Briefing Paper by Tonny J. Oyana for AAG's Catalyzing Research on Geographies of Broadening Participation

Title: A Creative Way to Teach and Learn Advanced Technical Concepts in Geographic Information Systems

Background

Teaching geographic information systems (GIS) courses can be challenging because of its breadth and interdisciplinary nature (Wikle, 1998; Doering, 2004; Baker and White, 2003; Kerski, 2003; Johansson and Pellikka, 2005; Favier and Van Der Schee, 2012). Both the teacher and student must cope with constant changes particularly new software applications and emerging areas of interest. Learning outcomes should be aligned to reflect any rapid technical changes so as to provide students with relevant GIS knowledge and job market skills. This dynamic situation creates a serious demand upon curriculum and instructional strategies, thus there is a consistent need to adjust learning goals and objectives to fit new challenges, which can at times, can be overwhelming for new GIS instructors.

The briefing paper presents a creative case-based modern-style pedagogical approach for teaching and learning advanced technical concepts in GIS using classroom observations covering an eight-year study period, 2004–2011. Assessment data was collected and analyzed to provide useful insights about this approach. Included in this paper are results of specific case studies that were analyzed using a sample of students between 2004 and 2006. The assessment data and respondents consistently indicated that a case study approach offered them an excellent and enabling environment to learn advanced technical concepts.

Development of an Active Learning Pedagogy

The Geography program at Southern Illinois University Carbondale (SIUC) offers a range of GIS and Remote Sensing Courses; in which GIS is one of three concentrations for both undergraduate and graduate students. We have witnessed an increase in enrollment and strong interest among students since 2003 after a major overhaul of the curriculum design. Our GIS program follows the proposed GIS pedagogical approaches (CTGV, 1990; CTGV, 1992; Baker, 1999; Carolin, 1999; Kirschner and Davis, 2003; Doering, 2004; Mishra and Koehler, 2006; Favier and Van Der Schee, 2012) and employs a mixture of three instructional models: Basics First, Immediate Feedback Direct Instruction; Structured Problem Solving; and The Guided Generation Model (CTGV, 1990; CTGV, 1992). We promote anchored instruction (Savery and Duffy, 1996; Doering, 2004) through the use of lecture and laboratory-based active learning experiences with a key goal of strengthening apprenticeship training among our students. We train GIS students to become independent critical thinkers and learners rather than simply being able to perform basic computational tasks or retrieve basic knowledge. Our central mission is to help develop the core ability of our students so that they can identify and define issues and problems on their own rather than simply responding to problems that others have posed (Doering, 2004). This is consistent with the CTGV learning and instructional goals (CTGV, 1990; CTGV, 1992; Favier and Van Der Schee, 2012) and we try to cultivate a sustained interest and motivation among our GIS students through the process of active learning (Savery and Duffy, 1996; Favier and Van Der Schee, 2012).

The design of a collaborative case study to teach and learn advanced technical concepts is informed by two instructional models: the Structured Problem Solving and the Guided Generation Model. The former focuses on the importance of learners making errors and struggling with a task and the latter emphasizes the role of the teacher in the learning process to support inquiry-based geography education (Favier and Van Der Schee, 2012), in this model, the teacher serves as a facilitator and student peers engage in cooperative learning (Savery and Duffy, 1996; Favier and Van Der Schee, 2012). The assumption for the success of this model is premised on the view that learners taking Advanced GIS Studies have already been exposed to the first instructional model of Basics First, Immediate Feedback Direction Instruction through the introductory level course of GIS.

The way learning occurs among individuals still fascinates many prominent educators (Chickering and Gamson, 1991; Carolin, 1999; Summerby-Murray, 2001; Jennings and Huber, 2003; Drennon, 2005), but a detailed book edited by Wilson provides some guidance on this very important matter (Wilson, 1996). In one of the chapters, Savery and Duffy (1996) have explored at length the theory of constructivist learning environment, which they have conceived following three primary propositions:

1. That understanding is in our interactions with the environment
2. That cognitive conflict or puzzlement is the stimulus for learning and determines the organization and nature of what is learned
3. That knowledge evolves through social negotiation and through the evaluation of the viability of individual understandings.

