

**Utilizing Geographic Information Systems (GIS) to Influence State Policy: A new  
descriptive, diagnostic, and analytical tool for higher education research**

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**Abstract**

*The purpose of this paper is to examine the utility of Geographic Information Systems (GIS) as a descriptive, diagnostic and analytical tool in higher education research and public policy development. In this paper GIS and how it has been used as a research tool in higher education and other disciplines is described, and a state level example of how GIS was utilized to inform higher education policy through exploration of local community contexts is provided. While consideration of geographical differences can make the policy making process more complex due to the recognition of the nuances inherent in individual communities across various demographics, the benefits are significant. Using GIS as a research tool to inform policy enables researchers and policymakers a means by which to identify unique barriers to access and affordability of higher education among targeted populations by geography. In this capacity, GIS holds great promise for developing strategies that are tailored to serve citizens in ways consistent with their specific needs, desires, and location. The authors offer a variety of suggestions for further use of this tool in higher education research and policy formation.*

We live in a society divided by politics, religion, economics, and educational level. We are accustomed to viewing our voting behavior by red and blue colored states. We have all seen population maps showing towering blocks located primarily in Southern California and Manhattan. We recall a time when insurance and real estate agents would shade certain areas red on metropolitan maps to eliminate business operations in poor and/or majority-minority locations – a practice now illegal, but arguably ingrained in our perceptions of perimeters whereby we are ever-conscious of where we will live and where our children will not go to school.

We find maps useful in their ability to detail the geography of many statistics, but can this ability to map data enable us to study an issue with policy implications, such as access to higher education? Can we use this type of information to influence policy in ways that cannot be done by other means? The primary purpose of this paper is exploring these two basic questions – is mapping of data a useful analytical tool, and is it unique when used to inform policy development?

### **Introduction**

In this paper, the authors examine one approach to formulating state level policy that is in part informed by considering the local and community contexts within which our education institutions exist. In particular, this paper examines the use of GIS as a means by which to understand local community contexts and to inform the development of state level policy that is responsive to these differing sets of needs. During the course of the 7-month commission, researchers worked to provide commission members with valuable and relevant data that answered their questions and informed the direction of

their recommendations. By understanding the statewide education landscape, they were better prepared to find creative and innovative solutions that were not previously explored.

### **Geographic Information Systems (GIS)**

GIS is a relatively new and fast developing methodological approach designed to look at data geographically and spatially. The U.S. Census Bureau for example, utilizes GIS capabilities to map to look at median household income, level of education, employment and a host of indicators gathered from their survey of the universe of United States residents at a fine resolution down to the street level. Environmental Systems Research Institute (ESRI), one of the leading GIS software manufacturers, characterizes this software as linking the location of information with what information represents (2002). GIS has been frequently applied in a variety of ways, including market research, landscape design, epidemiology, and classroom instruction. The only requirement is that data be clearly linked with some map-able characteristic, which may include a city, state, county, zip code, census tract or a variety of others.

GIS was first developed by government agencies and later by private industry as a powerful means to store, organize, and analyze data that can be described or modeled spatially or geographically (Black, MacDonald, & Black, 1998). It is now being utilized in the academy in a variety of disciplines, primarily environmental and other applied sciences. Individual scholars from the social sciences and humanities are beginning to incorporate GIS as an analytical tool in their research as well, including history (e.g., Black, MacDonald, & Black, 1998; Knowles, 2000), economics (e.g., Healey & Stamp,

2000), demography (Brewer & Suchan, 2001), and public health (e.g., de Lepper, Scholten, & Stern, 1995). Its greatest application, however, is in support of developing and implementing policy at the federal, state, and local levels.

#### *Use in Policy Formation*

GIS has been most widely utilized in the development of policy through studies of regional economic feasibility (Monsef, Smith, & El-Ghawaby, 2003), sustainable development (Monsef, Smith, & El-Ghawaby, 2003), and public health (de Lepper, Scholten, & Stern, 1995). Typical information includes data on the region's population, demographic variables, health indicators, political boundaries, employment statistics, ethnic status, and natural and land resources. In other instances GIS information is utilized in the implementation of policy, such as in determining where benefits or resources should be distributed (Skoufias & Parker, 2001). Recently a number of geographers have utilized GIS to map inequalities on multiple dimensions in the city of New Orleans in the wake of Hurricane Katrina (e.g., Deleware, 2005; ESRI, 2005).

The strength of GIS software is its ability to match a single data record, like educational attainment of an individual, and place the record's address on a latitude-longitude point in space and then on a map (Cooke & Maxfield, 1967; Drummond, 1995). GIS enables researchers to control for scale (Healey & Stamp, 2000) all the way down to the neighborhood level where local policies have a significant impact on residents (Sawicki & Flynn, 1996). Given the shift of responsibilities for social and economic welfare from the federal to the state and local levels, there has been much interest in neighborhood-scale indicators (Wallis, 1994). Displaying trends

geographically in the form of maps can greatly influence public opinion (de Lepper, Scholten, & Stern, 1995) – a persuasive tool. Jeffress (2001) argues that society is increasing its reliance on GIS spatial information in decision-making.

#### *Use in Education Research*

Use of GIS in education research is limited to studying the benefits of integrating GIS in teaching a variety of subjects at the K-16 level and in teacher training (e.g., Baban, 2002; Bednarz & Audet, 1999; Kerski, 2003; Lloyd, 2001; Meyer, Butterick, Olkin, & Zack, 1999; Peterson, 2000; Roach, 2004). The issue in education has primarily been one of curricular decision making, the biggest hurdle being attainment of knowledge about the software and how to manipulate it in ways that will promote better teaching and learning. The field of education research has yet to harness GIS as an analytical tool for research in the same ways as other fields.

