Use of geographical information systems (GIS) mapping procedures to support educational policy analysis and school site management

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Introduction

With the introduction of books such as the Visualization of Quantitative Information[1], educational policy analysts and school site administrators were introduced to powerful methods of representing and visualizing quantitative information via graphs and charts. Presenting statistical information in the form of images and pictures has been found to be an effective method for educational policy analysts and school site administrators to convey enormous amounts of “noise free” information to client groups — especially less statistically sophisticated groups such as school boards, the general public, media representatives, teachers and parents. Recently, a class of procedures called geographical information systems, or GIS mapping, has been added to the list of methods and techniques for management, policy and planning that are designed to display information[2-5]. Of course paper maps have been used a great deal in educational research, but they are limited in the types of information they can convey to client groups. More importantly, these maps cannot be used to illustrate client population changes and are difficult, as well as expensive, to update. Recently, microcomputer-based, digitized mapping procedures have become an extremely powerful and inexpensive mechanism for presenting a visual image of geographical information. Using an actual map, a large scale atlas, for example, is applicable to nearly all educational geographical features[6]. The GIS procedure, of course, is applicable to nearly all areas of the world, and most of the major cities of the world have now been mapped with a GIS type of format. When specific demographic information for a specific region on the map (average household income, parent minority, percentage of single parent household, etc.) are colour coded, the map and then linked to geographical locations, a more complete “picture” of the geographic service area emerges. For the school site administrator when all three data sources are used and displayed in combination, i.e. map, individual address location, man-made and natural geographical features, and demographic theme, a powerful visual representation or “picture” of a policy issue, school administrative-management problem, or client service area emerges. Finally, geographical visual representations of information, when used in combination with more traditional statistical representations of information, permit the school site administrator or educational policy or management theme. Naturally, GIS mapping procedures can also serve as an excellent starting point on which to establish the need for further,
more sophisticated statistical and analytical studies.

The purpose of this study is to illustrate how geography and geographical distance might be an important, yet not fully recognized or appreciated component, in understanding certain problem areas in educational research, planning, management and administration. Because GIS procedures present both a picture of geographical distances to scale, along with the man-made and natural geography of the client service area, it can also serve as an important vehicle to enhance school site management and administration.

In the USA, GIS, although used extensively in business and commerce, have only recently been applied in the context of educational administration, management, planning and policy[7,8]. Most of these US-based GIS applications in education have been in the general area of school site location within specified school attendance areas that are experiencing enrolment growth. These applications of the GIS procedure directly parallel those applications which geographically map sales growth and site location in the retail and public utility industry.

Specifically, the purpose of this study is to illustrate how GIS mapping procedures are being applied in the context of school management with specific relevance to the unique problem found at American schools. Various "classes" of geography-relevant problem areas that deal with school equity (magnet school admissions, school restructuring, mapping of inequities), co-ordination of school services (outreach programmes to the community), school safety (crime and vandalism), and miscellaneous applications (white flight, fundraising, student transiency, parental participation, bussing) are illustrated. While these applications tend to be unique to American school management problems, the GIS procedures presented here are applicable to mapping school attendance areas at school sites throughout the world. While each of the above geography-based problem areas in school site administration and management have been successfully mapped, owing to space limitations only three representative GIS applications will be described. One GIS application deals with an important American educational policy issue associated with school "equity". Specifically, this application examines student applications and admissions to specially designed magnet or high quality centralised educational programmes in a large urban area. This type of GIS application should be of special interest to those educational researchers and policy analysts interested in examining issues associated with school choice and "equity". The second GIS application examines the important school site administration and management problem of locating important outreach services and programmes (in this case instructional support) in the community. This type of school-centred and geography-based application should be of special interest to school site administrative personnel. The third application explores the use of GIS mapping for locating new and continuing students enrolled at a large education centre. This type of application would be of important use for central office school administrative personnel co-ordinating special seminars, for designing car-pooling programmes, and for enhancing alumni relations.

**Equity and geographical distance**

Because of the unique nature and the legal constraints that impact on US public school policy, providing access to equal educational opportunity in a school service area is a major goal. The research literature on parental choice and school equity in large urban school district setting is vast[9-12]. Much attention in this literature is devoted to ensuring that there is equal access and representation in these high-quality instructional programmes located at "magnet" schools.

