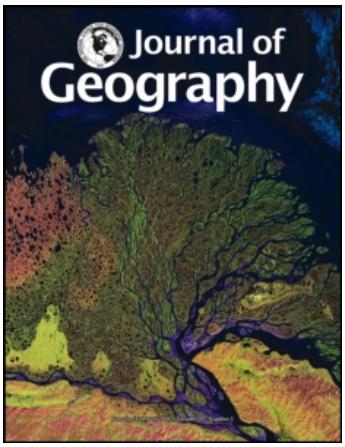

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Developing a GIS Program at a Tribal College

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Developing a GIS Program at a Tribal College

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ABSTRACT

Programs in geographic information systems (GIS) and related areas (e.g., GPS, remote sensing) have become important additions to the curriculum at colleges and universities of all sizes and types, including tribal colleges and universities (TCUs) such as Haskell Indian Nations University. This article discusses the recent development of a GIS program at Haskell that has been built around three major components: (1) courses; (2) outreach activities; and (3) projects. Key lessons learned from the experience include the importance of developing diversified goals and activities to promote student success, pursuing external funding, expanding GIS within the university through collaborations with other departments and disciplines, and ensuring that basic geographic principles remain a vital part of the GIS curriculum. The development of the GIS program at Haskell may serve as a model for other small colleges and universities, particularly tribal and other minority-serving institutions, that seek to add GIS to the curriculum.

Key Words: *GIS, education, Native Americans, tribal colleges, universities*

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INTRODUCTION

The demand for geographic information systems (GIS) and related geospatial technology has increased dramatically in Indian Country[1] in recent years. GIS serves a diverse range of applications on tribal lands, including environmental monitoring (e.g., air and water quality), land administration, wildlife management, and cultural preservation. In order to satisfy the escalating demand, an important role for the nation's thirty-six tribal colleges and universities (TCUs) is to offer courses in GIS and related areas such as cartography, geography, global positioning system (GPS), remote sensing, and surveying.

One such TCU that has recently developed a GIS program to support the growing needs in Indian Country is Haskell Indian Nations University, a four-year university located in Lawrence, Kansas. Founded in 1884 as an agricultural training school for Native American youth, Haskell is one of two federally funded TCUs operating under the auspices of the Bureau of Indian Affairs (BIA) and the Department of the Interior (DOI). Haskell functions as a central hub of Native American higher education in the United States, and holds great symbolic and sentimental value for those connected to the institution. Currently, Haskell offers four baccalaureate degree programs (American Indian studies, business administration, elementary education, and environmental science), and associate degrees in fifteen additional areas. Haskell serves students who are members of federally recognized tribes in the United States. Approximately 900 students are enrolled at Haskell each semester, representing over 130 tribes from thirty-five states (Fig. 1). The aim of the GIS program at the university is to provide the necessary tools and capabilities of geospatial technology to students who plan to return to their tribal communities or establish themselves in nontribal-affiliated careers.

The objective of this article is to describe the development of the GIS program at Haskell. Discussion will focus on three important components of the program: courses, outreach activities, and projects. The article will conclude with lessons learned in the development process, as well as keys to success for implementation. Collectively, such experiences and lessons learned in the development of the university's GIS program may serve as a model for other small colleges and universities, particularly minority-serving institutions, that wish to add GIS to the curriculum.

GIS CURRICULUM DEVELOPMENT

GIS instruction has become an integral component in geography departments and in undergraduate and graduate curricula at universities throughout the United States (Benhart 2000). Several discussions have ensued among geographers regarding GIS education, including the following: the place of GIS within the discipline (Kemp, Goodchild, and Dodson 1992); the integration of GIS into core geography courses (Lloyd 2001); *what* should be taught within a GIS curriculum (Kemp and Goodchild 1991); *in what manner* GIS should be taught and integrated into geographic education (Sui 1995); and what specific techniques and approaches for teaching GIS have been effective, such as Web-based courses (Foote 1997), project-oriented learning as a solution to the training-versus-education dilemma (Chen 1998; see also Kemp and Goodchild 1991), and/or cooperation with local organizations in project development and the execution of GIS-based research and applications (Benhart 2000).

