GIS CARTOGRAPHY COURSES IN GIS CERTIFICATION PROGRAMS

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ABSTRACT

With the advance and increase in popularity of the Geographic Information Systems (GIS) software, e.g. ArcGIS by ESRI, Inc., we see more colleges and universities starting to offer GIS certification programs of some sort. It is inevitable that these programs should include a course in GIS cartography, as the end product of any GIS analysis is a map. While the inclusion of a GIS cartography course in these programs is a healthy trend, one should not overlook the problems of what to include in such a course, how this course is taught, and who is qualified to teach such a course when the main objective of the course is that all students should learn how to make the best use of a GIS software in creating a *useful* and *easy to use* map. This paper will demonstrate the author's experience in the design and teaching of a GIS cartography course within such programs where the issue of communication is well stressed in the design of the course for the purpose of creating a useful and easy to use map.

1. THE NEED FOR A GIS CARTOGRAPHY COURSE

1.1 Introduction

During the first couple of years of the author's work at ESRI, and while teaching the software and observing maps at the ESRI's User Conferences, he discovered several interesting patterns in the course attendees and the map designers: That the majority of GIS employees lack formal cartography training; That they seem to accept software defaults as standard cartographic practice which they thought were based on correct cartographic research findings (simply because the software was written by a well-known company); That they seem to take it for granted that a scale bar is everywhere correct on the map without regard to a projection type; That they can simply use any projection they like despite the type of data or theme they want to depict in their maps; That they seem to think that all maps must have a scale bar or a north arrow regardless of the topic of the map; That they lack the basic knowledge of basic communication skills to design legible map symbology and apply the proper design guidelines by visually balancing the map to guide the map reader to read what is more important first, and go to the less important next.

The following is a sample of some of the few more specific cartographic problems that were observed by the author:

1.2 Adding a not-so-useful scale bar

Based on the scale bar frame that one might set, the software will draw a scale bar to fit that extent. This will force the creation of odd and not-easy-to-use scale intervals. The scale bar is a graphic equivalence of a fraction scale. It is originally designed as an aide to the map user in the field for making approximate measurements of distances on the map in real world units. The user has to mentally divide the interval to get the sub-interval readings. Figure 1 shows an example of this bad scale bar design. A 7000 interval cannot be mentally subdivided with ease. The 7000 interval to the left is even more confusing as it is subdivided into five subdivisions instead of seven resulting in a fraction division. Cartographic and software ignorance of the software user would help create this discrepancy in the final map.

1.3 Adding an incorrect scale bar

In one client site, the client showed the author a map that they have been using and giving away since two years. When the author looked at the map, he discovered that the scale bar was extremely unrealistic relative to the features extent that was depicted. Figure 2 shows this example. Although they were safe because this map was mostly used for police assignments to beats (the police already knew the city and never looked at the scale at all), however, one should be more cautious when the software simply results in an awkward scale bar, otherwise the map readers would believe what one places for them on the map.

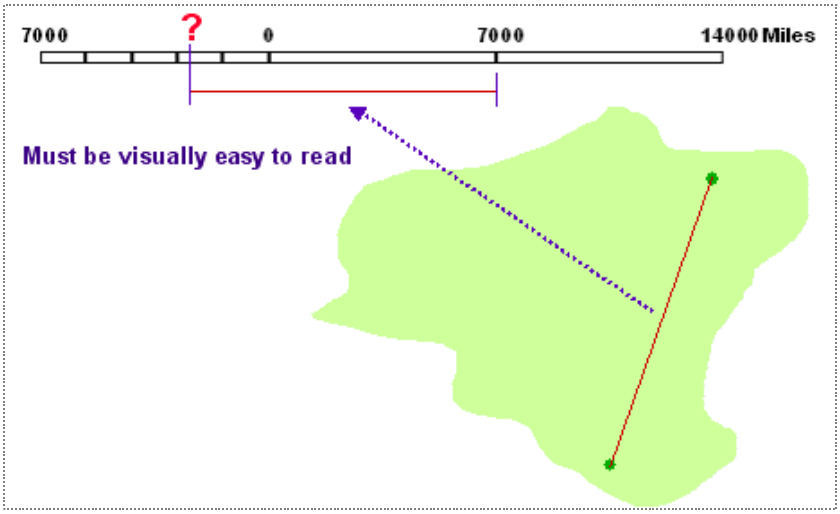

Figure 1. Accepting GIS software defaults. This scale bar is not easy to use.