The three propositions can be reinforced by eight core instructional principles (Savery and Duffy, 1996): (1) anchor all learning activities to a larger task or problem; (2) support the learner in developing ownership for the overall problem/task; (3) design an authentic task; (4) design the task and learning environment to reflect the complexity of the environment so as to enhance functional aspects of the learning process; (5) give the learner ownership of the process used to develop a solution; (6) design the learning environment to support and challenge the learner's critical thinking; (7) encourage the testing of ideas against alternative views and alternative contexts; and (8) provide opportunity for and support reflection on both the content learned and the learning process. Such nuggets fuel a variety of learning environments, thus enabling a strong atmosphere of active learning, inquiry-based or problem-based learning.

Problem-based learning strategies require some form of team-based collaborative environment that is similar to a case-based approach (Williams, 1992). The suggested teaching principles, including the CTGV are consistent and are inspired by constructivism (Summerby-Murray, 2001; Drennon, 2005). Whereas different language is used to describe Chickering and Gamson's seven principles for good practice in undergraduate education, the motivation for the teaching principles is the same. Adopting nuggets of constructivist teaching principles fosters strong collaborative learning environments enabling the growth of effective teaching practices, which can be used to set high academic expectations and close student performance gaps. This conceptual framework is the basis for the proposed *case-based modern-style pedagogical approach* (Figure 1). The use of this approach aims at maximizing the benefits of learning advanced technical concepts.

Materials and Methods

Study design

The study design comprised three evaluation instruments: (1) classroom observations, (2) content knowledge survey, and (3) oral and written interview protocols. Classroom observations were conducted during an eight-year period and recorded by using a set of standard assessment questions and grading rubrics. Content knowledge survey was conducted on a sample of forty students/subjects (n = 40) from three academic years between 2004 and 2006. All students who took advanced GIS during this three-year study period were requested to participate in this survey. Oral and written interviews were conducted at oral presentations and whenever the instructor met with each group before and after these presentations.

For the content knowledge survey, the first year class that was surveyed had twelve students (n = 12); second year had ten students (n = 10); and third year had eighteen students (n = 18). The sample was split into three time slices so as to glean unique experiences from each of them. In fact, the first time slice (spring 2004) consisted of those students already in the field, while the second time slice (spring 2005) consisted of those students who had just completed their education training, and the third time slice (spring 2006) consisted of students who were currently enrolled for the advanced GIS course. All of these study subjects used the same syllabi, the same case studies, and were taught by the same instructor.

The primary goal for conducting the content knowledge survey was to use it as an assessment tool for quantifying learning experiences from participating human subjects. The survey captured the attitudes of students after taking the courses based on three time slices: one group that took additional classes from other professors, another group included former students already in the job market; and the last one included a new group that was just beginning.

