How Much Instructions Are Needed For a Good GIS Map?

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Abstract. Geographic Information Systems (GIS) education is flourishing in GIS certification and academic programs. A *GIS cartography* course is becoming an essential component of such programs.

Creating a *GIS cartography* course to teach GIS analysts is a challenging task, especially if the objective of the candidates of such certification or degree programs is mainly mastering the GIS technology for solving real world problems.

This paper deals with the discussion of how much of the cartographic design principles, and how deep one wants to go into, in teaching such analysts enough to make them productive, and be able to create good, acceptable, and communicating maps.

This paper will go through the standard basic cartographic design principles and evaluate their effectiveness and practical use for such GIS analysts.

The structure of the designed lectures of the *GIS cartography* course is analyzed to check what works and what does not work for the GIS analysts. This is mainly deducted from how the course was developed over more than fifteen years that the author had taught such courses in these kinds of programs.

The structure of the designed exercises of the *GIS cartography* course is also analyzed to check their usefulness.

A check list was created and developed over the years of what critique questions a GIS analyst should ask himself or herself when designing a map. This check list is also analyzed and discussed.

The length and duration of these *GIS cartography* courses is also analyzed to determine how many meetings and how many hours per meeting will be necessary for maintaining an ample time of exposure with the students so they attain the proper proficiency in creating GIS maps.

This paper will demonstrate the results of teaching this *GIS cartography* course for over fifteen years in such programs, concluding that there is certainly a limit of what is needed to be taught as compared to similar programs that graduate people in pure cartography (not GIS-related environment).

The paper will be presented with some example maps created by students repeatedly and progressively over the history of teaching this course supporting the findings of this paper.

Keywords: Map Design, GIS Education, Visual Language for GIS, Map Critique

1. Introduction

There are many GIS or geospatial certification programs which offer cartography as part of their curricula. Here are few examples from the United States:

1. Loma Linda University, School of Public Health (LLU 2013) offers the *ENVH 521: Cartography and Mapping* course.
2. Penn State University (Penn State World Campus 2013) offers the *Geog486: Cartography and visualization* course.
3. San Francisco State University (SFSU 2013) offers the *Geog 9009: Cartographic Design for GIS* course.
4. The University of California, Riverside Extension (UCR-Extension 2013) offers the *Visualization using cartographic design and Web services* course.

A more extended list is reported by Wayne (2003). While Wayne was interested in how many graduate GIS certificate programs include a dedicated course in cartography, this paper is more on how much cartographic instructions are needed for a person graduating to become a GIS analyst.

The concept of having cartography as a core geospatial ability and knowledge required by those graduating in the GIS field is well recognized in several reports, e.g. DOLETA (2010) as reported by DiBiase (2010). The author (2003) reported the importance of a *GIS cartography* course because GIS analysts more likely lack any cartographic training while studying for their field of specialty, e.g. geology, engineering, environmental science, etc...

The author (2009) also reported that *while traditional cartographers would favor to comprehensively teach GIS analysts all the detailed theory and concepts of cartography, however, from the practical point of view one would limit such concepts to only what is useful and practical. The reason for this is that the majority of these GIS analysts (based on the author's experience in teaching GIS at a GIS software company), are specialized in applied sciences, where their job duties in most cases might require them to create a fast map for decision makers to make use of. Some of these analysts have to respond even faster especially when dealing with emergency response conditions. Esri's GIS software through its progress has resulted in introducing more tools for speeding up the mapping production time for such analysts. Coupled with this, Esri offered training for such analysts to support them in obtaining the required skills to use such tools.*

The above report listed sixteen different milestones that contributed to the speeding up of the mapping process while sustaining good cartographic products.

1.1 The challenge of creating a *GIS cartography* course

Creating a *GIS cartography* course to teach GIS analysts is a challenging task, especially if the objective of the candidates of such certification or degree programs is mainly mastering the GIS technology for solving real world problems. The author (2003 and 2009) outlined and discussed the details of such a course in an effort to propose a standardized model of such a course for GIS analysts. The course is built on critiquing maps as an essential tool in the learning process. Figure 1 shows the general structure for the *GIS cartography* course for GIS analysts which was proposed by the author in 2009.

The conclusion drawn in this paper is based on the author's extended experience in teaching GIS analysts whether at Esri or in universtities and colleges in Southern California. This is also suplemented by students evaluation

of the course as well as sending maps to him after they graduate to show how good their maps were because of taking that course.