There is a great deal of space to experiment with GIS technology as a descriptive, analytical, and diagnostic tool in education research. The authors were involved in deploying GIS to provide education policymakers with data displayed geographically. We also were able to analyze education data geographically in order to identify nuances at the community level with respect to issues of access, affordability, and completion of higher education, as well as migration patterns of educated residents. With the assistance of a geographer, Scott Swan, who was skilled in the use of GIS, we were able to traverse the hurdle of learning the new technology in order to explore multiple uses of the technology. Mr. Swan enabled us to manipulate the software to conduct our analysis and display the data for policymakers in a meaningful way.

### **The Cherry Commission on Higher Education and Economic Growth**

The Cherry Commission was an opportunity to utilize GIS technology to not only display education data in an informative and meaningful way, but to also analyze the data that led to significant discoveries of nuances in education access across the state of Michigan.

#### *Background*

In March of 2004, Michigan Governor Jennifer Granholm announced the creation of a statewide commission to explore the relationship between higher education and economic development in the state of Michigan (Hansen, 2004). Specifically, she charged the commission with the task of finding new and innovative ways to meet two primary objectives: (1) double the number of college graduates in the state within 10 years, and (2) more closely align higher education with economic growth in the state of Michigan. Nearly 40 commissioners from across the state representing K-12 education, higher education, policymakers, and the private sector met to develop a set of recommendations to achieve the Governor's goals.

During the first general commission meeting, there was a clear indication from participants that attempting to create policy to achieve these goals requires educators and policymakers to think differently about the state of Michigan. One member clearly articulated that we must begin to understand Michigan, not as a unitary state, but rather as a collection of regions, communities, and localities that each has a distinctive relationship with higher education, complete with unique experiences and expectations. If the people

of Michigan hope to achieve the goals established by the Governor, these realities must be taken into account.

This approach is entirely consistent with the direction now being advocated by the National Collaborative for Postsecondary Education Policy. The Chronicle of Higher Education reports that education policy researchers including Gordon Davies, Aims McGuinness, and Patrick Callan are working with the collaborative to find ways to ensure that the needs of communities are being met (Schmidt, 2004). The approach has been characterized as research-based and people-focused and this new model has been utilized in Washington, Missouri, Rhode Island, Virginia, and West Virginia. Of course, with any new effort to conceptualize effective education policy development, the response at the state level may be mixed.

Higher education faces a particular challenge in terms of the public faith people possess in the role colleges and universities play in society. People seem to recognize the value of earning a college degree, their confidence in higher education second only to their faith in the military (The Chronicle of Higher Education, 2003). Voters, however, are not convinced higher education is a high priority for public funding during economic crises as compared to competing interests for tax dollars, such as prisons, welfare, healthcare, and K-12 education.

Residents of Michigan, like other beneficiaries of the industrial boom of the 20<sup>th</sup> Century affected by changes wrought by the New Economy, are slow to see the necessity of a college education and the comparatively measurable return on investment in higher education at both the personal and public level. A recently conducted poll by EPIC/MRA

reported by the Detroit News suggests only 27 percent of parents who responded agreed that a good education is “essential” for “getting ahead in life” (Bray, 2005). The result is a familiar problem: too many priorities and too few resources to meet the needs. Perhaps a primary factor contributing to the challenge higher education faces is that the public does not see the relationship between higher education and society in the way that benefits them most directly.

### *GIS in the Cherry Commission*

In the context of the Cherry Commission on Higher Education and Economic Growth for the state of Michigan, GIS was employed to inform the policy making process. One of the realities researchers faced early on was that a great deal of data existed and was available, but there were few feasible ways to combine the data to create a meaningful and coherent picture. For example, with the help of the National Center for Education Statistics (NCES) it is possible to look at high school completion patterns across the state through the Common Core of Data (CCD). It is also possible to look at the Integrated Postsecondary Education Data System (IPEDS) to consider where colleges are most readily accessible, whom those institutions serve, and how many people successfully complete a degree in a given year. And it is also possible to look at Census Bureau data to see what the poverty rates look like across the state and within counties, in addition to median cost of a home, and the percentage of people with a college degree. These sources of data are all – in and of themselves – invaluable when attempting to understand the character of the state, and to determine how best to allocate scarce resources to meet political objectives.

What is missing from this approach is the ability to look at the interaction of these sorts of data and to apply additional sources of data that are less comprehensive but equally valuable. For example, how close are the high performing high schools to colleges across the state? Where do we have a high number of high school graduates that fail to consider college as an option? What communities have the lowest graduation rates from high school and have the greatest possibility for preparing more college graduates, given the appropriate interventions? What areas are similar across the state that share similar trends and challenges that may be affected by a well designed and specifically tailored social marketing campaign? We can map various educational indicators to answer any number of these questions. It is possible to consider each indicator by “layer” when using GIS applications.

#### *Sources of Data*

There are a number of data sources we have utilized over the course of the commission’s work. As mentioned previously, we gathered all pertinent data from the CCD, IPEDS, and the Census. In addition, we will look at state economic indicators including employment, household income, top employers and the work available by industry as well as admissions data from colleges and universities across the state indicating from where they draw students. We also were able to map emigration rates by county and MSA, although we were prohibited in our ability to map migration patterns (i.e., to and from where people are moving) because of unavailability of this specific type and level of individual data. Presentation of the available data in a GIS format provided a rich and compelling picture for policymakers and influenced the development of their

policy recommendations. This statement is supported by the commissioners' request and consumption of this data. Maps created for the initial commission meetings continue to be utilized around the state by the media and a number of policy makers and higher education professionals attempting to follow up on the recommendations.

