## Title
GIS in the K-12 Classroom: Research Agenda from EDGIS '96



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# EDGIS '96 Research Agenda Meeting

### 16-17 November 1996, Santa Barbara, CA

This meeting immediately followed the November 1996 Annual Meeting of the National Council for Geographic Education (NCGE) in Santa Barbara, California. At EDGIS '96, a group of researchers explored the issues facing the use of Geographic Information Systems (GIS) in the K-12 classroom.

The issues are presented on the linked pages in the following framework:

- Pedagogy Issues
- Curriculum Issues
- Software Issues
- Cognitive Issues

The four lists created are not exaustive and there is much overlap between these four areas. This Agenda as a whole is intended to serve as starting point for continued discussion and research in this area. The EDGIS '96 participants can be contacted for specific questions relating to their research in this area and to establish collaborative projects.

The EDGIS '96 meeting was sponsored by the National Center for Geographic Information and Analysis (NCGIA), Technical Education Research Centers (TERC), and NCGE. Comments with regard to this web page or the EDGIS '96 meeting can be directed to Paul Rooney at TERC or Steve Palladino (formerly the NCGIA Education Project Manager, now teaching at Ventura College).

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# EDGIS 96 Meeting activities

The EDGIS '96 Research Agenda Meeting took place on Saturday afternoon and evening and continued through early Sunday afternoon, November 16 -17, 1996. We began Saturday with a few short presentations on current research efforts in K-12 GIS followed by a general brainstorming session that continued into Sunday morning, followed by the designation of four discussion groups (pedagogy, curriculum, software, and cognition). Each group wrote down research topics for their area on large flip charts. After lunch these lists were reviewed and annotated by the whole group.

One person from each of the four groups (Sonia Wardley, Paul Rooney, Richard Audet, and Bill Albert) was assigned to clean up their group's list and circulate it among their group members. These cleaned up drafts were combined into a full draft Research Agenda for K-12 GIS. This World Wide Web document was distributed for comment to all who participated in the meeting.

The resulting web pages reflect the outcome of the meeting and a basis for continued dialog and action in the area of research into use of GIS in the K-12 environment.

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# Pedagogical Issues Group

## Summary of Principal Research Issues

Submitted by: Richard Audet, Charlie Fitzpatrick, and Douglas Gordin

**Assumptions:**

1. Functioning classrooms are ideally the theaters in which this research is conducted. Formative work on curriculum and materials development may need to occur under more structured conditions or in lab settings.
2. In pre-college curricula, teaching and learning with GIS constitutes the principal application of GIS.
3. The optimal use of GIS is not as a prop for didactic instruction, but as a tool for supporting project-based learning.

**Elements of the Research Program:**

1. Subjects of study: all of the stakeholders in the GIS supported teaching and learning environment. Software developers Data suppliers University educators School teachers and administrators Research scientists Students.
2. Sample population: teachers participating in studies should be drawn from diverse populations, e.g., urban/suburban, subject areas, amount of experience, etc.
3. Research setting: the classroom and beyond. Action research is a dynamic approach dedicated to the analysis and improvement of teaching practice.
4. Topics for analysis: Changes in teaching practice Inquiry based instruction Interdisciplinary connections Project based teaching Problem based teaching GIS and educational reform School wide impacts Strategic partnerships
5. Method: Identify exemplars of particular objects of analysis. Apply a case study approach. Another potential approach is via collaborative action research agendas.

**Questions: Educational Reform:**

- What instructional practices of teachers who use GIS encourage or support the goals and approaches of systemic educational reform?
- What aspects of the setting in which GIS is used contribute to the goals of educational reform?
- Does this situation vary among content areas?
- What aspects of the educational setting foster/promote interdisciplinary connections when GIS is infused into the curriculum?
- How is GIS being integrated with other educational applications of technology?

**Questions: Impact of GIS Technology on Teachers and Teaching:**

- What characteristics of GIS technology appeal to teachers?

Are there essential skills/attitudes/beliefs/predispositions/prior training goal structures that contribute to effective teaching with GIS?
- Are the above skills/attitudes/beliefs/predispositions/prior training/goal structures different for teaching with GIS than for other educational technologies?
- How is the process of teacher change supported or enhanced by a GIS-rich environment?
- How are instructional practices affected by the presence of GIS technology in the classroom?
- For teachers who use GIS, how does the progression from novice to expert occur?
- Are teachers personal and professional relationships changed by their association with GIS technology (e.g., peer interactions, community outreach, new collaborations, etc.)?
- What strategies do teachers use that help students relate digital data to places in the real world?

