Critical Thinking, Knowledge Retention and Strife: Reflections on Active-learning Techniques

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Abstract

Common practice in delivering introductory GIS involves students sitting down with a computer and "doing GIS". Methods of implementing these laboratory exercises vary widely from cookbook-like recipes for GIS (or task) success to unscripted exploratory free-for-alls where students are often left to sink or swim on their own. Somewhere in between is the golden path to GIS enlightenment. Based on past and current experiences in the classroom we hope to elucidate some rules of thumb for successful active learning exercises and more importantly to bring to light clear pitfalls associated with these instructional techniques. In addition to laboratory exercises, possibilities for increasing active content in lectures will also be discussed. Our evaluation rubric will focus on the ability of each technique to stimulate critical thinking and lead to increased knowledge retention taking into consideration cognitive load and time management constraints of actively engaging students in complex problem-solving activities.

Keywords: critical thinking, education, GIS, laboratory instruction, pedagogy

1. Introduction

One of the most critical requirements in the development of GIS professionals is the introductory course. This is invariably the course that recruits new enthusiasts into the field of GIS. The effectiveness of this initial course, to establish a firm foundation on which the student can build a solid understanding of the subtleties and complexities of the practice, is critical not only to the success of the student, but ultimately to the success of the profession. It is with this sense of urgency that we turn our attention to elucidating the critical components of teaching an introductory GIS course. Specific emphasis is placed on laboratory instruction as it is our contention that a solid hands-on component of this course is essential to its success.

This is especially true in regards to GIS as in actual practice, GIS is far less about theory than it is about doing something given a particular context. Lave (1988 & 1996) argues that learning should be situated in a real world context in order to maximize the ability for students to develop knowledge that is truly effective when performing the same tasks outside of the class room. This extends not only to software systems but social systems as well. Creating convincing proxies of tasks similar to those that the student might encounter when they find work in the field will certainly help the individual to excel. In addition it is important to create a community of practice for students to become a part of in their quest for GIS knowledge (Fenwick, 2000). Indeed, active learning is not a spectator sport. To illustrate this point I have included the following student comments:

> *"The last lab, for me was the best. It incorporated everything that I had been doing previously in the semester and tied it together in a project form, very similar to how a project may come together in the real world"*

"One of the main reasons that I enjoyed this lab was that I could see it being used in many of management activities and the knowledge that I gained from this lab would be helpful in my future career"

Rogoff (1990, 1993 & 1995) proposes that learning involves development in personal, interpersonal, and community process. It is therefore imperative that we maintain a high degree of variety in our approaches to instruction. This point is underscored by the fact that learners fundamentally differ in the ways that they approach a given subject (Kolb, 1984, 1988). Kruzich et al (1986) refers to this as "a personally preferred way of dealing with information and experience that crosses content areas". These personal preferences are compounded by the fact that instructors also have their own learning preferences. The path of least resistance for an instructor results in a tendency to teach to accommodate the learning styles that are most like their own. As instructors, it is important to become aware of and to counter this tendency. Constantly challenging our own assumptions is an important first step. Actively seeking outside help by choosing a teaching assistant or lab instructor that compliments us well, by bringing a different learning style to the instruction team, can be quite effective.

But what does it mean to be an effective teacher? While there are many answers to this question, there is one idea that is at the core of most of them. Effectiveness in teaching should result in profound and deep understanding of the material being presented. This does not mean that learners are simply adept at being able to remember and repeat information but rather, that they have developed the skills that allow them to find and use this information (Simon, 1996). Proficiency in critical thinking is central to their ability to do this. It is therefore essential that we move students up the critical thinking ladder; from the unreflective thinker to the master thinker (Elder & Paul, 1996). To do this it is helpful to think not only of the learning objectives of the course but also the structure of the learning environment as it changes throughout the progression of the course. The remainder of this paper is devoted to illuminating a few of the critical dimensions of introductory GIS courses as they relate to teaching effectiveness.