The Commission voiced the impact these maps had on their conceptualization of the current situation and the need for a "sea change" in the state, and the strategies that would address the barriers to access, completion, and economic benefits of higher education in the state. They noted that the map of educational attainment by county, in particular, would be a compelling portrait of the serious situation in which the state finds itself. Several of the maps were subsequently included as evidence for the commissioners' recommendations, and to create a sense of urgency with respect to the serious economic and education issues facing the state.

Following the Commission's Final Report, the media and other researchers requested and consumed mapped data related or inspired by those presented to the Cherry Commission. Today, a number of these maps are influencing the implementation of Cherry Commission policies, and have also been incorporated into larger regional projects, such as the Brookings Institution supported Great Lakes Economic Initiative and University of Michigan President Emeritus James Duderstadt's Roadmap Project.

### *Findings*

There are two initial hypotheses with which we began our exploration of this data. The first is that students generally attend college close to home. This may not be a surprising claim to make, but when you look at where colleges and universities exist

across the state and what types of institutions they are, a picture begins to emerge. For example, in the state of Michigan, there are twenty-four counties that do not have a single college or university. In some cases, those communities are served by extension services through Michigan State University or a variety of other creative means. When we look at high school completion rates, the rural communities happen to be as low as or even lower than many of the urban centers like Detroit or Flint. For example, Newaygo Public Schools had a 41.7% completion rate in 2002 while the Detroit City School district was at 39.1%. Both are equally low but the communities are very different. Detroit has 62 colleges and more than 100,000 college students within 30 miles while there is not a single college in all of Newaygo County; Detroit is 98% African American while Newaygo is 95% white; Detroit was the motor city and Newaygo relies on livestock and tourism; yet both are 13% below the state average in terms of the number of residents with a Bachelors degree or above. The more data we layer, the more clearly it becomes that the needs of both communities are remarkably different, but no less significant.

Consider Figure 1 as an illustration of attainment patterns juxtaposed with all 2- and 4-year public and private non-profit institutions. A couple of trends are worth noting. First, the concentrations of degree-attainers are located in close proximity to colleges. This is not particularly surprising as this trend is evident across the country, in areas like the research triangle of North Carolina and Silicon Valley in California. What may be more surprising are the areas where degree attainment is lowest. Detroit as mentioned earlier, is home to more than 60 colleges, universities, and various postsecondary institutions and there is a halo of degree attainment that circles the periphery of the city.

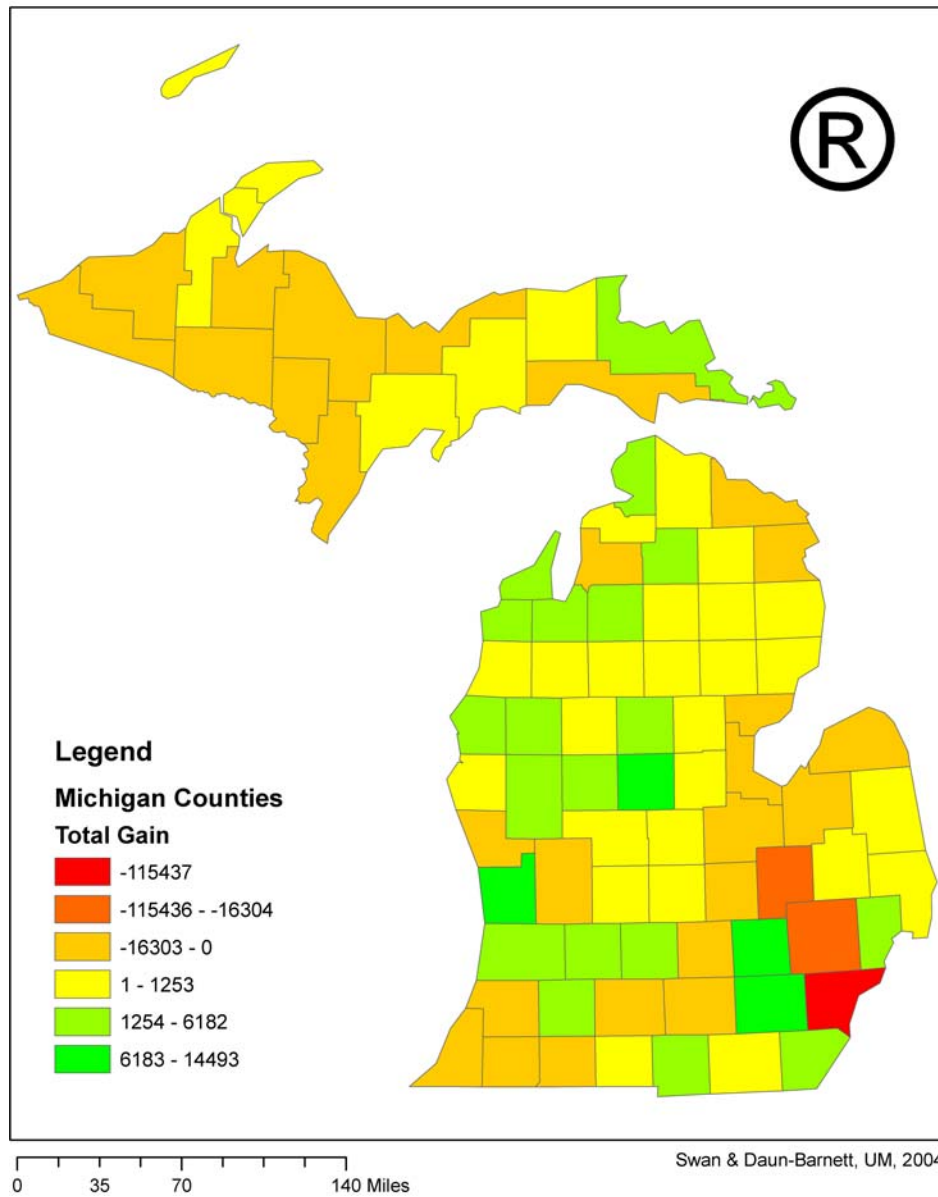
However, within the city limits, the percentage of degree attainers is significantly lower. The map paints this picture in much more convincing fashion than the narrative above because it shows these disparities in sharp relief. But Detroit is not alone with respect to low levels of degree attainment. Alpena and Montmorency counties in the upper portion of the lower peninsula share in this challenge; a fact that is important for upstate politicians and commissioners who saw that the work of the commission was about more than just Detroit.