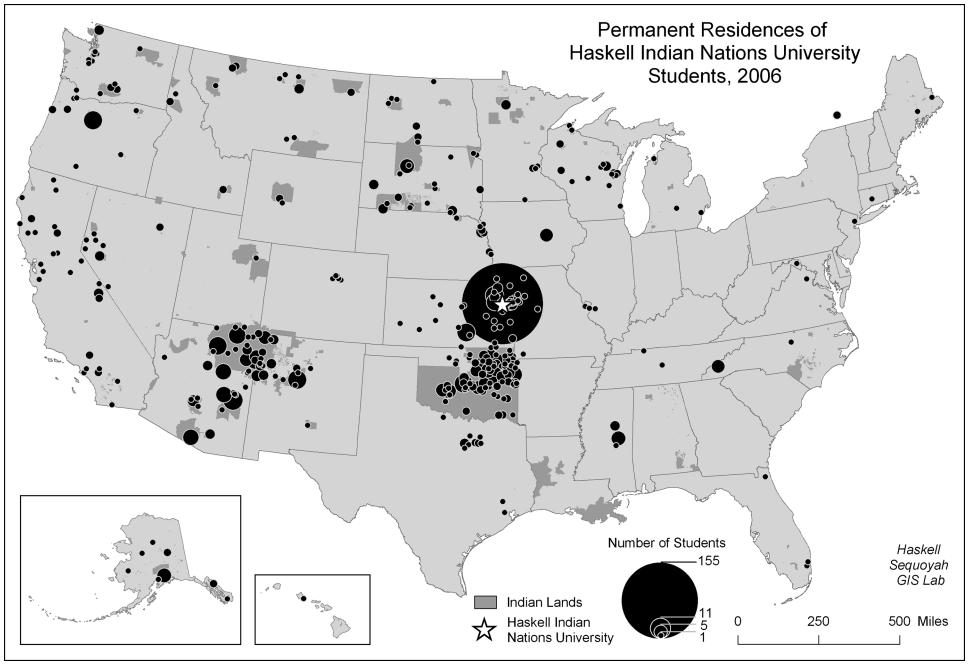

Figure 1. Map of the distribution of Haskell students. Note: Lawrence, Kansas, is on record as the permanent residence for many students, although most came to Haskell from other locations.

A particularly relevant topic for GIS education has been the development of core, or model GIS curricula, that have been proposed by organizations such as the University Consortium for Geographic Information Science (UCGIS) (e.g., DiBiase *et al.* 2006) and the National Center for Geographic Information and Analysis (NCGIA) (2000). An important goal for GIS educators includes training future GIS professionals to recognize the distinction between geographic information science (Goodchild 1992) (e.g., the theory, concepts, and science that are integral to the GIS process) and the use of GIS software as a tool that may be applied to various topics (Wright, Goodchild, and Proctor 1997).

Although some researchers have used specific examples and descriptions from their respective university GIS programs in their discussions of GIS education (Chen 1998; Benhart 2000), little has been written about *how* GIS programs have been developed within small colleges and universities. Furthermore, an important void in the GIS curriculum development literature is discussion about how GIS has been integrated into academic programs at TCUs specifically, and minority-serving institutions in general. A notable exception that is particularly apt here is the work of Mannel *et al.* (2007) describing the GIS program at Oglala Lakota College, a TCU on the Pine Ridge Reservation in South Dakota. In this article, we expand on their research and describe additional experiences and strategies for adding GIS to the undergraduate curriculum at such institutions. In addition, the development of the program at Haskell serves as an example of how GIS may be added in the absence of a geography department; prior to the development of the GIS program, the only geography course offered at the university was an introductory world geography course. Haskell's unique role within Indian Country also provides a rare insight into how a GIS program can gain integration into a larger community beyond the classroom, and even beyond the college or university campus.

GIS and Indigenous Communities

In addition to research related to the development of effective GIS programs in education systems, there is a rich and growing literature concerning the relationship of GIS and cartography to indigenous communities and marginalized populations in general. For example, Rundstrom (1990) has documented the cultural role of maps in indigenous communities as well as what a European or American observer would consider the technical prowess of indigenous mapmakers. Sieber (2003) has considered the role of participatory GIS and explored the possibility that use of GIS by tribal governments is not always a democratizing force. Sui and Goodchild (2003) cast the study of GIS as that of an ascent of a new medium that replaces text-based representations with those that are characterized by narrative and storytelling, a perspective that resonates with indigenous traditions of storytelling as a part of scholarship. Issues of the control of GIS and mapping, and with it the power to establish a dominant narrative about the landscape, shapes the GIS program at Haskell, as it attempts to meet the three simultaneous goals of doing GIS analyses that speak to indigenous communities, providing GIS support to tribal governments, and training a new generation of individual GIS practitioners.

