computer software, land-use planning, geography, agriculture, environmental science, and natural resources to the appropriate level. The course evaluations and comments provided positive reinforcement that the instructors had made the class interesting for students who were accustomed to being entertained and educated by highly-technical digital and visual equipment and software. When asked for additional comments, the responses were "Class was fun," "Overall, it was great," "Exceeded expectations," and "Very interesting." Lessons learned in the first two years of this venture will be used to improve the instruction and projects and serves as an example to other institutions considering similar activities.

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