TEACHING CRITICAL THINKING SKILLS USING GEOSPATIAL TECHNOLOGY AS INSTRUCTIONAL TOOLS

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ABSTRACT

Techniques in data collection and analysis of data are important concepts for students of precision farming. Also needed in conjunction with these concepts are critical thinking and problem solving skills. Employers often list critical thinking skills as one of the most important characteristics for new employees. Helping students experience and acquire critical thinking skills can be difficult. Geospatial technologies are not only useful precision farming tools, they are also educational tools to develop these skills. Kirkwood Community College offers two courses, Geospatial Data Collection and Agricultural Spatial Analysis, in which a primary focus is for students to experience critical thinking within a client/consultant relationship. Specifically in Geospatial Data Collection, a project based course, students are not given a project. Students must develop their own project based on a "client's" need. Working with a client, students must discuss and clearly define issues and questions. This in turn determines data that needs to be collected. Students must think critically to develop a project that provides the data that will address the issues or answers the question. Many students have difficulty with this which presents various problems in class organization for the instructor. This presentation will review some of the techniques used in Geospatial Data Collection, examples of projects, classroom issues that an instructor might face, and a proposal to deliver this course on-line.

Keywords
Geospatial Education, precision farming, critical thinking

OUTLINE

- Description of Critical Thinking Skills – brief description of critical thinking and its importance to industry
- Value of Geospatial Technologies – description of author's approach to precision farming and its use as an instructional technology
- Description of Courses – detailed description of Geospatial Data Collection

DESCRIPTION OF CRITICAL THNIKING SKILLS

Critical thinking is "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends (1)."

This early definition John Dewey in 1933seems to be the basis for many subsequent definitions of critical thinking as it applies to education. The concepts presented within, which have been expanded by additional research, infers questioning, analysis, and evaluation of information and resulting interpretation. This should be an important aspect of education.

> If we teach children everything we know, their knowledge is limited to ours. If we teach children to think, their knowledge is limitless.(2)

The "3 R's", general education, and technical education all have their place in the education system. There has been a regular stream of pedagogy or "programs" that focuses on specific aspects of learning. The latest, No Child Left Behind (NCLB), attempts to document and assess individual students reading and math abilities, a sort of return to the basic 3 R's.

Career and technical education have had a recent focus on contextualizing science, math and general education skills. As an example, agriculture science instructors have incorporated more biology and mathematics into their lesson plans through the use of aquaculture. Students must test water for various nutrients and contaminants and use mathematical formulas to determine feed rations. These exercises provide technical skills as well as showing how math and science are use in careers and job tasks.

Likewise, critical thinking skills can be incorporated into education. The use of instructional materials that provides students with the opportunity to question, analyze, and evaluate information can be used in a variety of coursework. Not only does this provide valuable life skills, but it is good pedagogy.

> Critical thinking requires deeper analysis of the lesson. Deeper analysis produces deeper understanding, resulting in better grades and higher test scores. Critical thinking empowers students to be independent, innovative, and helps them succeed in school and in life. (2)

> Research has found that the more often a student is exposed to critical thinking, the greater the probability that the student will transfer critical thinking to other areas of his or her life. Based on this research, it is important to expose students to critical thinking in education wherever possible.(2)

Critical thinking has been identified by industry as an important skill needed by new employees. The Defining Agriculture Technology Conference (DATC) was used by AgrowKnowledge to identify new and emerging careers within agriculture. Approximately 30 industry representatives attended the conference and took part in facilitated small groups that identified specific emerging careers and skills need for those new careers. As part of the process the industry participants read through and ranked a list of personnel skills based on their importance in a new employer. Results are available within the published DATC report (3). Ranked first as the most important personnel skill is critical thinking. It should be noted that skills related to critical thinking skills, such as trouble shooting skills, also ranked high.

Specific skills related to critical thinking has been identified by the Critical Thinking Co. and are listed on their website. A partial list of these skills as related to the courses discussed within this paper is found below.

- Focus on a question / Identify or formulate a question
  Ask and answer questions of clarification and/or challenge/
- Observe, and judge observation reports.
- Make and judge value judgments/ Consequences of accepting or rejecting the judgment
- Attribute unstated assumptions (an ability that belongs under both clarification and, in a way, inference)
- Integrate the other abilities and dispositions in making and defending a decision
- Proceed in an orderly manner appropriate to the situation. For example:
- Follow problem solving steps
  b. Monitor one's own thinking (that is, engage in metacognition)
  c. Employ a reasonable critical thinking checklist
- Employ appropriate rhetorical strategies in discussion and presentation (orally and in writing). (2)

VALUE OF GEOSPATIAL TECHNOLOGIES

Global Positioning System (GPS) and Geographic Information Systems (GIS) represent two of the most common geospatial technologies and therefore will be used within this paper to demonstrate critical thinking skills. It will also be assumed that a detailed description of GPS and GIS is not needed as most of the readers will already be familiar with those technologies.

The use of GPS is increasing rapidly on a worldwide basis and many students will have heard about GPS. As I personally have visited schools giving GPS demonstration, and have noted the increase in GPS awareness. Ten years ago

within a class of 20 students, one student may have heard about GPS. Last year when making school visits, the majority of students indicated awareness of GPS.

Geospatial technology specifically GPS, is fascinating to students, initially because of its uniqueness but also because of its positioning functions. Because of this fascination, GPS has been used by many teachers to draw students to their classes and programs. For students in the classroom, GPS, GIS, and the resulting maps, represents new technologies. It represents something different and unique.. it is something that is fun to explore. Teachers use the units to promote awareness of geospatial technologies and possibly providing data such as speed and direction. However the use of GPS for plotting function or to demonstrate basic scientific concepts has been limited.