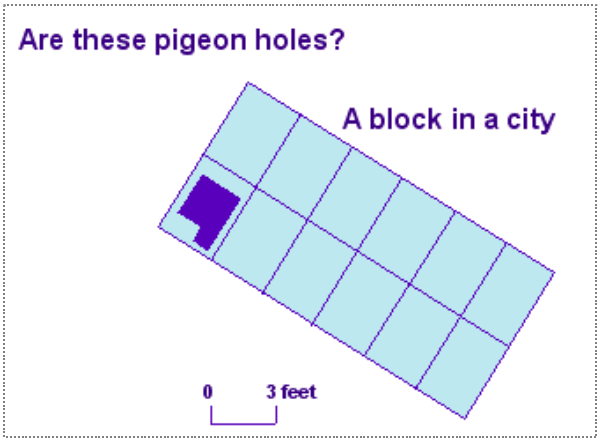

Figure 2. A non-realistic scale bar resulting from ignorance and/or from the use of software defaults.

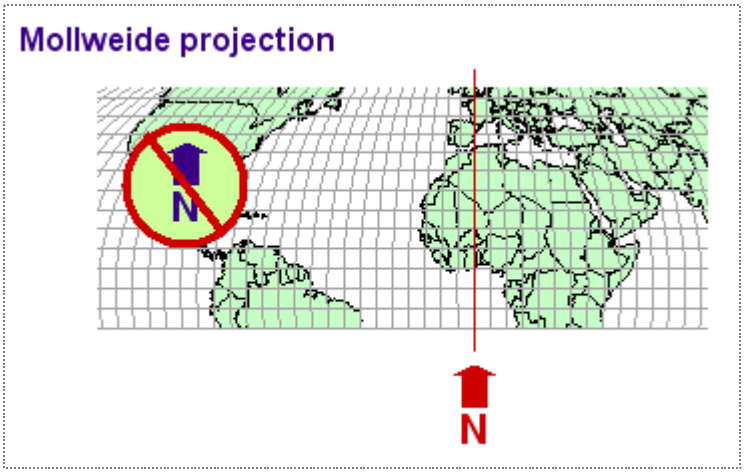

Figure 3. North is not true everywhere on the map.

1.4 The North arrow issue

The type of projection one uses for a map will dictate where the North arrow is correct. There is a misconception among GIS software users who have no formal training in cartography or projections that the North arrow is correct

everywhere on the map regardless of the projection used. So, they plug the North arrow in the map without showing the projection type used, or without disclosing a statement on where on the map is this North arrow correct. Thus, the map-reader is misled by this information. See Figure 3.

1.5 Is the North arrow or the scale bar necessary on every map?

Some software when instructed to create a map layout, would throw into the map a dark scale bar and a dark North arrow by default. These would attract attention at the wrong time when reading a map. In cartographic design one avoids secondary map objects to appear more conspicuous, such as a dark or black North arrow symbol or a dark scale bar. At times, these two map objects are not even needed to appear at all on the map. Figure 4 shows an example of a population density map where both the scale bar and the North arrow are redundant for the topic this map is trying to achieve.