**Questions: Impact on the School:**

- What are the entry points for GIS technology in the curriculum?
- How does GIS fit into different educational settings?
- What are the different models for introducing GIS into the curriculum (e.g., one teacher/one computer, GIS lab, etc.)?
- What are the details of the implementation sequence from adoption to full scale implementation?
- What are some examples of the impact of GIS within school communities?
- What administrative roles/styles facilitate the inclusion of GIS as a school-based educational technology?
- How does diffusion of GIS technology occur within schools?
- Does the school library/media center have an impact on the curriculum integration of GIS?

**Questions: Strategic Partnerships:**

- What is the potential for GIS to serve as a common ground between schools and GIS professionals?
- What impact does GIS have on the relationship between schools and the community?
- What is the nature of successful school and business/government partnerships that include GIS technology?

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# Curriculum Issues Group

## Summary of Principal Research Issues

Submitted by: Sonia Wardley, Monica Ramirez, Bob Loudon, Dan Barstow

### Issues discussed:

1. The teacher implementors of K-12 GIS can be broadly divided into two groups: the GIS informed and creative and the GIS receptive. Each group will have different expectations of a GIS curriculum.
2. Any curriculum framework must be linked to national content standards and benchmarks in the discipline in which it is to be used, if it is to receive wide spread acceptance.
3. All curricular materials should be investigatory in nature, to encourage problem solving, independent thinking, and individual learning.

### Research Goals:

1. To develop independent GIS disciplinary curriculum frameworks which correlate with existing geography, evironmental science, or earth science curricula and address national standards and benchmarks in these disciplines. The supposition here is students studying these curricula would receive the appropriate social studies or science credit, depending on the course emphasis.
2. To develop GIS programs which can be integrated into different disciplines. Here GIS will be used as a tool to facilitate exploratory learning in other subject areas, for instance: geography, earth science, environmental science, and math.
3. To develop exemplary materials including data sets, which are investigatory in nature. These will use GIS to help students learn key concepts and skills and meet national content standards and benchmarks in geography, science, or math.

### Ancillary Research Questions:

1. What should a GIS curriculum include?
2. What is it essential to know about GIS theory to successfully use it as a tool, from both the teacher's and the student's perspective?
3. How can GIS be used in scientific inquiry?
4. What are the relative educational merits of externally directed versus teacher-student generated investigations for student learning?
5. Which aspects of remote sensing should be included in GIS educational materials?
6. What are the specific connections between GIS classroom materials and the national standards.
7. How can curricula be designed which will lead teachers and students to independent usage of GIS.
8. Which specific topics within a curricular framework would be most amenable to GIS

supported learning.

# Software Issues Group

## Summary of Principal Research Issues

Submitted by: Angie Lee, Holly Dodson, Steve Palladino, Paul Rooney

*n.b. The group discussions looked at software issues from the standpoint of Interface Design, Data Handling, and Software Use and Design. Much of the discussion featured points that overlapped issues. I have attempted to place discussion points within the issue I felt most appropriate, based on our notes.*

### Graphic User Interface Issues

**Summary:**
The group identified a need for Interface Design Research in many areas.
Taken as a whole, these elements address the need to offer greater simplicity, ease of use and flexibility to GIS users through interface enhancements, and the need for specific interfaces to achieve context-specific tasks.

Specifically (and in no particular order) they include, but are not limited to;
*1.* **Improving student/user ability to personalize GIS tools:**
The group discussed student/user's ability to personalize sets or bundles of tools, and then embed that set or bundle to an icon the student/user designs. The example used was Microsoft Word 6.0's ability to add user-defined functions to a new icon, and then add that icon to a toolbar.

*2.* **Designing systems featuring the incremental introduction of functionality:**
Arc Voyager is the best existing example of the tiering of GIS functionality with the specific intent of introducing certain software capabilities over time. This idea seems to hold much promise, although little study has been done as to the most effective interface design or functionality selection to support the tiering. It might be interesting to test Voyager and other similarly constructed applications with several age groups, or "points of entry" in mind. More on this later.

*3.* **Designing iconography more appropriate to both the task/function being represented and to the perceptual capabilities of the targeted user:**
What makes an icon representative of a function? Is "iconography" a field of cognition? If so, are there design principles, or "best practices" that might be applied to their use in GIS? Similarly, are there design principles that might relate to the user skill levels associated with the tiers, or points of entry, identified in #2 above?

*4.* **Determining the most effective means of organization and presentation of functionality:**
Is redundancy a source of confusion or comfort throughout GUI design? If one method of functional representation is favored, are pull-down menus preferable to icons? If a balance of textual and symbolic controls are preferred, is it preferable to group like functions with like

representations (i.e., the ability to add themes of data is menu-driven, while the ability to change a themes color or symbology might be accessed through a color wheel or symbol palette).