The second hypothesis was that the state of Michigan experiences a general out-migration of college educated people and this has limited the potential growth of important sectors of the economy, particularly the tech sectors and engineering. The Detroit News reported in March that the state experienced a net loss of nearly 42,000 adults between the ages of 15-44 (Heath & Wisely, 2003). However, the state demographer clarified that much of what appeared to be a “loss” was actually the result of 50,000 more people leaving this age bracket than there were entering (Darga, 2004); an indication of an aging population. Regardless of which version is correct, with GIS we can tell that the more interesting story is the gains and losses by county. For example, Oakland County north and west of Detroit, saw 186,000 people move into the county according to Census Bureau data, but lost 212,000 for a net loss of 26,000 people. At the same time, Washtenaw County welcomed only 89,000, but experienced a net population gain of 12,000 people. The importance of this map cannot be understated in the context of the Cherry Commission work. One of the first concerns put on the table was the

notion of brain drain – meaning we were losing more young educated professionals than we were gaining.

Figure 1.  
Migration Patterns by County in Michigan, 1995-2000

### Michigan Migration by County



The map of net migration patterns by county paints a more nuanced picture than what was first envisioned. Michigan as a state was in fact, experiencing a net loss of

bachelor's educated 25-44 year olds, but it was not uniform across the state. In fact, the counties of the western portion of the state were experiencing net gains. The greatest losses were found in counties that are homes to Detroit, Flint, and Dearborn, not coincidentally, the home of the auto industry in Michigan. This illustration allowed the commission to think in more targeted ways about how to stem the tide in particular areas and perhaps with more involvement at the local level.

### **Three Purposes for GIS Mapping**

Generally there are three effective purposes for GIS mapping in the context of creating policy – descriptive, diagnostic, and analytic. Each of these can be an effective tool for state level policy formation depending upon the nature of the question and the types of policies being considered. The following three sections articulate two additional examples from the actual work of the Governor's Commission Research Team and the third provides an example of an analytical approach that could have been utilized to address one of the challenges facing the commission. The third analysis was not conducted due to time constraints but it provides a clear illustration of how GIS could be used as an analytic tool in the context of a particular policy making event.

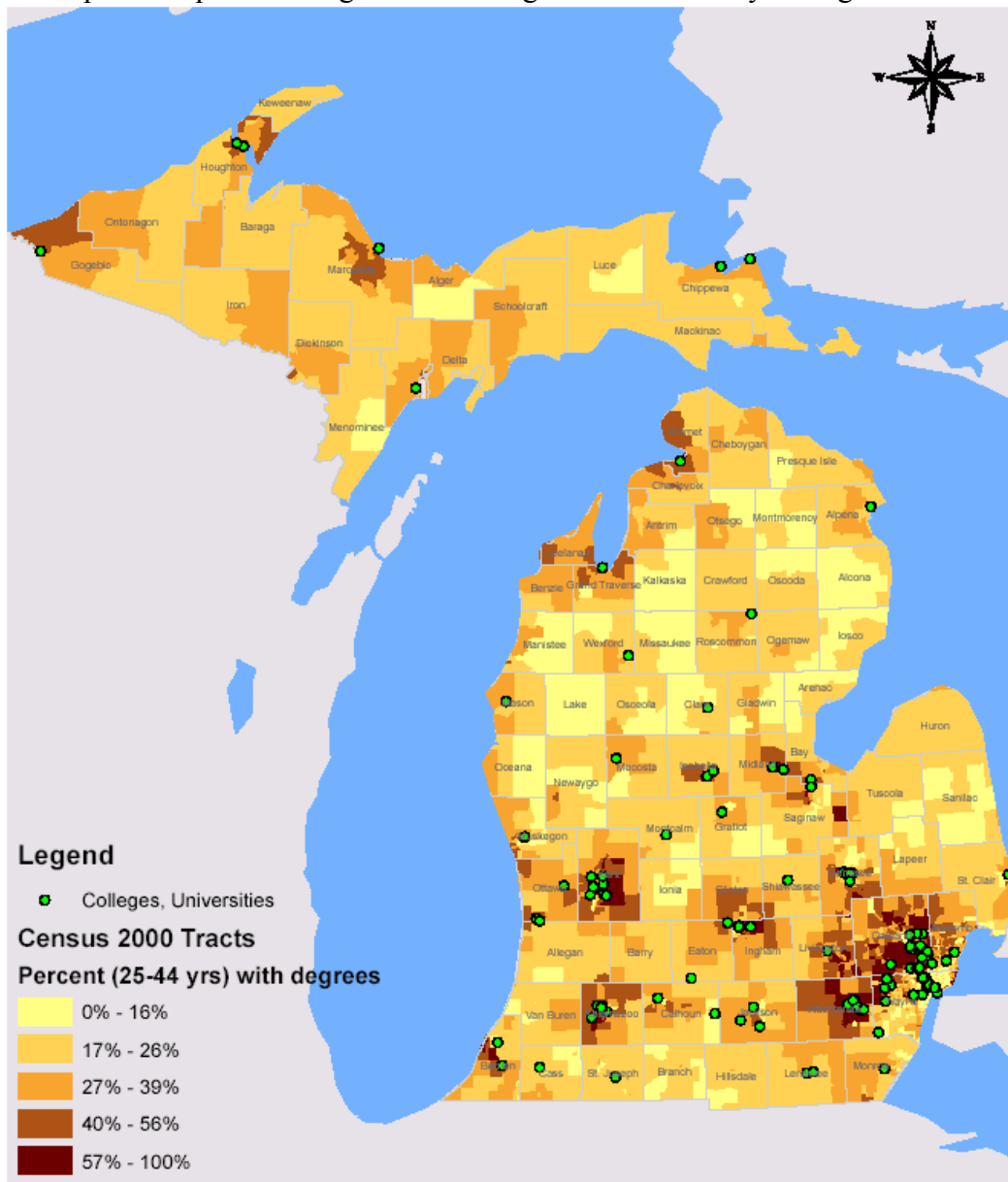
#### *Descriptive Applications of GIS – the case for attainment*