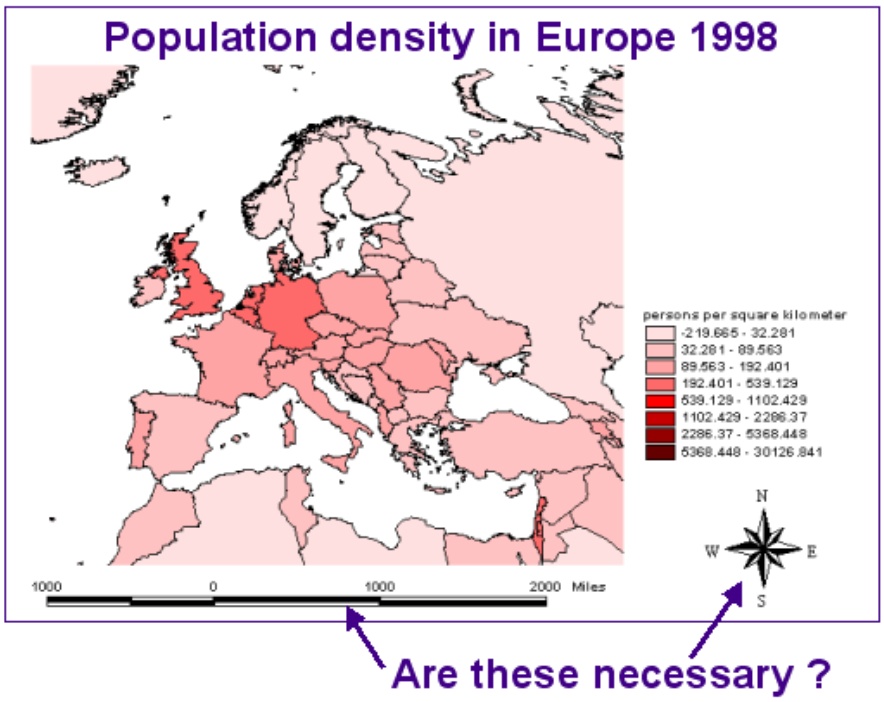

Figure 4. Inheritance of default map objects that are redundant.

1.6 Text size, symbol size and map viewing distance

Many a time, one would try to read a map at a distance, which might not be the distance the original map was created for, or the map designer might not have tested the size of his/her symbology or text at the distance the map will be viewed at. Many maps are placed on walls while they were originally designed for being read held in a hand and to be viewed at a shorter distance. Figure 5 shows a relationship between the smallest symbol size (a) and the viewing distance (b). The 2' angle is the minimum size angle required in cartography for selecting the (a) minimum symbol size to be viewed at the (b) distance. One can practically test legibility of his/her symbology by getting up from his/her chair move away from the screen to a (b) distance and check to see if the smallest (a) symbol size is still legible.

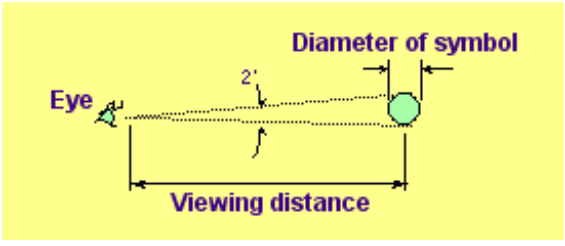

Figure 5. Can the symbols or text be deciphered at the viewing distance?

1.7 Wrong projection choice

If one were not careful, he/she would select a wrong projection for his/her data and thus will end up mapping the wrong impression. Areas can be exaggerated when one moves further away from the equator on a Mercator conformal

projection. This projection will not be a good choice if one is trying to convey area-related data, such as the population density.

1.8 Wrong number of classes in a choropleth maps

While the GIS software allows the use of almost unlimited number of classes, yet the human eyes are limited to how many colors or shades of the same color they can decipher in one map. Lack of knowledge in color perception capabilities of the eyes will result in perhaps beautiful maps but not useful or not easy to read.