2. Issues in GIS laboratory instruction

Having been involved in teaching GIS in the laboratory for a number of years, we have come up with four continuums that help to resolve issues critical in establishing a robust pedagogical setting. They are:

1. Step-by-step instructions vs. exploration
2. Individual responsibility vs. group work
3. Instructor lead vs. student lead
4. More content vs. less

By no means is this an exhaustive list of issues to be dealt with but in our experience they are the ones that deserve the lion's share of the attention. The discussion that follows, details our experiences and insights in the laboratory and our attempts to integrate various aspects of these issues as discussed in the literature, through our own introspection and most importantly based on direct student evaluations and feedback.

2.1. Step-by-step instructions vs. exploration

First of all we thought it important to deal with the issue of writing instructions for lab assignments. No matter who you are, if you have taught an introductory GIS course, you will have had to wrestle with this issue. Writing quality assignments is always challenging and if one hopes to accommodate multiple learning styles as well as maintain some variety though out the course it becomes even more complex. In this section we concentrate on the specificity and clarity of the instructions given to students in relationship to interacting with GIS software. Issues of variability along this dimension are addressed.

All too often lab handouts read like a cookbook or a computer help-desk transcript where the instructions painstakingly specify every minute detail of the task to be accomplished. To illustrate this point we have included the following excerpt from the beginning of a hypothetical lab handout.

"*Click on the word "File" in the file menu located at the upper left hand corner of your screen. A drop down menu will appear. Click open. The open file dialog box will then appear on your computer screen. Navigate to the folder C:\workspace. In that folder you will find the file named "Lab_01.mxd". Select that file and click the button labeled "Open".*"

While this instruction certainly represents an extreme end point on this continuum, it is meant to illustrate the point that one can certainly go too far in helping the students to navigate a given piece of software. At the other end of the spectrum that same instruction might read:

> "*Locate Lab_01.mxd on your computer and open it in ArcGIS*"

Though the first instruction virtually guarantees that the student will be able to accomplish the first task in the assignment, opening the map document, it also offers very little opportunity for the students to explore the software in whatever way they might see fit.

One of the most important learning objectives of any given lab assignment is the development of a rich and robust mental model of how to guide the software to accomplish numerous more general tasks such as opening a file or, in the case of GIS, projecting spatial data. These general tasks should be largely independent of the underlying software and represent practical examples of key learning objectives of the course. In so doing, not only will the knowledge acquired by the student be transferable to new versions of the software as it is revised, but may also apply more generally to similar software packages. In the case of file management this is fairly simple but these principles can also be applied to domain specific tasks as in the projection example cited earlier.

An obvious difficulty in choosing an appropriate level of detail in your instructions is the fact that today's university students are quite diverse in their levels of computer experience (Furst-Bowe et al., 1995; Sweaney et al., 2001). This means that a student with good computer skills will quickly become fed up with the instructions given in the first example. However, students without these computer skills would have little idea where to begin if given the second set of instructions. This issue is typically resolved with course prerequisites (i.e. a basic computer skills course) or simple self administered pre-tests but speaking from experience this does little to really address the problem of vastly different levels of student experience. A partial solution to this lies in the possibility of starting out more slowly by using a greater degree of detail in the beginning of the course and gradually weaning students off of this by giving less detail in the instructions as the course progresses. However, we find this approach less than desirable and opt in favor of varying the detail in our instruction in a more cyclical fashion while still decreasing the degree to which we lead them through the exercise as seen in Figure 1.

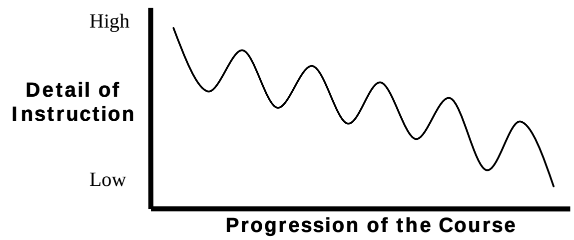

Figure 1: Step-by-step instruction vs. exploration over time

This achieves the same goal as the more linear trajectory while allowing the students to experience a number of instances of decreasing and increasing detail in the instructions, allowing them to more gradually become comfortable with exploring the software on their own. For more advanced students we typically include an overview so they can skip detailed instructions they already know and optional challenges along the way to keep them from getting too bored.