The commissioners were selected intentionally to represent a range of education, business and political leaders from across the state. Each represented a particular sector but they also represented their local communities. In order for the charge from Governor Granholm to receive widespread acceptance, the problem had to be framed in ways that all stakeholders could identify the interests of their communities. An early fear of some

entering the commission was the propensity for conversations about education and access in Michigan to result in conversations about Detroit and race. In those cases the state becomes divided predictably along geographic lines – dividing north from south and east from west. The issue of race was not discussed directly in the context of the commissions work, but there was quickly a discussion regarding the need to understand the challenge of doubling the number of college graduates in the state as a series of unique challenges best addressed by local communities.

In order to illustrate the need for this sort of community level policy development, the research team set out to illustrate what degree attainment looked like across the state. The first two methods were generally not illuminating. The first was to create a series of case studies to illustrate how Grand Rapids differs from Alpena in terms of greater education and economic opportunities, and yet has pockets of high and low attainment, which suggests a common need to improve college attendance and access everywhere. The problem is that not everyone can relate to the challenges of Alpena or Grand Rapids, but rather to their local communities. The second method was to create a table of all the major cities across the geographic areas and list the degree attainment levels for both associates and bachelors degrees. More commissioners could find their communities, but the table lacked a sense of dimensionality that allowed for easy comparison and contextualization. It is one thing to see the attainment rates for a number of discrete cities and towns, but to show the variation that occurs in contiguous census tracts and counties would make for a much more insightful picture. At that point, we chose to map census data for degree attainment (see Figure 2).

Figure 2.  
Descriptive Map Illustrating Levels of Degree Attainment by Colleges and Universities



The initial analyses conducted for the Cherry Commission provided a unique and vivid picture of the state educational landscape that was previously not imagined by the commissioners. The Commissioners were very moved by some of the maps that confirmed or contradicted their previously held assumptions and influenced their

recommendations. The final report was filed with the Governor at the end of December and was subsequently accepted by her. Today, she is working with a number of affinity groups to implement most of the recommendations embodied in the Cherry Commission Report.