Recent trends towards school site management and the development of specialized magnet programmes in large urban school districts that are designed to enhance "equity", underscore the need to examine how geographical distance might be associated with the nature of applications to the magnet programme and the eventual selection of a subset of these students[13]. An added benefit of geographical studies to this type of policy issue is that those students with close geographical proximity to one another, yet choosing different magnet school instructional programmes, can be specifically identified and examined. The information these "pairs" of students use to make their "choice" or decision to attend one of the two different types of "magnet" school programmes, can have enormous implications for research on family choice. In short, the notion of "choice" can now be specifically examined in the context of similar geographical distance "pairs"
rather than investigating the issue of choice by aggregating all the data.

Masking important information that relates to why certain schools were chosen over other schools is one of the limitations of studying family choice using aggregate data.

In research studies of family choice, usually all respondents are surveyed for the various information factors (safety, attainment, programmes, etc.) which impact on their decision to attend a certain school site in a large district. The usual survey research type of procedure thus tends largely to overwhelm, in a statistical fashion, the most important factors that constitute choice for parents who have similar geographical distances from each other yet chose different schools [9,14,15].

The geographical map of applications of students to magnet programmes can thus become a powerful mechanism for visualizing the impact of certain school choice, policies, and for evaluating the effectiveness of various types of information about the magnet schools to parents.

In this illustration, two magnet school programmes, ten miles apart, were submitted to a geographical mapping analysis. The results of this GIS map of student applicant location are presented in Figure 1. Note that thematic layers, such as average household income and per cent black by geographic region on the map (zip code or census track), could also be overlaid on the region map. Owing to the prohibitive cost of generating a color map, only client (student applicants) locations and zip codes are represented. Note the obvious clustering of applications by families which live in close proximity. Far more interesting for the family choice researcher, however, are those applications which are found in close proximity to each other, yet who chose different schools (see Figure 2). Also note how a man-made geographical barrier, such as a major highway or freeway, also seems to impact on the school choice decision (see Figure 2). Note how the highway seems to divide those who desire to go to one school from those who desire to go to the other school.

In summary, those educational researchers and policy analysts interested in school-family issues of choice would find this type of geographical information extremely useful for examining the impact of geographical distance on choice and finding "choice" pairs of applicants who could be surveyed in more depth in order to provide a better understanding of the role of information in the final choice selection of a magnet school site.

Figure 1
Map of student applications to magnet school site X and site Y
School outreach services to the community and geographical location

The second illustration of the GIS mapping procedure entails the systematic planning of school site outreach educational programmes to the community. School site administrators would be particularly interested in these types of GIS applications since they can be used to locate students with special academic needs. Once these populations are identified on a map, school administrators might be better able to address those academic needs with remote, off-site instructional support programmes and/or other social service support programmes[16,17]. In this application, a geographical analysis was used to locate all students who were significantly above and below grade levels. Again, the map could be layered with demographic information, such as average household income, and percent minority, and then colour coded by region (in this case zip code).

Note from Figure 3 that there were clusters of students in specific regions of the community where many of the below grade level students resided. Most of these clusters of students were some distance from the actual school site, therefore, geographical distance impeded the attractiveness of offering after-school, on-site instructional support programmes. Instead, a project was developed which made use of a trailer-van equipped with computer workstations, tables, and staffed with educational personnel. The trailer-van was then brought to the community location containing the highest clusters of below grade level students. In short, GIS procedures were used to provide educational and instructional support services to students at locations which were in close proximity to their address, rather than providing these services at the school site. Note that in this application a geographical map is generated to determine the clusters of students (see Figure 4). The same map can then be used to determine the best location for the remote or off-site instructional support programme. Geographical distance, as a factor in underachievement, can then be partially addressed by the geographical location of a service vehicle for educational support services in the community. In a similar and earlier application of the GIS mapping procedure for community outreach, mothers of low birth weight babies and single parent homes were matched to inoculation service centres in the Atlanta, Georgia area[17]. When using GIS mapping procedures for these types of geographical “location” applications, certain specific questions must be addressed. These questions include:

![Figure 2](image_url)

Map of student applications to magnet school site X and site Y with man-made geographical barriers (freeway)
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Figure 3
Location of instructional support services for above and below grade level students

Figure 4
Location of instructional support services remote off-site location analysis
an exact assessment of community needs; research into the location of current community resources to service those needs; and developing a service component that links the needs of the community to the resources available. All three of these issues can be addressed using GIS mapping procedures.