All these examples point somewhere or another to how the cartographer should consider these issues, and perhaps others, when trying to communicate with the map-reader. Figure 6 shows a flow diagram illustrating the communication channel concept. The cartographer would have looked at all the data, and would have even visited or lived in the place where he/she is creating a map for. He/she then selects what is in compliance with the map objectives, starts using his/her cartographic skills to select, classify, and simplify the data, and later symbolize the map. The map reader receives the map, reads it, analyzes it, and interprets its (and sometime infer beyond what the map depicts). He/she does this in order to create his/her own mental image of the reality that was known to the cartographer. Unfortunately, the map-reader activity cannot result in a 100% true image of the reality as seen by or known to the cartographer. This is why the cartographer needs to be cautious of what symbols to use and how to depict them in the map in order to improve the quality of the reality imagined by the map-reader through these symbology. The topic of correct and effective communication becomes the main objective when creating a GIS cartography course for GIS certification programs in colleges and universities.

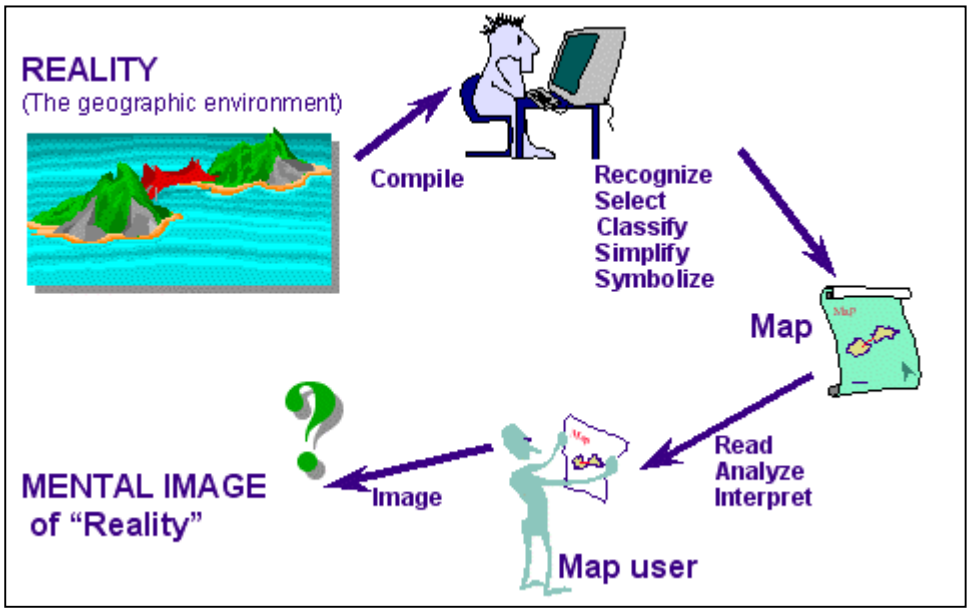

Figure 6. The communication channel.

2. THE COURSE DESIGN

During the course of years and while working for ESRI, the author was called upon to design and teach GIS cartography courses for different durations of time. Most of these courses were for colleges and universities in California, USA and within the vicinity of where the author lived. The following table shows these example situations:

Table 1. GIS Cartography courses in different colleges and universities in California, USA

College or University	No. of meetings	Hours of lectures per meeting	Hours of exercises per meeting*
1. San Bernardino Valley College 2. Riverside Community College	18	2	2
3. University of California – Riverside Extension 4. California State University – San Bernardino Extended Learning	10	1	2

Students have access to the Lab room to finish their maps on their own time if two hours were not enough.

At one time the GIS Cartography course was requested by a client site (Dade County, Florida, USA) where they wanted to have a two and a half day of basic cartographic principles course in order to improve their GIS staff's cartographic knowledge and thus produce better maps. The author offered two days of intensive lectures. The remaining half data was dedicated to a map-critiquing workshop.

3. TYPICAL CONTENTS OF A GIS CARTOGRAPHY COURSE

Table 2 shows a list of typical contents for a GIS Cartography course. These topics form a good structure of basic cartographic principles that students find important to understand and later apply in their maps that they design.

Table 2. Typical contents of a GIS cartography course taught in colleges and universities in California, USA.