*Diagnostic Applications of GIS – the Adoption of the ACT*

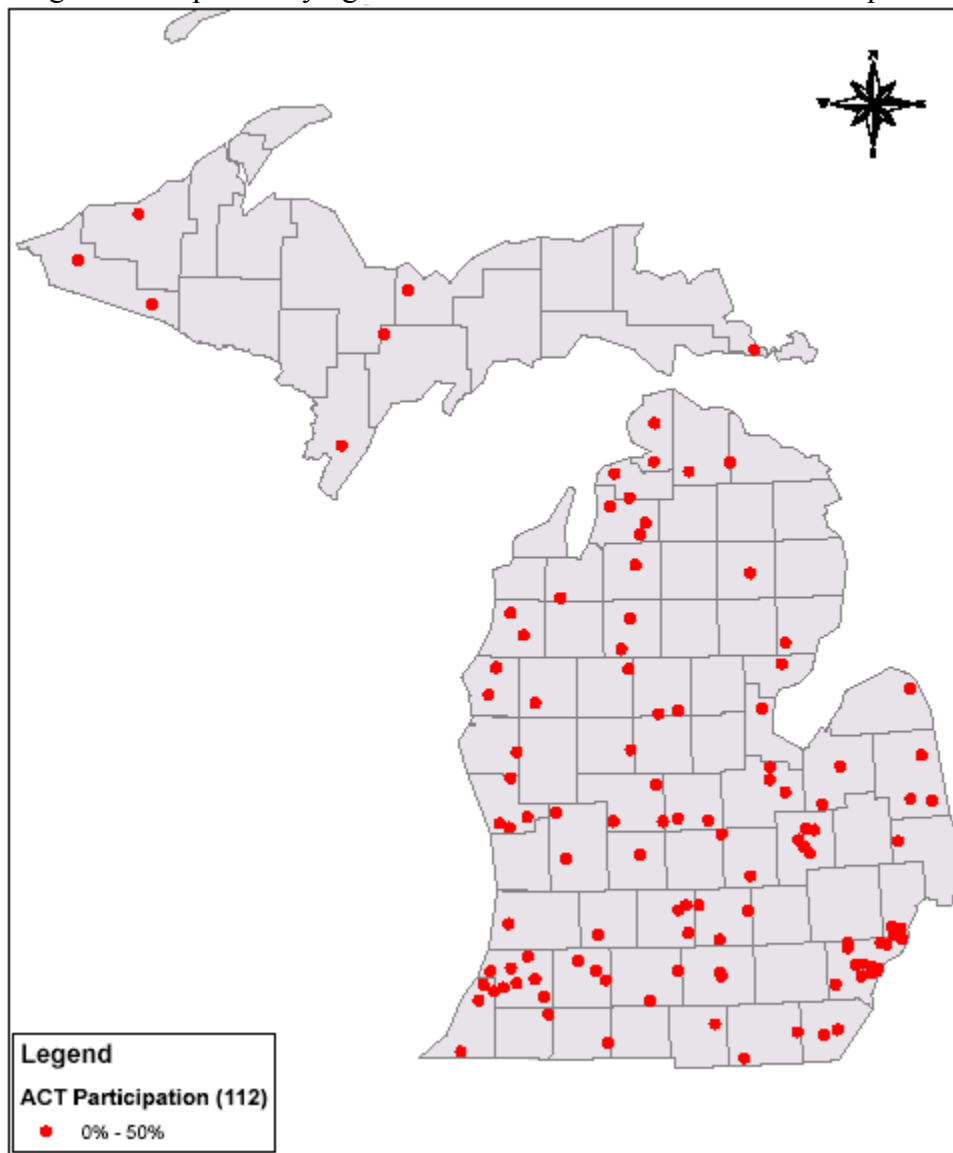
One of the single most contentious issues on the education policy agenda for the state of Michigan is the issue of testing. There was a debate in the state of Michigan regarding whether to replace the MEAP with the ACT Assessment (Feighan, 2004) and subsequent to the commissions recommendations the change was made. There are advantages and disadvantages to each set of assessments that depend largely upon what educators intend to measure and how those results are intended to be used. The MEAP was designed specifically to align with the standards set forth in the curriculum framework and is intended to establish a criterion for successful mastery of the material taught (Michigan Department of Education, 2004). Since the MEAP is a voluntary assessment, it is difficult to make definitive statements about how much students are learning; however, a baseline has been established for students to be considered for state Merit Scholarships. The ACT, on the other hand, is the primary college entrance test for Michigan and much of the Midwest, and is intended to help predict whether a student is likely to succeed in college. College entrance exams are designed to discriminate, meaning that they give colleges and universities a way to compare students across school districts and states as they make difficult decisions about whom to admit (Zwick, 2002). It should be clear that both tests are designed with standards in mind. The standards for

the MEAP are established in the curriculum framework, while the standards for the ACT are defined more broadly upon what students should have learned in the areas of math, scientific reasoning, writing, and reading comprehension to prepare them for college.

The MEAP was largely supported by the Department of Education and opposed by the Michigan Association of School Superintendents and Principals (MASSP) and it became a central focus of the commission workgroup looking at the preparation students receive for college. One of the strongest supporting arguments for making the switch to the ACT is that all students will have taken the test, which might increase aspirations for some students to attend college, or at least help more students clear the hurdle of completing a college entrance exam – a requirement to further education. One of the analyses that we consider diagnostic, was considered to look at where participation rates in the ACT were low. See Figure 3 for the illustration.

The map itself appears much simpler than the previous map, but it represents a more complex procedure that speaks to the power of GIS as a policy tool. We were able to get ACT participation rates for each high school in the state from ACT, Inc. Mappable characteristics for all of the schools were available through the Common Core of Data (CCD), and the GIS software could create cut scores to demonstrate which of the institutions fell below 50 percent. Of the more than 500 high schools in the state, 112 stood out with less than half their students completing the ACT. From the standpoint of college participation, this is an important group to look at because when attempting to double the number of graduates in the state, you have to know where the largest pools of potential students reside.

Figure 3.  
Diagnostic Map Identifying School Districts with Low ACT Participation Rates