We have included some student comments that illustrate these points below:

> *"Clear instructions in labs 2, 3, and 6 gave me a feeling of confidence and interest in the material. The increasing difficulty in the labs, and my having to make choices once I was familiar with the program helped to really facilitate the learning process. This was well done in labs 8 and 9"*

> *"In lab 5 which is one of the hardest labs among the rest of it, we created our own personal geodatabase. This is the lab that we sort of treated as an intermediate test of what we learned. We have to throw in everything that we learned in this lab in order to have it complete. Even though this is a very tough lab to say the least, the amounts of knowledge we get out of it are definitely worth it, I personally think"*

> *"Since this lab didn't have much instruction, we had to go and look at old labs to find out many of the steps in order to be able finish this lab. This helps us to review the previous labs as well and see*

how each steps and instruction gets tied in to completing a project. This lab involved many critical thinking and it was great to be at the end of the semester, since it really helped to tie all the labs together"

Our point is not that one of these endpoints of the continuum is correct and the other incorrect but rather that neither approach should dominate the style of instructions given to students. Variation is the key to success. This helps students to stay engaged in their learning by challenging them in a supportive environment. By giving them a series of successes in solving increasingly more difficult problems with a reduced amount of directed support we hoped to foster a sense of comfort in the student's exploration of the software. This has the added benefit of engaging and testing the student's emerging conceptual model of GIS, whilst allowing them to incrementally build up task specific knowledge. This method of encouraging self-directed, active learning allows individuals with a great diversity in learning styles to approach their personal consolidation of knowledge in whatever way works best for them.

2.2. Individual responsibility vs. group work

The benefits of group work are often cited in the pedagogical literature and often this instructional method better approximates real life situations where professionals work in teams to solve a variety of problems. However, anyone who has taught a course where group work forms a large percentage of the student's tasks knows that this is not simply a matter of forming groups and turning them loose on a set of problems. Invariably there are a number of problems that crop up when assigning group projects. For example, assigning equitable marks is always challenging as individual performance can to some degree be limited by the collective. In addition to difficulties in assigning marks, personality conflicts can also be quite paralyzing to the group at times. Interestingly enough, this adversity is often one of the best reasons to incorporate group work into your class. By dealing with these conflicts in a supportive and mediated environment, students are exposed to a greater depth of context for the core material and subsequently learn more than just how to do GIS.

Incorporating group work still allows a large percentage of the course to be individual in nature. Students must also learn to function independently if they are to be effective contributors to a team at a later date. For this reason we typically start out the term with a very limited group component and progress to more substantial interactions later in the term. Related to this is the fact that many of the assignments that are considered individual work are often solved by groups. Students tend to band together into informal working groups in a laboratory setting and our philosophy is to encourage students to work together to solve problems whenever possible. For that purpose we have incorporated e-discussion groups into the course and try to foster an environment where students are asking questions of the group and as well as are taking responsibility for answering those questions. An example of this is illustrated in the student comment below:

"Task 11 was a group effort because it was sometimes difficult to discern which layer represented a particular feature, but it's a good thinking exercise. Task 12 on the other hand, seems so obvious now, but at the time I can remember struggling."

2.3 Instructor lead vs. student lead

For most instructors the idea of relinquishing some control of one's course can be a bit intimidating. This opens the door to possible chaos in the classroom which would benefit no one. In addition, for some, the idea of having students do the teaching makes little sense as students have signed up for the course to learn not to teach. In fact, many students themselves are resistant to this idea for similar reasons. They are typically paying to attend an academic institution and some have voiced the concern that if they were tasked with doing some of the teaching they would not be getting their money's worth. However, we should keep in mind that learning is the the primary objective when teaching any given course. If, for example, students will in fact learn more by teaching (a fact most teachers can attest to) then it would be remiss to back away from a potentially valuable and effective method simply to placate those in opposition.