*5.* **Designing context-specific interfaces:**
This was discussed from two perspectives. The first has to do with designing interfaces to mirror the experiences and/or cognitive abilities of particular groups of users, and has been discussed in sections 2, 3 and 4 above. The second perspective looked at the notion of designing interfaces that addressed specific contextual issues (such as natural resource management, urban planning, population growth, or possibly the sorts of relationships between physical and human systems that Susan Radke has incorporated into Geodesy.) Further discussion in this area might address context-specific help through intelligent systems agents that provide predetermined assistance, based on known relationships between data, or valuable background information on the data, and where to find other related data sets (see context-specific help, below).

*6.* **Designing contextual help***:*
This issue, too was discussed from a number of perspectives. One issue dealt with the development of tools that might better provide metadata on spatial and attribute data (including a tool similar to Macintosh balloon help to show a more complete description of field names in attribute table.) Other possibilities included the development of an intelligent help system related to specific types of data (see #5 above) or based on the nature of specific functionality. It would also be interesting for users to specify their own help for functionality they might create on their own.

*n.b. One suggestion for iconography and interface study would be to survey and review existing successful games packages.*

**Data Handling**

The topic of "Data Handling" featured discussions on data sharing between packages, the need for and requirements of data creation by students/users and for students/users, increased data resource awareness, and explorations into educational applications of enhanced two- and three-dimensional representations. In a broad sense, the discussions looked at data as a commodity, and at how that commodity might be better utilized toward the needs of the K-12 user. Specific issues are addressed below.

*1.* **Data Sharing between different software packages:**
The discussion focused on the need/desire for students/users to port spatial data, increasing the utility of different types of software in meeting an analytical need,

*2.* **Metadata Creation by and for Students/Users:**
Accountability in data creation, use and reporting is a vital concept to convey to students/users. Creating opportunities for students/users to document their data creation and usage will encourage this documenting to become habit, and might lead to increased confidence in reporting both their process and their findings. Therefore, research into efficient, timely documenting procedures ought to be explored. Similarly, any prepackaged data sets ought to feature an easy-to-understand metadata standard. Research could be

conducted that might yield each state's metadata standards (if they exist) and then existing data sets might be updated to reflect these metadata standards,

*3.* **Data Resource Awareness:**
Research efforts here might focus on an updatable K-12 GIS search engine, featuring catalogs of software, curricula and data sets. Each contributor might provide information on their data, software or curriculum efforts, including metadata, design methodologies, or an overview of curricular framework. This resource might be Web-based, with appropriate links throughout. Other users might provide reviews and ordering information of the various elements within the list. Examples cited include the Alexandria Project (a spatial data catalog being developed at UCSB and other places), the USGS on-line data selection, and www.amazon.com (an on-line book service),

*4.* **Data Representation:**
Two areas were discussed here. The first considered exploring student use of two- and three-dimensional representations through existing software, specifically through packages like ERMapper (Windows NT version now out), and through games packages like SimCity/Town/Farm/Earth etc. The second issue was interest in applying what we're learning about cognition to enhanced two- and three-dimensional representations. Cognition and its relation to visualizations has been an on-going focus of the Visualizing Earth project (Penn State, UCSD, SDSU, NASA, TERC). For more on that project, consult the Visualizing Earth homepage via http://hub.terc.edu

**Software Use/Design**

This final section touches on the exploration of the K-12 uses of "non-traditional" GIS packages, the uses of different GIS packages (other than ESRI or IDRISI products), the possibilities/limitations that exist for the use of GIS over the Web, and some of the issues that might lead to the ground-up design of a GIS designed to the needs of the K-12 audience.

Taken as a whole, these issues concern themselves with environments for spatial learning in K-12. They address these environments from the standpoint of expanding "traditional" GIS implementation in schools (to the extent that the use of certain software packages and implementation strategies bear enough similarities between schools so as to be considered "traditional") to include other GIS packages, opportunities for use of non-traditional GIS, as well as the use of multiple packages (both GIS and non-GIS focused) that as a whole foster greater spatial learning in the classroom. A more detailed discussion follows.

**1. Explore the use of different GIS packages:**
ArcView has enjoyed ongoing widespread use throughout efforts at GIS in K-12. IDRISI, designed with education in mind, also enjoys great acceptance as a raster-based option. What possibilities do other packages offer? What are the limitations to their use ("are there teacher training options for these packages?", "is the hardware necessary to run them more or less of an issue than ArcView or IDRISI?", "is data transfer into and out of the package an available and easy-to-perform capability?", etc.)