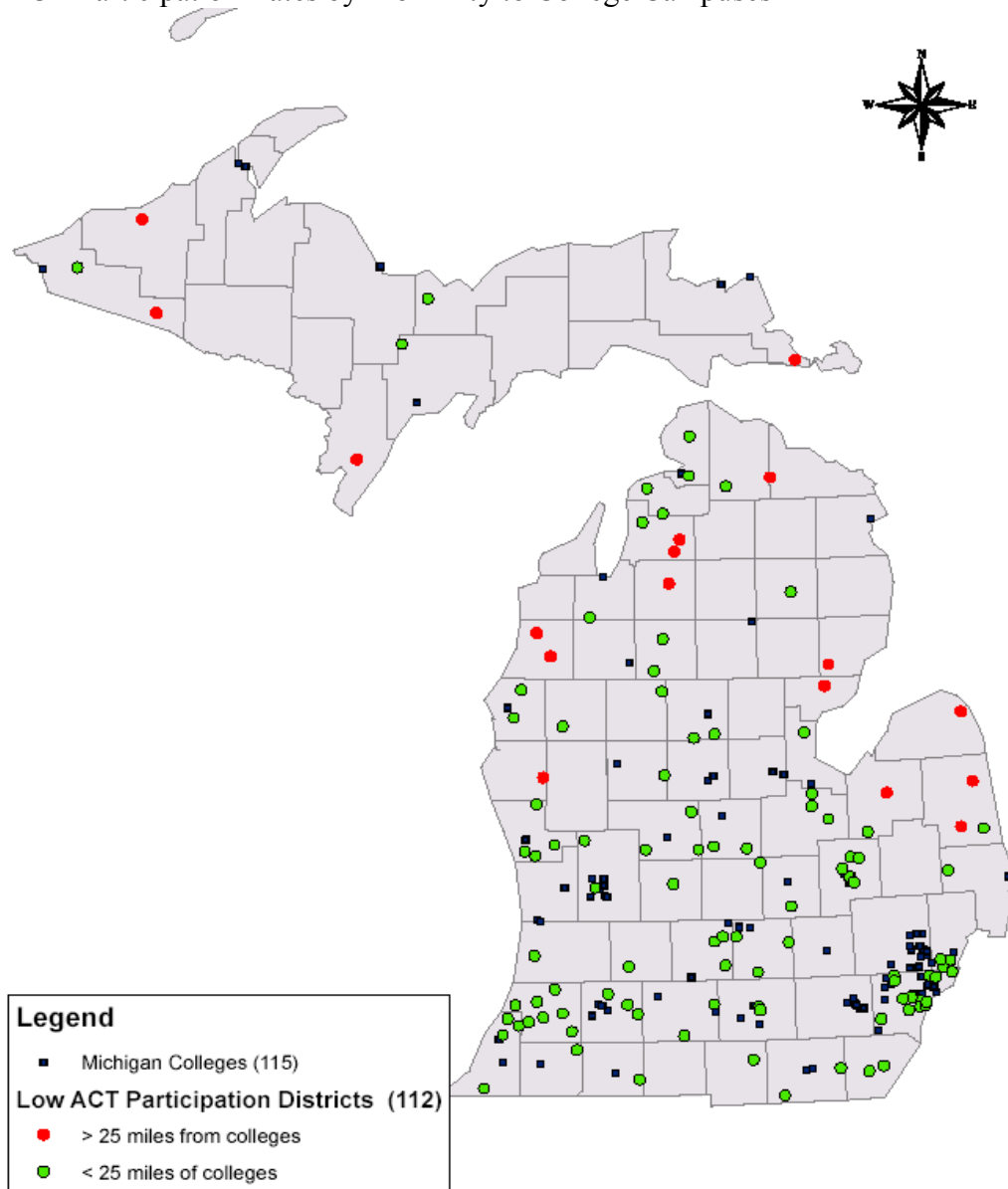
An additional analysis that would have been useful, given the time and inclination of the Commission, would have been to further differentiate between those high schools in close proximity to four year colleges and those with two year colleges or less, or no colleges at all. The high schools with low participation rates in Huron and Sanilac counties have no four-year colleges and are either served by Michigan State extension

services or technical/vocational institutions. In those cases, low participation may reflect the fact that students do not require the ACT for institutions close to home.

*Analytic Application of GIS – testing the Proximity Hypothesis*

Vincent Tinto (1973) considered the influence of proximity on rates of college attendance and found generally, the only students affected in either Illinois or North Carolina were those characterized by lower ability when they live near a community or junior college. Roweton (1994) has recently found through interviews with students, that proximity was one of several persistent themes in decisions about whether to attend college. Clearly the problem is more complex than proximity, but it is an important factor to consider at a time when we know the students less likely to attend college are from lower SES backgrounds and more frequently are underrepresented minority students. The limitation of these prior methods is that they lacked uniform and reliable methods to quantify proximity to college. Roweton utilized self reporting of students while Tinto depended upon imprecise measures of whether a college was present in a community without regard to actual distance from high school or home. This limitation is particularly misleading because in a large metropolitan area it is possible to be characterized as living in close proximity because colleges are present, when in fact, distance is still very much an issue. GIS allows for a more precise treatment of proximity as an actual measure of distance from a high school or place of residence (depending upon the data). Consider Figure 4, which is an extension of the previous map on ACT participation as an illustration.

Figure 4.  
ACT Participation Rates by Proximity to College Campuses



In this case, we have distinguished between those high schools with low rates in close proximity to colleges (defined as within 25 miles from one zip code to the other) and those with low rates in areas where colleges are not present. Clearly, some communities have far less proximal access to campuses than others and the 17 high

schools that are further than 25 miles away from colleges certainly face different circumstances than those who reside much closer. In the work of the commission we did not have access to student level data in order to test the proximity hypothesis in ways similar to Tinto, but those data are available at the national level through NCES. The National Education Longitudinal Study for example, can give researchers zip codes for high schools and locations. Meanwhile the mappable characteristics of all colleges and universities are available through the Integrated Postsecondary Education System (IPEDS) and combined they can be used to measure proximity to a college in terms of miles between high schools and the closest available college. This distance can then be stored as an independent variable for use as a measure for proximity in a regression analysis. Of course, like all national level analysis, this may mask some differences by state. For example, extension services and branch campuses may be more prevalent in some states than others and may not be detected in the analysis. This is a potentially very useful tool for researchers attempting to control for selection bias in models of college access and success. One approach utilizes an instrumental variable – which is related to the variable upon which selection bias occurs but is not related to the other variables in the model – to adjust for selection and proximity is one variable that has been tested in this capacity.