While instructor lead teaching is unquestionably the norm, it can be successfully augmented by increased student involvement in leading the course. That is not to say that students should teach themselves. This would clearly not work. Even if some component of the course is student lead, instructors must be responsible for the largest part. Instructors must lead the course, either as lecturer, mentor or facilitator. In the case of GIS education this is particularly true as the content is both expansive and highly technical. The broad scope of GIS requires instructor based teaching to help students grasp the broad concepts. As GIS instructors, we must deliver this content in the most parsimonious and effective manner possible. Once this mental model of GIS has been understood, student based teaching can be effectively used to "fill in the gaps" in the conceptual model.

The reason this method is successful is that student lead pedagogy better adapts to the constructivist nature of learning. The basic principle at work here is that new knowledge must be connected to existing knowledge to be best retained by the learner (Bruner, 1960). Student lead activities help an instructor, often separated by age and culture, to include context sensitive content to the course. By allowing the students to bring their current experiences, in the program or otherwise, to the course, increased relevance and therefore connection to past learning can be achieved. Heterogeneous student bodies, such as adult learners, make this more challenging but not untenable. To help make this point we have included the following excerpt from our student's summative course evaluation.

> *"Furthermore, presenting a topic requires a sound grasp of the material being presented. The benefits of presentation are therefore twofold: understanding of the subject and concepts involved, as well as the development of practical speaking skills and peer review. In this course, labs 4 and 10 were strong points because they integrated these important skills. Even a brief presentation, such as those that were done on our final maps, vastly increases the subject retention by the individual"*

2.4 More content vs. less

As an instructor, one of the most serious pitfalls is the urge to incorporate too much content in one's course. This is true for both breadth and depth of the topics covered. Often the architect of a course has unrealistic dreams of how much a student in their course can absorb in a given term. This is especially problematic for those of us who are passionate about the material that we teach. While understandable, it is a most insidious desire and if left to run unchecked, will increase with time as new interesting content and details are uncovered. It is obvious that the opposite end of this continuum, in most extreme case, is also untenable. Any good introductory GIS course must cover certain basic aspects of course content (NCGIA core curriculum, 2005). In effect, this limits the practical aspects of setting this endpoint in terms of breadth, even though there are no clear guidelines regarding the depth to which these aspects of course content are treated. To some degree the number of credit hours assigned to the course sets this but there are wide fluctuations in how that is expressed across institutions.

Insights can be drawn from the educational literature. Prior learning assessments can help to anchor expectations (Smith, 1990). By applying prior learning assessments wisely, minor modifications in pedagogical methods as they are employed in the course can be made to be more precise in achieving desired learning objectives. This concept should also be applied at the curriculum level by integrating program level learning objectives to more accurately gauge appropriate educational targets for individual courses (Diamond, 1997, 1998). Often this is overlooked, as truly integrating learning across the curriculum can be a Herculean endeavor (Stark et al., 1997).

Overwhelmingly, student response to this is clear; more content is not preferred.

> *"Lab 5 was a weak point in the lab curriculum. …the lab took an inordinate amount of time when there was a lot of other things going on in the term. Lab 5 was simply too long."*

Students are often asked to assimilate huge quantities of content (information) but the key to successful higher education is fostering the internalization of knowledge in the learner based on creative presentation of the facts, rather than focusing on ensuring that the listed facts are exhaustive. That is to say we should be moving up the hierarchy of learning objectives (Bloom et al., 1956).

The answer is almost certainly found via balance and flexibility (Aitken, 1982). Balance, in that the course must challenge but not overwhelm the student body as a whole, and flexibility so as to recognize and accommodate a diversity of learners. Most importantly, achieving balance and flexibility requires that the instructor ensure that the course itself does not become entrenched. Every group of learners is unique. They start in different places, are composed of varying distributions of individuals and progress at different rates. If an instructor is unwilling or unable to respond to those changes then it is clear that the course will be suboptimal.