01. Why GIS cartography? - An introduction to modern cartography
02. Map data accuracy and scale issues
03. Cartographic design and the communication channel
04. Execution of design
05. Projections
06. Name placement
07. Generalization
08. Symbology
09. Statistical mapping
10. Color in cartography
11. Map critique

A typical teaching procedure for such courses would contain lectures on these topics, followed by a reinforcing exercise of a map design applying the concepts learned. The exercises build upon themselves, so students might design the map twice whereby improving his/her map after more lecture topics are learned.

Students can create their maps in ESRI's ArcView 3.x, ArcGIS 8.x, or workstation ArcInfo, depending on what is stalled on the machines in different teaching institutions.

4. THE IMPORTANCE OF MAP CRITIQUE

Map critiquing by the instructor on each map will inform the student on his/her strong and map design points. This way the student is continuously refurbishing his/her map design skills and help them develop the skills of avoiding bad map design habits and acquiring only the good design habits.

One thing the author did and the students found extremely beneficial was to bring to class, at day one, existing maps where each novice student would receive a map and a four-page critique questionnaire. At that time, novice students were not yet exposed to any cartographic terms, yet they would fill in a complete critique of the map, as they would interpret the topic items of each question. The author would collect the map and the critique of all students at the end of the session, and save them until the last day of class, where students get their maps and critiques back, and re-critique the maps again, and discover for themselves how their learning curves increased at the end of the course. Appendix A shows a sample of the map critique questionnaire. In lieu of the author's map collection, students have the option to bring a map of their own, but since the practical map critique exercise is done on the first day of class, students should be previously informed of this activity and the option of bringing one's own map.

5. EVALUATION OF STUDENTS

5.1 College and university courses

For college and university courses, a mid term and a final exam determine the performance of students on the cartographic concepts. Exams questions is not only limited in to written questions, but also includes graphics designed by the author/examiner that students must enhance/complete by adding lines, points, shades, legends, text, etc. to reflect their knowledge on the concept that the question is asking.

Each student accumulates his/her lab grades on the weekly labs he/she attends and submits a colored hard copy map. Student maps receive written critiques from the instructor directly marked on their maps. When a map has to be repeated after the first critique received, enhanced through new concepts learned, the student has to submit the previously critiqued map, the new enhanced map, and a paragraph of self-critique on his/her attempt to enhance the new map. Each map the student submits will get a grade. A mid term lab results in a map that receives twice the grade of a regular lab. The final lab involves critiquing the map students have critiqued on day one.

Courses taught for the continued education programs, e.g. universities marked numbers 3 and 4 in Table 1, students have the option of either requesting a letter grade (A, B, C, or D) or a Pass/Fail grade.

5.2 Client site courses

While this issue is not purely academic, however the author wanted to share this additional experience, since academics can have opportunities to serve outside their colleges and universities atmosphere in conducting industry-specific education courses.

The two and a half day course that the author had designed for Dade County, Florida had neither tests nor grades. The client was not interested in any academic grading. They just wanted to improve the quality and cartographic skills of their employees. However a map was distributed at onset for critiquing using the same mentioned questionnaire, and later at the end of training, the map was revisited for a new critique to discover their learning curve. Also, since training was done at the client site, employees brought their own maps for critiquing, giving them an advantage of feedback from the instructor to enhance their mapping efforts.

6. ACKNOWLEDGEMENTS

The map on the Title page, and the page titled *The communication channel* are the intellectual property of ESRI and are used herein with permission. Introduction to ArcInfo using ArcMap, ArcCatalog, and ArcToolbox, Copyright © 1999-2000 ESRI. All rights reserved. These materials were designed by the author while working for ESRI, Inc.

The *Population density in Europe 1998* map was created in ArcView GIS using the data from ESRI's ArcWorld and used herein with permission. Copyright © 1992, 1994 ESRI. All rights reserved.