In order to develop critical thinking skills a different pedagogical approach must be taken. An approach in which students not only get experience in making a decision, but are synthesizing and creating the basis for the decision. They must be able to not only follow the guidelines for the project decision; they must be able to determine the guidelines.

DESCRIPTION OF COURSE

Geospatial Data Collection (GDC) is a 3 credit class designed at Kirkwood Community College as part of the Agricultural GPS/GIS Technology AAS degree. GDC is the third course in a sequence of four geospatial courses (Introduction to Precision Farming, Introduction to ArcView, Geospatial Data Collection, and Agricultural Spatial Analysis.). Student s are typically second year students in their third term of study. It is a project based course, but there are several techniques which enhance the focus on critical thinking skills.

The objective of Geospatial Data Collection (GDC) is to develop technical skills of the student to collect data using GPS and build a project within GIS for the purpose of answering a specific question. In addition to the technical skills, the course is designed with objectives of project management, communication with a client, and problem solving and critical thinking skills.

Each student is responsible for building a project. It must an individual project but the can coordinate their classmates for gaining additional help with certain tasks. Students are presented with a basic timeline and work structure, but they are responsible for defining the project. This is a key, since in most project courses the instructor provides the project and a specific task list for completing the project. Making the student define the project requires a higher level of cognitive learning, specifically the synthesis level.

General steps that students are given include:

- Identifying the area of study. This should be a specified location and extent and an area that the students have ready access to and is familiar with.
- Identifying the client. There must be a manager or person responsible for the study area that can serve as a client for the student’s project. There must be communication between the student, as the consultant, and the manager, as client.

- Problem, decision, or purpose must be defined. Based on discussions with the client, an issue, problem, or decision is identified. This must be clearly stated as part of the initial report.

This initial report is one of the key concepts for building critical thinking skills. Identifying the question themselves is a key ability for critical thinking. More importantly instead of the student being given a project to complete, the student must synthesize the project themselves. This is along with developing the question, can be very difficult for the students but provides key experience in critical skills.

When the question or issue has been defined, the next main task is to determine what data needs to be collected to answer the question and how the data will be collected. Students are required to create a data dictionary showing an outline of data and features. This task again uses critical thinking skills and is very difficult for the students to synthesize. There is no absolute correct method for developing a data dictionary and there are usually multiple ways for arranging the features and attributes. The student must create the structure and self evaluate. It is up to the instructor to assist with this self evaluation, guiding it without completing it.

The majority of the course is the collection of data using GPS for field collection or internet for base data. The students usually will collect the data by themselves, though the possibility exists for coordination of classmates to do bigger tasks. This coordination is another source of critical thinking skills.

The creation of the final project is composed of two aspects, the creation of a final map document in ArcView and a presentation to the client. The creation of the final map document is mostly related to the technical aspects of the GIS. Students must discuss the process and progress with the client through the semester. When the semester is over the student must give a final report to the client. The development of the presentation to the client and fellow students is also a critical thinking skill.

Final evaluation of the student is based on both the technical aspects and the manner in which the student completed their role as a consultant. Technical aspects include an electronic component for maintaining data collection hardware, collecting representative samples, entering attribute data in the field, and including appropriate base data from internet sources. Evaluation of the consultant role includes the timeliness with which they complete the initial report and other data collection responsibilities, the outline of data attributes to be collected and methods used, and the final report.

Matt W. was a full-time student at Kirkwood within the Ag GPS/GIS Technology program and will be used as an example of a student that completed a relatively advanced project. As a study area, he selected an uncle’s farm that was within two miles of the college and for which he was working part time while attending classes. His uncle served as the client.

Identifying the problem or issue was difficult at first. Matt wanted to do a simple soil sampling/ crop recordkeeping project for which the result would be a series of nutrient maps. As an instructor, I advised him to work with his client to try and discover something more useful; a problem that would be more difficult to answer without geospatial technologies. They came up with a field that sustained

heavy damage from deer on a regular basis and a question was developed: How much damage are the deer causing?

Identifying the data collection process was also difficult at first. Working with Matt, I questioned whether he would be able to really gauge how much loss was occurring by using only yield maps from this year and previous years. Ideas such as counting the actual number of deer going into the field were also thrown out because of the time commitment. Finally a system of sampling field damage was created. Matt had already mapped the deer trails that entered the fields and had investigated some basic patterns of damage. He designed a regular pattern of sample points 100 ft, 200 ft and 300ft into the field and 100 ft apart for which he would assign a damage score of 1 to 5 based on the level of damage. This was done just prior to harvesting of the grain with a yield monitor.

The data was collected and yield points and damage points were interpolated to create a yield surface and a damage surface. Matt created a presentation that outlined the basic results to his uncle. The data was presented in a way that provide the factual information without making inferences in amounts of yield lost (which would have taken further analysis beyond the scope of that class)

This is an excellent example because Matt had to use higher cognitive skills of synthesis in: identifying and defining the question, making judgments on the value of data, evaluate assumptions (on deer trails were associated with damage), developing a data collection strategy, and defending his data to a client.

SUMMARY

In summary, the Geospatial Data Collection course uses several techniques to help develop critical thinking skills. Most of these techniques are based on allowing the student to create their own project, make decisions on the data requirements and developing a presentation and defense of their data project results.

1. Dewey, J. How We Think, Courier Dover Publications 1933: pg 118 ISBN 0486298957

2. http://www.criticalthinking.com/index.jsp, The Critical Thinking Co., June 4, 2008

3. Defining Agricultural Technology, AgrowKnowledge, 78 pgs 2007