3. Application in Lectures

While the discussion thus far has focused on laboratory instruction it is also important to turn our attention to the lecture component of GIS instruction. In order to be most effective, lectures must work in concert with the lab exercises by providing the students with a solid grounding in the theoretical underpinnings of the applied exercises. However, it is insufficient to simply schedule lectures to coincide with lab exercises. Some degree of integration is needed. One method for achieving integration is to link the lecture content back to previous labs. Additionally one can start off lab sections in much the same way, referring back to lecture content that will be used in a particular assignment. This helps students to make the connections between lecture content and practical application. Explicitly stating learning objectives at the beginning of each lesson (lab or lecture) is also advisable. This helps the student to understand what they should be taking away from a given lesson and allows them to assess their progress in the course.

Another critical aspect of effectiveness in a lecture setting is related to issues of timing, tempo and style. Given that the attention span of an adult is approximately 10–15 minutes, varying your delivery in longer sessions can significantly increase factual recall in learners (Johnstone & Percival, 1976; Cantillon, 2003). This can be accomplished by including active learning components in your lectures such as questioning exercises, think-pair-share or other activities. It is important to be creative in structuring the flow of your lectures as well as being true to your self as these techniques are less effective if the instructor is uncomfortable with them.

Timing, tempo and style are important because the human brain does not function as a video recorder. We need time to integrate what we have learned by associating discrete chunks of information with similar knowledge already assimilated. This is why the pre-assessment of our students is so essential. We need to know what we are trying to connect things too when we first begin teaching a course. This becomes easier as the course progresses as we are able to tie into things we have already delivered. Once we have succeeded in delivering a kernel of wisdom then we must allow our learners to practice that concept in order for memory consolidation to occur. This is the central concept behind interlinking lecture and laboratory exercises. One reinforces the other and allows multiple exposures to information to be learned from multiple perspectives, thereby increasing the likelihood that a particular pedagogical method will hit home.

If your goal is to enable higher level learning to occur, teaching methods which encourage student activity and involvement are preferable to more passive methods (Sorcinelli, 1991). This is particularly effective if students are actively engaged in collaborative learning techniques. This moves them out of their traditional role of passive absorption and forces them to become the "teacher" in order to explain their own internalization of the material to their peers. This gives them the opportunity to practice with concepts important for them to learn. This also transforms the classroom into a social learning situation as opposed to a solitary one.

Another aspect of effective lecture instruction is related to the content continuum previously discussed. Given a finite amount of contact hours with your students and the fact you need to break up the lecture every 10–15 minutes, it is imperative that you cover the right amount of material in each lecture as well as over the course of the semester. The initial tendency for most instructors is to view all of the content as critical. This leads to lectures that move too fast and are ineffective in facilitating learning. While the instructor feels justified in covering all the required material, one must ask what the students have gotten out of it. Over the years we have found that an incredible amount of content can be covered by less traditional means if dealt with creatively. By distilling the lecture messages to their essence, more time is left for learning. Details and subtleties can then be uncovered actively by the students in a well designed laboratory exercise. This again underscores the importance of a well integrated course that weaves its learning objectives through out its entire fabric.

4.0 Conclusions

While we can not offer perfect solutions to all the issues brought to light in this article we can help to raise awareness of the importance of considering these dimensions when planning a new course or revising an existing one. We strongly encourage our colleagues to think deeply about the issues presented and hope that our analytical framework is helpful in this regard. The answers lie not in a one-size-fits-all solution but rather in careful consideration of paths to take. This is a complex task and one should never discount the power of creativity and insight to aid in the navigation of this rocky terrain. The ground is always shifting underneath our feet and the departure point and target are also always in motion. It is no wonder that we sometimes miss the mark. It is our contention that by acknowledging this complexity and approaching it from multiple perspectives (i.e. maintaining a high degree of variability in pedagogical methods) that our likelihood of success will dramatically increase.