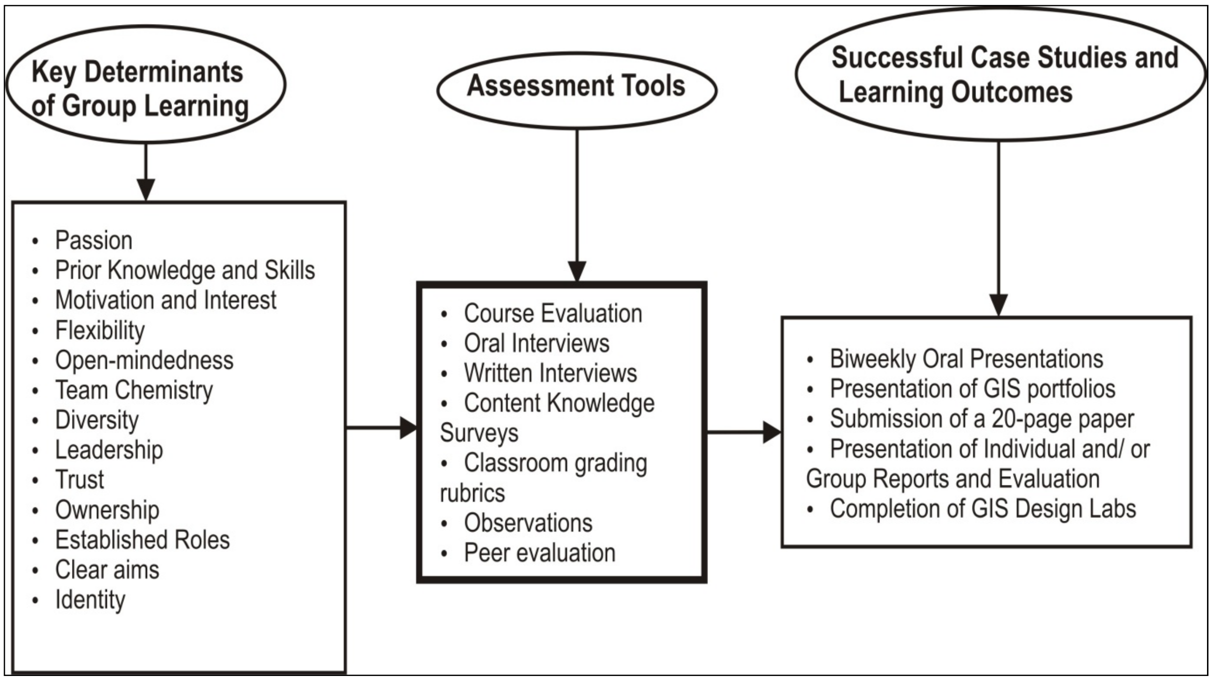

Figure 1 presents a framework for an active learning pedagogy

Results and Discussions

During the study period, they were 119 students who did the course. On average, about 15 students were enrolled annually. The official SIUC Instructor and Course Evaluation Reports for evaluating teaching performance for the study period, for the Question on whether the course was taught effectively on a scale of 1 to 5 (5 being excellent), the overall average score was 3.8 for the eight years. Regarding whether the course was good, the average score was 4.0 confirming further what the instructor observed during learning process both in the laboratory and classroom. The nine laboratory exercises also corroborated the data because, on average, students earned 90% or higher during the study period. This was followed by coursework, where on average students scored 87 or higher, then the midterms and course project scored 82 or higher. Consistently, the overall average score for the key graded items was 85 or better while the overall average score for instructor and course evaluation was 4.2.

A total of forty human subjects were surveyed for content knowledge and the survey had a response rate of 65 percent. Of these 36 percent human subjects were drawn from spring 2004, 24 percent from spring 2005, and 40 percent from spring 2006. The majority of subjects provided positive responses regarding pedagogical related questions and the usefulness of case studies. Overall, the findings are consistent with classroom grades obtained during the three year period. There was high level of enthusiasm and energy in the class. Although most of the students were able to adequately understand advanced GIS concepts some of the students remained confused regarding issues related to GIS data structures and algorithms.

The teaching and learning of advanced GIS must be demystified through innovative and practical approaches using case studies and everyday life examples of applied GIS applications. The findings support the premise that a pedagogical approach based on a well-designed case study drawn from the natural setting facilitates the learning and teaching of complex GIS concepts (Savery and Duffy, 1996; Summerby-Murray, 2001; Drennon, 2005; Favier and Van Der Schee, 2012). In thinking about the case study teaching model, deliberate emphasis was placed on the seven principles for good practice in undergraduate education (Chickering and Gamson, 1991), which entail encouragement of student-faculty contact, encouragement of cooperation among students, encouragement of active learning, provision of prompt feedback, time management, the communication of high expectations, and the respect of diverse talents and ways of learning. Recent work in GIS education (Read, 2010; Yang et al., 2011; Ma, 2011; Dahal et al., 2011; Harvey and Kotting, 2011; Fagin and Wilke, 2011; Favier and Van Der Schee, 2012) supports the development of an optimal design for inquiry-based, collaborative-based active learning approaches. This paper has effectively responded to this call.

Pedagogical Implications for Broadening Participation

In our GIS and Remote Sensing Program, we have registered tremendous success in broadening the participation of underrepresented populations in spatial science courses. This is in part due to the fact that we have carefully thought-out mechanics (i.e., how we recruit, teach, retain, assess etc.) and also because we have established benchmarks to measure educational performance and achievement. We prepare our students to acquire life-long educational skills and encourage them to think about spatial sciences as a way to relate, organize, and exploit places. We are firm believers of the active learning pedagogy and diligently use it to define successful pathways for the underrepresented populations. The increase in enrolment since 2003, especially among a few notable underrepresented populations, including White female, and Black and Hispanics race/ethnic groups, is a result of the following progressive strategies.

1. **The creation of specific diversity recruitment goals and targets.** SIUC’s long range plan “Southern 150” has a provision on the growing of diversity
2. **Empowerment through specific leadership roles**. Encouraging minority to take up group leadership roles in course projects
3. **Mentoring and identifying diversity champions**. Having successful minority play a key role as advocates or champions of spatial sciences
4. **Rewarding success and promoting success stories**
5. **Defining clear pathways to succeed and achieve success in Science, Technology, Engineering and Mathematics (STEM) fields**
6. **Building “pipelines” through core curriculum courses and outreach GIS activities**
7. **Engage in exciting spatial science field-based activities**

Reference

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