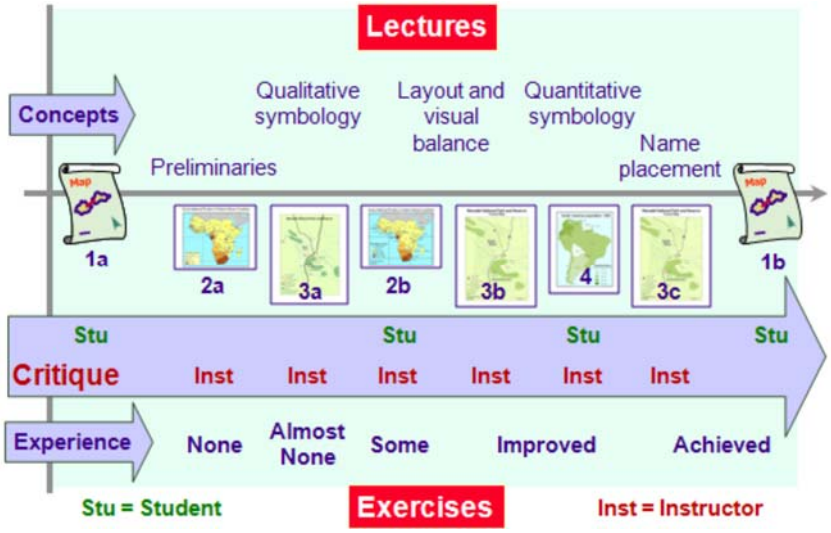

Figure 1. The *GIS Cartography* course as proposed by the author (Murad-al-shaikh, 2009)

A *GIS cartography* course for GIS analysts, in the author's opinion, should be designed with the objective to teach cartographic design based on how people would be *using* the map, i.e. how *useful* is the map to its reader, rather than focusing on the art in cartography, i.e. making the map beautiful. It is consoling that other cartographers agree with this, e.g. Wood (2003). The author, however, always preaches that if the map looks also beautiful, it would be an added advantage but it should not be the main focus of his students when designing their maps.

1.1 How many hours are sufficient?

The duration of a GIS Cartography course depends on the university or college GIS certification program. This also depends if the students are already familiar with the GIS software they are using.

In the case of the example the author is presenting in this paper, students are using the Esri's ArcGIS for Desktop software and, during projects, ArcGIS for Server. Also a pre-requisite was set for the *GIS Cartography* course where students should have already taken an introductory course on

the use of the GIS software, so that the *GIS Cartography* course will only be limited to learning the skills on how to create a useful and communicating map.

Based on the above criteria, the author feels comfortable teaching such a *GIS cartography* course in 25 to 30 hours. From the experience of the author these hours can extend anywhere between 8 to 10 weeks. In some cases these can also be taught during weekends for students' convenience especially for those who are in the process of changing careers to GIS analysts. Students thought these hours were sufficient to teach them the concepts and be productive almost immediately in their GIS career.

2. Dissecting the cartographic design principles

In order to discuss how much of the cartographic design principles, and how deep one wants to go, in teaching GIS analysts, enough to make them productive and be able to create good, acceptable, and communicating maps , the following is a discussion of such reasoning why some of the terminology used in pure cartography programs might not be suitable or practical for GIS analysts.

2.1 Visual variables vs graphic charactersistics – a focus on terminology

When searching for the term *visual variable* in multiple cartographic publications, it certainly shows that it is a very popular term in the cartographic discipline. However, the author experimented with his GIS analyst students asking them what did they think the visual variable means before he started explaining this concept to them. It was disappointing to learn that very few could figure out what this term meant in English, at least for the GIS analyst students.

Checking further in other literature it was a relief to discover that some scholars realized the importance of coming up with a different terminology that is easier to understand and decided on a more practical terminology like *basic graphic variables* (Kraak and Ormeling, 2003), or *symbol visual dimensions* (Dent, 1999). The author would further suggest a simpler term: *graphic characteristics*. This concept, in the author's opinion, emerges from the fact that a symbol that makes it to the map, must have gone through a series of decision making and graphic enhancements on its *characteristics* until it becomes a final symbol. The GIS analyst does that as he

or she explores different existing symbols or creates new ones to choose for his or her map. Most of the author's GIS students agreed that *graphic characteristics* was easier to understand and predict its meaning than other terminology.

2.2 Classifiying map's hierarchical organization

Robinson et all (1995) discuss the internal graphic structuring of a map in terms of a *hierarchical organization process* in which they list three kinds of such organization: stereogrammic, extensional, and subdivisional. Krygier and Wood (2005) refer to these as *intellectual and visual hierarchies*. Dent (1999), and Kraak and Ormeling (2003) simply refer to them as *visual hierarchy*.

While the author teaches these concepts, he stresses how to *use* them to enhance the map more than on what to label them. In the final exam of the course, instead of referring to these concepts as divided into the above-listed three kinds of organizations, he asks students to apply them graphically on a previously designed dedicated graphics to test for understanding of the students whether or not they can apply the enhancment without referring to them by such names. The exam question would read: enhance the following graphic to show, say, different visual levels to the map reader. The author is still working on how to simplify the terminology on this concept for GIS analysts and certainly welcomes any suggestions.