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References

Aitken, R. 1982. *Taking the Path of Zen,* North Point Press, New York.

Bloom, B., Englehart, M., Furst, E., Hill, W., & Krathwohl, D. 1956. *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. New York, Toronto: Longmans, Green.

Bruner, J. 1960. *The Process of Education*. Cambridge, MA: Harvard University Press.

Cantillon P. 2003. ABC of teaching and learning in medicine: teaching large groups. *BMJ* 2003, *326*: 437-440.

Diamond, R. M. 1997. Broad curriculum reform is needed if students are to master core skills. *The Chronicle of Higher Education, 43*(47), pB7.

Diamond, R.M. 1998. *Designing and Assessing Courses and Curricula*. San Francisco: Josey-Bass Publishers.

Elder, L., & Paul, R. 1996. Critical thinking: A stage theory of critical thinking: Part I. *Journal of Developmental Education, 20*(1), 34-35.

Fenwick, T. 2000. Expanding conceptions of experiential learning: A review of the five contemporary perspectives on cognition. *Adult Education Quarterly, 50*(4), 248–272.

Furst-Bowe, J., Boger, C., Franklin, T., Mcintyre, B., Polansky, J. & Schlough, S. 1995. An analysis of required computer competencies for university students. *Journal of Research on Computing in Education*, *28*(2), 175-189.

Johnstone, A. H. & Percival, F. 1976. Attention breaks in lectures. *Education in Chemistry*, *13*, 49-50

Kolb, D.A. 1984. *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice-Hall.

Kolb, D.A. 1988. Learning styles and disciplinary differences. In A.W. Chickering, (ed.) *The Modern American College.* San Francisco, CA: Jossey-Bass.

Kruzich, J.M., Friesen, B.J., & Van Soest, D. 1986. Assessment of student and faculty learning styles: Research and application. *Journal of Social Work Education*, *3*: 22-30.

Lave, J. 1988. *Cognition in practice: mind, mathematics, and culture in everyday life.* Cambridge, England: Cambridge University Press.

Lave, J. 1996. The practice of learning. In S. Chaiklin and J. Lave (eds.), *Understanding Practice: Perspectives on Activity and Context.* Cambridge, England: Cambridge University Press.

NCGIA core curriculum, n.d., Retrieved May 27, 2005, from http://www.ncgia.ucsb.edu/giscc/cc_outline.html

Rogoff, B. 1990. *Apprenticeship in thinking: Cognitive development in social context.* New York: Oxford University Press.

Rogoff, B. 1993. Children's guided participation and participatory appropriation in sociocultural activity. In R. Wozniak and K. Fischer (eds.), *Development in Context: Acting and Thinking in Specific Environments.* Hillsdale, NJ: Erlbaum.

Rogoff, B. 1995. Observing sociocultural activity in three planes: Participatory appropriation, guided participation, and apprenticeship. In J. Wertsch, P. del Rio, and A. Alvarez (eds.), *Sociocultural Studies of the Mind.* Cambridge, England: Cambridge University Press.

Sorcinelli, M. D. 1991. Research findings on the seven principles. *New Directions for Teaching and Learning, 47*, 13-25.

Simon, H.A. 1996. *Observations on the sciences of science learning.* Paper prepared for the Committee on Developments in the Science of Learning for the Sciences of Science Learning: An Interdisciplinary Discussion. Department of Psychology, Carnegie Mellon University.

Smith, R. M. (Ed.). 1990. *Learning to learn across the life span.* San Francisco: Jossey-Bass.

Stark, J. S., Lowther, M. A., Sharp, S., & Arnold, G. L. 1997. Program-level curriculum planning: An exploration of faculty perspectives on two different campuses. *Research in Higher Education,* 38(1), 99-130.

Sweaney, A.L., Manley, K.S., Meeks, C.B., & Valente, J.S., 2001. Computer experience and skills of family and consumer sciences undergraduates and professionals. *Education, 121* (4), 773-780.

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