The author is indebted to Professor Judy Olson of Michigan State University, who supplied him with samples of her students' maps printed on postcards. Professor Olson encouraged her map design students to excel in their design so their work will be printed on such postcards that are sold at the university bookstore; a unique idea indeed. These post card maps were excellent resource for the author in conducting the map critique exercise at the onset of all his GIS cartography courses he taught.

7. RECOMMENDED COURSE REFERENCES

The author could not find a unique book that covers the objectives of a GIS Cartography course, so he created his own colored presentation graphics in PowerPoint slides that were projected while students have printed black and white copies of the slides to add their own notes on them. The current technology is not yet cheap enough that students can receive handouts in color.

8. CONCLUSION

Designing a GIS cartography course for teaching in GIS certification programs can be a flexible event. A course can be tailored to the needs of the design of this course and how it fits within the curriculum. A trained cartographer, however, must conduct teaching such a course. The ability to critique maps in order to help students acquire a good mapping design skill, coupled with GIS software skills are vital characteristics and requirements for anyone who is asked to teach such a course.

9. REFERENCES

[1] B. Dent, Cartography – Thematic Map Design, McGraw - Hill, 5th ed., 1999. ISBN 0-679-38495-0

[2] ESRI, Managing a GIS, Environmental Systems Research Institute, Inc., 1996.

[3] E. Imhof, "Positioning Names on Maps", The American Cartographer, Vol. 2, No. 2, pp. 128-144, 1975.

[4] B. O'Sullivan-Kachel, "Cartographic Design Using ARC/INFO" poster, ESRI Users Conference, 1995.

[5] M. MacEachren and D. R. Fraser Taylor, "Visualization in Modern Cartography", Pergamon, Vol. 2, 1st ed., 1994. ISBN 0-08-042416-3

[6] M. Monmonier, How to Lie with Maps, The University of Chicago Press, 2nd ed., 1996. ISBN 0-226-53420-0

[7] P. Muehrcke and J. Muehrcke, Map use, Reading, Analysis, and Interpretation, 4th ed., JP Publications, Madison Wisconsin, 1998. ISBN 0-9602978-4-7

[8] Robinson, J. Morrison, P. Muehrcke, A. Jon Kimerling, S. Guptill, Elements of Cartography, 6th ed., John Wiley & Sons, Inc., 1995. ISBN 0-471-55579-7

[9] T. Slocum, Thematic Cartography and Visualization, Prentice Hall, Inc., 1999. ISBN 0-13-209776-1

[10] C. Wood and C. Keller, editors, Cartographic Design, Theoretical and Practical Perspectives, John Wiley & sons, 1996. ISBN 0 471 96587 1

APPENDIX A

A MAP CRITIQUE CHECKLIST

Introduction
You can use either a map that you have prepared or you can get a map from the instructor. Use the map critique bullets below to record your opinion about the important aspects of communication in cartography.
Note: You can use these bullets as a checklist when you design your own map.
Remeber that critiquing involves that you have to outline the good points as well as the bad points in the map design.
Write the information against each action bullet

General map properties
Title
Author(s)
Organization
Scale (fractional or bar)
Data of data
Date of map publication
Projection
Method of preparing the base information (any pre-processing was done on the data before display)
Method of printing
Color or black-and-white symbology
Other information

Identify the type of map
Remember that different type of maps require different cartographic treatment in terms of the selected symbology.
Is your map a general or thematic map?
Is your map a qualitative or quantitative map?

Identify the apparent map objective

Remember that when you are designing a map for a client, normally the client will dictate the objective(s) of the map.
Is your map showing research findings?
Is your map teaching concepts?
Is your map illustrating relationships?
Others
Layout and visual balance

Are the map objects laid out so the map is visually stable?
Are the map objects placed logically?
Is there any outstanding gap (empty spaces)?
Does the map object that attracts you most, comply with the apparent map objective?
Do you think the design optimally uses the visual center?
Do all the map objects work well together?
Are the letter styles in harmony with one another or are they in a visual competition on the map?
Do the chosen patterns create a pleasing appearance or they clash with one another in some manner?
Is the reader's eye led through the map appropriately?
Any comments? remedies?