2.3 Choroplethic maps vs administrative maps

Almost all cartographic literature list such maps, that are related to administrative boundaries, as choroplethic maps. While the term choropleth has become standard in pure cartographic academia, however, to the GIS analyst it is another hard to learn term that is coming from another discipline. The author suggests to replace it with *administrative maps* because it is simpler to relate to by these GIS analysts. *Qualitative*, or as sometimes referred to them as *categorical* thematic maps (Brewer, 2008), and *quantitative* thematic maps can be the subclasses for these administrative maps.

3. Dissecting the teaching tools

Teaching tools simply represent the lectures and exercises used in passing the concepts to the learners. The following is a shortened version of the discussion presented by the author in 2009.

3.1 Designed lectures

The structure of the designed lectures of the *GIS cartography* course was very well thought off and developed over the years to check what works and what does not work for the GIS analysts and as being taught in GIS certification programs.

The lectures portion of the *GIS Cartography* course included delivery of the concepts listed in Table 1.

Introducing GIS and contemporary cartography
Cartographic design principles and the communication channel
Projections
Symbology and color in cartography
Generalization
Statistical mapping
Name placement
Map critique

Table 1. Typical contents of a *GIS Cartography* course taught in colleges and universities in California, USA. (Murad-al-shaikh, 2003)

A typical teaching procedure for such courses would contain lectures on these topics, heavily loaded with example maps, followed by a reinforcing exercises of a map design applying the concepts learned. Earlier, Figure 1 showed the general structure for the *GIS cartography* course for GIS analysts which was proposed by the author in 2009.

3.2 Designed exercises

The structure of the designed exercises of the *GIS cartography* course is was very well thought of to check their usefulness for GIS certification programs.

The exercises build upon themselves, so students might design the map twice whereby improving their map after more lecture topics are learned. Figure 1 showed how frequently student's maps are updated and critiqued. Two such maps, one qualitative or categorical and the other quantitative undergo such repetitative update and critique. This gives students the op-

portunity to improve their maps and benefit from someone, in this case the instructor, to critique their maps and offer pertinent improvements.

Some maps are critiqued by the students to test if they can discover any issue in their map. Students create their maps in Esri's ArcGIS software.

Maps were created and printed in color on the same printer to have fair evaluation of the students' performance when compared.

With the recent increase of web maps and the availability of GIS software that allows publishing map services, e.g. Esri's ArcGIS for Server, designing internet or maps created for projection devices, were recently encouraged in the form of a project. This way, students would learn how to design for another media and not be limited in learning how to create maps for print.

3.3 A map critique checklist

The author created a checklist in 1996 when he first started teaching *GIS cartography* courses at universities and colleges in Southern California. This checklist was used by students in map cririquing ever since. The checklist was also adapted in the *Cartography with ArcGIS* course that the author included when he wrote it in 2003. The author of this list attempted to use simpler language and terminology suitable for those who are studying to become GIS analysts. This checklist was designed for students who were taking the *GIS cartography* course where all the used terminology were explained during lthe lectures. The checklist appeared in the proceedings of ICC2003 (Murad-al-shaikh, 2003).

Also in 2003, the author used the same checklist when presenting a preconference seminar on cartography at Esri's International Users Conference. The list was shortened and edited in 2004.

In 2006, the author started a new activity within the annual Esri's Intrenational Users Conference. He called it the *Map Critique Station*. Its objective was to have GIS analysts, who attend the conference, bring their maps to be critiqued by professional cartographers who work at Esri as well as volunteer cartographers who are attending the conference. The author distributed the same 2003 checklist to those critiquers and were also given out, on request, to the conference attendees who participated at the Map Critique Station.

Esri's Mapping Center (ca 2010) printed a one page list called *Map Evaluation Guidelines*. While this was an additional attempt to create a checklist for distribution, it did contain few items that were too much detailed than necessary for GIS analysts's practical use. Two such examples are: trying to

classify the map objective into two types *affective* objective and *substantive* objective. While this detailed terminology, although briefly defined within the document, is more valid for students who may be studying to become cartographes, it is certainly not suitable for GIS analysts. They simply want to deal with an easier to use terminology. The author's view would have been to simply remove these two terms and keep their simpler definitions.

Later Buckley and Field (2011) published another checklist *for compiling more effective map*. This was more an article with an attempt to explain, with map examples, concentrating more on the content of the main map body and left out the other map elements and the visual balance of the map. The latter was then supplemented with another article by Buckley (2012).

The author still thinks that that the 1996 checklist (created orginally for the author's course at universties and colleges) and the 2003 checklist (created for Esri's cartography course) are still valid for GIS analysts.

4. Conclusion

Cartographic design principles should be delivered differently to the GIS analysts as compared to the traditional cartographer. The GIS analyst tends to create his or her map sometimes in haste. Because they mostly come from applied sciences or technologies, these GIS analysts need simpler terminology when studying the cartographic design principles. Their design objectives should be focused more towards the effectiveness of their maps in their usage rather than how beautiful they look. The cartography course they take should be limited to what they need to learn with simpler terminology.

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