*n.b. One package that came to immediate mind was ER Mapper. It features both raster and vector data analysis, as well as the ability to generate and display three-dimensional* *surfaces,*

*2.* **Explore the use of "non-traditional" GIS:**
This section has a subheading of "exploring the spatial qualities and opportunities of 'non-traditional ' GIS. In short, what can packages like SimCity/Town/Earth/etc., or various types of mapping plug-ins like Map Objects offer educators and students? What opportunities do they present to software developers? For example, how might Map Objects be used to design applications targeted at K-12? Or how might Excel be expanded with mapping capabilities added?,

*3.* **Explore Web-based GIS/Mapping/Spatial Tools:**
Tools that feature Web-based mapping capabilities are beginning to appear (i.e., Map Quest), and offer first signs of the potential for distributed GIS. As the number of Web-based student/ scientist oriented projects continues to grow, the opportunities for development of centralized GIS databases of student-generated data will flourish. Research into the logistics of such data bases ought to occur.

*4.* **Explore the use of multiple packages/platforms/means of communication:**
Each of the above serves as a possible element in a diverse, multi-faceted approach to spatial learning; one that takes advantage of the best features of various packages, platforms and means of data creation, organization, transfer, and communication. What options might exist in GIS design to accommodate "multiple entry levels" (users with different cognitive levels based on age or prior spatial learning experience?)

*5.* **Designing a GIS for K-12 users:**
What functionality is most important in meeting the educational needs of the K-12 community? What method of presentation is best suited to the K-12 community. If one were to build a GIS from the ground-up, what architecture would be used to support it, and why? How can data entry be improved to meet the desire of student-created data? How can data access, presentation and querying be improved so as to lessen the unnecessary and counter-productive burden of software administration that is all to often placed on the K-12 user? How can tutorial and interactive help systems be designed so as to address content and technical issues in a manner appropriate to a range of user abilities? How can those abilities be determined as a user is interacting with the software? Can a GIS software package be designed so as to learn specific user learning styles, thus allowing for a broader route over which one could address spatial issues and arrive at answers to spatial questions?

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# Cognitive Issues Group

## Summary of Principal Research Issues

Submitted by: Bill Albert, Susan Radke, and Paul Van Zuyle

**1. Map elements:**

1a) What are the effects of different map elements (such as scale, abstraction, generalization, and symbolization) on a childs understanding of the map?

1b) Can any of these map elements be easily altered within a GIS to better facilitate learning?

1c) How might these different map elements relate to a child's developmental sequence? (i.e., when do children typically understand concepts of thematic mapping? etc..)

**2. Cognitive representations of multiple spaces:**

2a) Is a spatial representation developed through the use of a GIS any different than that of map reading? If so, how might they differ in terms of their structural or functional characteristics?

2b) How do we teach children about the connection between space as perceived in the world and space as represented in a GIS? At what age might children fully understand multiple representations of space?

2c) Do children need to know spatial primitives (points, lines, polygons...) before effectively using GIS?

2d) How do raster or vector data models relate to our understanding of objects in space?

**3. The role of cognitive abilities and the use of GIS:**

3a) Is it possible to establish a connection between specific cognitive abilities and specific GIS tasks? Or,is the understanding of GIS concepts based on acquring a set of skills or a combination?

3b) Is it possible to develop a series of cognitive strategies which might enhance the use of GIS?

3c) Are the strategies developed by children in map reading tasks similar to what be required in the use of a GIS?

3d) Are children able to understand process better by using a GIS vs. paper maps? If yes, then how is it better?

**4. GIS functions:**

4a) How do children perceive and use standard GIS functions (i.e., map overlay, buffer, etc.)?

4b) Which functions are easier and more difficult to conceptually understand and apply to specific problems?

4c) Are there systematic errors which are made using certain GIS functions either due to technical or conceptual issues?

**5. Geographic education:**

5a) What role does geographic education play in our ability to use GIS effectively?

5b) What is the connection between GIS and geographic concepts?

## EDGIS '96 Participants

| Name | Institution | |
|---|---|---|
| Bill Albert | Boston University | |
| Richard Audet | Roger William University | |
| Greg Barker | Thousand Oaks High School | |
| Dan Barstow | TERC | |
| Sarah Bednarz | Texas A & M | |
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| Holly Dodson | University of California San Diego | |
| Charlie Fitzpatrick | ESRI | |
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| Bob Loudon | US Forest Service, Skyline Forest, CA | |
| Judith Meyer | University of Connecticutt | |
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