Visual contrast (visual weight) and hierarchy
Remember you will be thinking about these issues with the objective and the type of map in mind.
Are the visually heavy map objects justified?
Is there any apparent hierarchy created by the symbology used?
Is that hierarchy needed for this type of map?
Are the symbols explicit and easy to understand?
Is there an apparent hierarchy in the text symbology used?
Is the hierarchy in text symbology really needed?
Is the text visually contrasted and explicitly distinct in the main map body?
Any comments? remedies?

APPENDIX A (continued)

The marginalia

Are the positions of the marginal map objects justified (are they all in their proper places)?
Is the legend information sufficient to understand the map?
Is it easy to compare the symbols in the map body to their counterparts in the legend boxes?
Are the legend boxes conveniently close to the map body? (This is especially important in large sheet maps)?
Are the legend box symbols properly displayed, without ambiguity?
Are the colors really representing the mapped phenomena?
Do you think the user can easily decipher the colors?
Is the scale bar too long?
Does the scale bar have units?
Is the scale bar placed at the bottom of the map where it can easily be used?
Is the scale bar easy to use? (i.e. the number and value of the subdivisions on the left)?
Is the scale absolutely important to have (for this map's objective)?
Is the north arrow absolutely important to have (for this map's objective)?
Is the text legible (size) in the marginal area?
Is the text visually contrasted and explicitly distinct in the marginal area?
Do you think you can locate the areal extent of this map on the earth? What is missing?
Do you think this map is current? What is missing?
Can you rely on this map for extracting information? What is missing?
Any comments? Remedies?

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Biography

Mr. Murad-al-shaikh has over 30 years of experience in the educational field in a variety of disciplines ranging from civil engineering, cartography, and GIS. He joined ESRI in 1993 as a Senior Instructor and teaches both introductory and advanced courses focusing on ESRI technology. Mr. Murad-al-shaikh received his B.Sc. in Civil Engineering in 1969 from Al-Hikma University in Baghdad, Iraq, a certificate in Educational Technology from Huddersfield Polytechnic in England in 1979, and his M.S. in Cartography from the University of Wisconsin-Madison, USA in 1983.

While as a senior instructor in ESRI's Teaching Services group, Mr. Murad-al-shaikh has been involved in designing and conducting training courses for ESRI software users. Mr. Murad-al-shaikh has trained users at universities, companies, and government agencies both in the United State of America and abroad. He is the course manager, co-author, and author of several instructor-led courses at ESRI; among those is the Maplex course that teaches the techniques and capabilities of the powerful Maplex software designed for automated labeling on maps, a dream software of all cartographers. He has participated in several courses where his graphics capabilities were used to enhance the figures for better communication of cartographic and GIS concepts. Recently, he finished the design of the prototype for the *Cartography with ArcMap* course to be soon taught as a standard ESRI course.

Between 1970 and 1993, Mr. Murad-al-shaikh worked as an Assistant Professor at the Institute of Technology in Baghdad, Iraq. Since 1983, he was responsible for the instruction of cartography and remote sensing courses at various levels at that location. Mr. Murad-al-shaikh also taught various cartography and remote sensing courses on a part-time basis in the graduate and undergraduate programs at the Geography Department of the University of Baghdad, Iraq. He was the first cartographer to introduce GIS concepts as part of the curriculum in both institutions he was teaching at in Iraq.

Since 1996, Mr. Murad-al-shaikh has been teaching GIS cartography courses within the GIS certification programs of four local colleges and universities in California, USA.

Mr. Murad-al-shaikh has written thirteen text and reference books in civil engineering, calligraphy, educational technology, cartography, Geographic Information Systems (GIS), and remote sensing. He also has published several papers on calligraphy, cartography, remote sensing and GIS.