The point of this third section is to illustrate the areas within which we have not fully explored the potential of GIS as a data analytic tool to complement all of those we currently have at our disposal. The descriptive and diagnostic applications of GIS provide strong visual images that can be persuasive to a policy audience and are valuable

for that reason. However, the analytic applications of GIS are perhaps more appealing for researchers attempting to tackle more difficult questions of prediction and explanation of relationships. GIS provides a rigorous and reliable way to take Geo-spatial relationships into account so long as we have access to the linkable geographic features.

The GIS enabled analyses of data continue to be utilized by these groups and are now being transferred for use by other research projects focused on economic and educational development of the Great Lakes Economic Initiative – a Brookings Institute project. We have continued our work using GIS software to present data relevant to education issues in the policy arena as requested.

#### *Significance of the Study*

A number of states have convened commissions to explore the nature of the relationship between higher education and society and it is likely that many more will consider this approach in the future. It is clear that higher education is a catalyst for economic growth and vitality in the state, but what we have failed to capture to this point is how these differs by region, community and locality in a given state. This approach makes the policy making process more complicated because it recognizes the uniqueness of communities, but it also holds the greatest promise for finding ways to serve the citizens of our states and regions in ways consistent with their needs and desires. GIS is one analytic data tool that allows us to consider data in ways that were previously much more difficult and it should allow the statewide commission to recognize the shortcomings of broader policy brushes. This work will not, by any means simplify their work, but it will make their recommendations more meaningful, targeted and effective.

### **Limitations of GIS in Policy Development**

GIS technology offers tremendous promise to policy makers who are concerned with the geographic dimensions of policy. However, there are important limitations that prevent GIS from becoming more widespread in policy literature. The first limitation is the level of analysis. Geo-spatial relationships are important and useful in our attempts to look at differences by county or across urban and rural areas. They are less useful at the individual level without strong analytic tools for multi-level modeling. Knowing a student resides in a particular zip code may say something of the community within which they grew up, but there is still tremendous variability within any geographic space. Hierarchical linear modeling (HLM) and other packages allow for multi-level analyses but they become ever more complex to analyze and interpret, making the application less practical for many researchers.

Second, many data sources are not designed with GIS applications in mind. In this case, there are two problems. The first has to do with the sampling design and cost limitations of most surveys. Surveys are expensive to administer and decisions are made regarding the level at which the data are representative of the given population. For example, NCES, the primary source of data for many researchers in education, sample students to be representative at a regional level and are only now looking to be representative at a state level for some states on the National Postsecondary Student Aid Study (NPSAS). The result is that while you may be able to say something about where a student comes from, you could not aggregate and say something about the community or even the state. Other sources of data need to be utilized for this purpose. The second has

to do with the available data. Even well designed surveys and data collection tools lack linkable information at levels lower than the zip code, such as street level, with the exception of the census data. Further it is difficult to aggregate data to the community level (but below the county level) unless one is looking at a metropolitan statistical area. Given the descriptive case that can be made for community level policy based upon GIS, it would be nice to have the power to conduct more robust statistical analysis at this level.

Finally, the software itself is a limitation. It is an incredibly powerful tool but it is not intuitive for the novice user. Part of the challenge is the collection and preparation of data to be mapped, but the complexity involved once the data are organized can make GIS difficult to use without expert consultation. In many cases, depending upon the phenomena under investigation and the complexity of the analysis, one might settle for the US Census Bureau maps available through their factfinder tool.

### **Implications for Education Policy Research**

Douglas and Maitin (1996) note that GIS has emerged as a strong integrating technology that in graphical user-interface systems. As environmental scientists, they argue that spacial relationships are inherent to environmental data. The same can be argued in the field of education where researchers and practitioners of higher and postsecondary education could utilize education data spacially to further understanding of issues of access, affordability, equity, and diversity. In our research, policymakers had an interest in seeing various education data factors graphically displayed on maps.

The potential for GIS to be used as a database system that can support long-term collaborative research projects has been demonstrated in other fields, such as the National

Integrated Land System (NILS) project that enables the sharing and unification of land record information within the government and the private sector in land surveying of the world (Cone, 2003). Already the Census Bureau is utilizing GIS software to give researchers and the public the ability to map nearly all stored data from the 2000 Census. Theoretically the higher education community could utilize GIS capabilities in a large-scale collaborative survey project similar to CIRP and NELS.

The possibilities of utilizing GIS software for data warehousing is great, and so too as a diagnostic, analytical tool in research. The implications for such research is in the ease of transfer of findings into the policy context in order to make a compelling case for decision-makers. This is true at the institutional, local, state and federal levels.

One emergent example at the institutional level deals directly with issues of equal access with respect to race. Many flagship, public institutions struggle to achieve their diversity goals, particularly when use of affirmative action is limited or prohibited. Some universities have developed outreach and scholarship programs that target characteristics that may serve as proxies for race, such as socio-economic status (SES), college-going rates, and location (Murphy, Martinez, & Affolter-Caine, 2002). Through GIS technology, institutional data on high schools (e.g., sending and completion rates of graduates to flagship campus) can be mapped with SES variables (e.g., percentages of free and reduced lunch within a district and median family incomes) and other demographics (such as race, if legal in region). With limited resources, universities can target specific high school that could provide students who would meet institutional enrollment goals.

The possibilities are endless as we begin to harness GIS technology for research and policy formulation. We invite readers to consider options for research where utilization of GIS as a descriptive, analytical and diagnostic tool may yield unique information not supported by other tools.

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