New and continuing student participation and geographical distance

In the final illustrative application of GIS mapping, clients (new and continuing students) of a large educational centre were identified in terms of their geographical distance. The purpose here was not only to examine geographically new and continuing student locations at the educational centre, but to provide some insights regarding the distances travelled. Once new and continuing student locations were determined, questions such as where to place a satellite campus, how best to establish car pools, where to place alumni centres and functions, where to place recruitment, centres etc., could be addressed.

Figure 5 displays all new students enrolled in the educational programme. Overlaid on the map can also be community resources, such as libraries and other educational facilities, so that more effective co-ordination of social services could be attained. Figure 6 shows both new and continuing students in the programme. Here, possible pairings of students by geographical distance can be achieved. Pairing of new and continuing students for purposes of car pooling, seminars, etc. can also be achieved with this type of map.

Finally, if community representation at the education centre is a goal of the community, then thematic information, such as family income, percent black, etc., in each region of the map (zip code) could be overlaid on the map.

Extensions of GIS

These three illustrative applications of the GIS mapping procedure nicely demonstrate that the visualization of geographical distance in a school attendance area can be used to present an important “picture” of need to the educational researcher and school site administrator. In one of the three illustrative applications presented here, the GIS map served as the introduction to the complex policy issue of ensuring “equity” with regard to school choice in a large urban setting. The
second GIS application examined the question of how to provide educational support services in the community through an off-site, after-school instructional support programme. The third application was a purely descriptive client location type of analysis for a large centralized education centre.

While these applications represent a class of problems in management (location) and policy (choice), there are other classes of geographically sensitive problem area where GIS mapping procedures could be of important use. With recent marketing or client-driven efforts in America towards breaking up large urban school districts into smaller and more manageable units, GIS methods could prove to be an invaluable tool for locating those clusters of reconfigured schools[18]. Not only could students be located and then compared with existing school site attendance areas, but demographic themes could also be overlaid, to ensure that the reconfigured school attendance area is culturally and economically diverse. Natural geographical barriers such as rivers and mountains, as well as man-made geographical barriers such as freeways and railways, could also be mapped so that travel time and convenience for the student and parent could be maintained. This type of application of the GIS procedures represents a class of planning or site location problems which can be extended to include school bus routing and car pooling. This type of GIS problem is similar to those found in the retail sector which focus on ideal storefront locations in a community, given customer patronage patterns.

One could also use GIS to examine decibel readings, school site locations and flight paths to airports. These data can then be visually displayed on the same geographic map and their impact on student performance noted.

Finally, GIS mapping could be a valuable information conveying mechanism for parents and teachers for describing certain characteristics of a school site. For example, the mapping of liquor stores, crime and vandalism (felonies and misdemeanours) across an entire school district might provide information to school boards concerning where to increase school site security and to parents concerned with school safety. These types of descriptive school informational GIS applications could perhaps be the most valuable contribution of the mapping procedure to school site management and planning.

Conclusion

In conclusion, the visual representation of geographical data has widespread application in educational policy analysis and school...
Use of geographical information systems (GIS) mapping procedures to support educational policy analysis and school site management. The formal recognition of geographic location, geographical distance, and man-made and natural geographical barriers in addressing important problem areas in policy and management make the procedure extremely appealing in both the USA and the rest of the world. Of course, GIS maps could also be made on a month-to-month or year-to-year basis and the change in the geographic information itself could be mapped. This type of change-oriented GIS procedure would be used to provide a dynamic quality to the map and might prove very useful in school site management where there is high student turnover. Finally, the visualization of economic, cultural, demographic and political information in a geospace provides the school site administrator and educational policy analyst with a powerful visual technique for understanding migrations, white flight, and other school behaviours that are associated with geography. Specialized topic areas from attendance boundary optimization that considers race, grade level and school size to the enhancement of community outreach services could also be explored with the GIS procedure. In essence, with GIS mapping one gets to “see what we think we know” displayed on a perfectly proportioned map. As microcomputer mapping procedures become more widespread and the procedure is taught in graduate programmes in school administration in the future, we should find mapping to be as common as preparing charts and graphs for parents and school boards.

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