Catalyzing the Context and Contextualizing the Catalysts: Potential contributions of Geographic Information Science to the Science of Broadening Participation

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Fall enrollments in degree-granting institutions in 2009 illustrated dramatic geographic variations by race/ethnicity of student (NCES 2009). Were these variations solely a reflection of demographic trends, number of institutions, or presence of historically black colleges and institutions or did other educational pathways or barriers influence the participation of underrepresented groups? Although these enrollment figures indicate that participation has a geographic dimension, recent programmatic efforts (e.g. NSF 2009) to develop a framework for evaluating the impacts of broadening participation have focused on individual, institutional, and foundation metrics of participation, such as number of participants or inclusion of equity-friendly policies, without explicit attention to the role of space or place.

Theories and methods from Geographic Information Science (GISci) and Geographic Information Systems (GIS) could further efforts to broaden participation by underrepresented groups by analyzing the spatial distribution of participation rates, modeling spatial dynamics, examining the impact of scale, integrating heterogeneous yet related spatial datasets, and visualizing data in novel ways that uncovers interesting spatial relationships, among many other methods. The potential of GIS to contribute to the science of broadening participation (SBP) is a broad topic that merits further examination; however, this briefing paper focuses the discussion on two possible avenues for further inquiry to propose how GIS approaches could lead to a more contextualized and spatially explicit understanding of the geography of participation of underrepresented groups in Science, Technology, Engineering, and Math (STEM) fields in higher education institutions.

1) Spatial analytical techniques can be employed to examine local variations in the relationship between participation and educational pathways
2) Qualitative analysis of volunteered geographic information (VGI) could provide relevant information regarding the experiences of underrepresented groups in higher education.

These two proposed avenues draw on emerging techniques in spatial analysis and qualitative GIS, as further explained below, and have potential to contribute to the science of broadening participation, as well as emerging research on novel applications of local regression techniques and approaches to analyzing VGI.

1. Catalyzing the context: Examining local variations in the relationship between participation and educational pathways

The set of issues surrounding the participation of underrepresented populations in STEM fields is complex. Facilitators, barriers, and other factors influencing participation could vary by individual, population, and location. Assuming that any of these factors remain constant over space or time oversimplifies this real-world complexity. While many conventional statistical techniques, such as global regression techniques, assume stationarity in phenomena, spatial statistical techniques, including geographically weighted regression (GWR) and spatial autoregressive models, have been developed to further explore local variations. These models uncover spatial variations in relationships among variables. Geographically weighted regression (GWR) has been used in applied social and geographic contexts to explore spatial variations in quality of life issues (Ogneva-Himmelberger et al. 2009, Ogneva-Himmelberger et al. forthcoming), population segregation (Yu & Wu 2004), and the educational system (Fotheringham et al. 2001).

There are many opportunities for original and innovative applications of these spatial statistical techniques to the field of broadening participation. Such applications could identify factors, or educational pathways, such as neighborhood resources, labor markets, transportation infrastructure, or others that influence participation among underrepresented groups and model how these factors vary across space and scale. For instance, Estaville et al. (2006) found that spatial proximity is an important factor in student attendance in an institution of higher education (i.e. students are more likely to attend institutions in close proximity to their homes); however, the relationship between distance and participation could vary by regional context. For instance, proximity to institution could be a strong predictor of participation at an urban institution, such as Temple University, but less so at institutions in rural or suburban settings. In other words, the influence of educational pathways might vary from location to location or institution to institution. Spatial regression techniques can identify these patterns of variability and highlight the relative importance of particular pathways over others in different locations. These studies could be conducted at multiple spatial and temporal scales and among different underrepresented groups to better assess local variations and broad trends over space and time.

Understanding such local variations in factors that influence participation could improve participation and "catalyze the context," in which the relevant context is the place of higher learning, in a variety of ways. To begin, identifying factors that are most important in certain locations could be used to improve recruitment/retention programs, refine metrics employed to evaluate participation, and, over time, better understand the changing dynamics of participation. Further, spatial modeling could be integrated into a mixed-method study that includes in-depth qualitative analysis of local experiences. Hence, better understanding the complex spatial contexts that influence the decisions of underrepresented groups promises to improve decision making and guide policy efforts that promote diversity in higher education and science professions.

2. Contextualizing the catalysts: Exploring student experiences in higher education through the analysis of volunteered geographic information

Advances in geospatial and communication technologies over the past 15 years have led to the proliferation of spatially referenced data created by many users from around the globe (Goodchild 2007). Inexpensive GPS receivers, location-aware "smart" phones, and widespread high speed internet access have enabled the georeferencing of photographs, social media posts, blog entries, and alternative media reports. Currently, the geospatial web contains a wealth of information on major and minor events worldwide, from the Arab Spring to reflections on yesterday's class lecture. This crowdsourced geographic information, termed volunteered geographic information (VGI), captures the diverse experiences, perceptions, and events in real time and creates rich and heterogeneous datasets for analysis.

This deluge of data, though exciting, has been subject to some scrutiny and questioning regarding data quality. Unlike more conventional forms of geographic information distributed by government organizations or corporations, VGI is asserted and may suffer from positional, attribute, logical, conceptual errors (Goodchild and Glennon 2010). Did the user remember the correct location of the photograph? Was the user's GPS calibrated and receiving a clear signal? Is this user prone to exaggeration or error? While VGI is undeniably subject to multiple sources of inaccuracy and uncertainty, several studies have attempted to make the case that VGI can provide meaningful and helpful information in the wake of a crisis event (e.g. wildfires in Santa Barbara or the 2010 earthquake in Haiti), in spite of concerns of the quality of the data.

Even while the quality of VGI remains an area for further research, the geoweb enables new opportunities for in-depth qualitative analysis in ways that authoritative surveys and geographic data do not (Elwood 2011). VGI often contains information about perceptions, emotions, and opinions. Further, these pieces of information are recorded in real-time, and often with a focus on place-specific experiences. Qualitative analysis of the everyday lived experiences of users promises to yield insights from diverse identities, recognize the importance of place, and challenge existing power structures (Elwood 2011).

This area of inquiry has exciting implications for SBP. Analysis of VGI could shed light on student experiences and attitudes in STEM fields that are not recorded in formal settings or captured by standard program evaluations. Elwood, Goodchild, and Sui (2012) contend that new analytical methods will need to be developed to handle such large and diverse datasets. Currently, data mining, and knowledge discovery offer some approaches. However, Elwood, Goodchild, and Sui (2012) suggest that the most promising approach lies in the synthesis of multiple heterogeneous datasets and methods, with an emphasis on iterative, participatory approaches that involve mixing methods and constructing narratives to describe different experiences of places. Hence, qualitative approaches to geographic analysis could further "contextualize the catalysts," in which the catalysts are research initiatives, providing a more holistic and representative

understanding of the diverse experiences of underrepresented populations in higher education.

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