Overview of the GIS Program at Haskell

GIS has had a continuous presence at Haskell since the early 1990s. Initial support for GIS at the university was provided by the United States Geological Survey (USGS), which allotted the necessary equipment to furnish a GIS laboratory as well as an instructor to develop and teach an introductory GIS course. Over the years, numerous grants have sustained GIS at Haskell and have supported the development of an expanded program in recent years.

In its current implementation, the GIS program at Haskell is analogous to a three-legged stool and is supported by

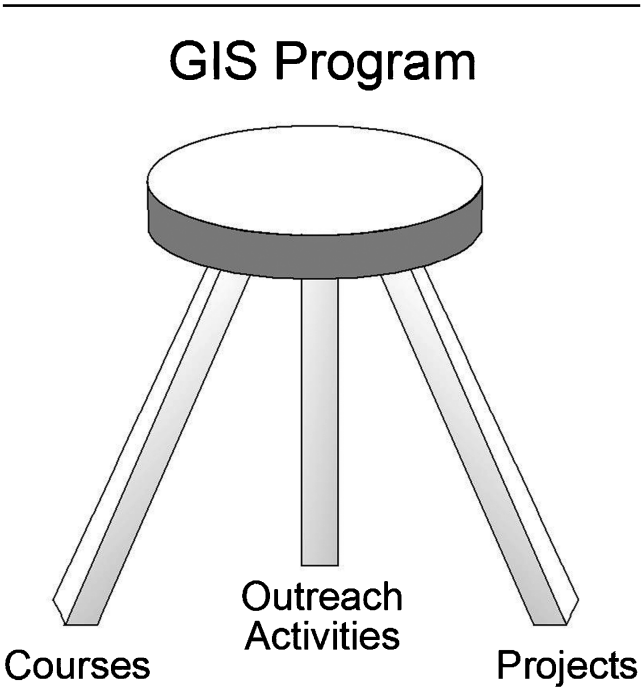

Figure 2. The "three-legged stool" model used to develop the GIS program at Haskell.

three integrated components representing the stool's legs: (1) courses; (2) outreach activities; and (3) projects (Fig. 2). Courses are designed to teach core GIS, mapping, and geographic concepts and techniques. Outreach activities provide students and instructors the opportunity to assist tribal members and leaders through GIS workshops or site visits to tribal offices on reservations. Projects provide advanced students with "hands on" experience applying GIS and project management skills to a variety of topics. Collectively, these activities provide a diverse program with a variety of opportunities for students.

Courses

The core of Haskell's GIS program is a sequence of three courses: (1) Introduction to GIS (Geography 310, three credits); (2) Applications of ArcGIS (Geography 320, two credits); and (3) Advanced GIS and GPS (Geography 330, three credits). The Introduction to GIS course provides an overview of basic, introductory GIS and mapping concepts, including map projections, digital data sources, GPS, spatial analysis, and cartographic output. The material is taught in a computer laboratory in order to combine lecture and lab components of the course. The Applications of ArcGIS course is an intermediate course also taught in a computer laboratory environment. Whereas the objective of the introductory GIS course is to provide students with a basic understanding of core GIS concepts and an introduction to GIS software, the primary goal of the intermediate course is to improve their mastery of ESRI's ArcGIS© software through a substantial number of hands-on tutorial exercises that demonstrate numerous applications. The Advanced GIS and GPS course is a continuation of the Introduction to GIS course emphasizing advanced GIS topics (e.g., raster analysis, spatial interpolation, database design, and mobile GIS) and is also taught in a laboratory environment. All courses require a final project for successful completion of the course with a substantial research project that students design and complete from start to finish serving as the capstone of the Advanced GIS and GPS course.

Both lecture and laboratory components of all GIS courses take place in a "smart classroom" equipped with built-in digital projector, screen, and sound system. This has allowed instructors to easily employ various methods of technology in their teaching. In addition, holding the entirety of the course in the same room has allowed for a seamless transition between instruction, demonstrations, and lab exercises completed by the students. For example, the introductory course is taught in a two-hour block twice a week with the first hour typically comprised of lecture material and demonstrations and the second hour reserved for lab exercises. We have found this method to be helpful for students to apply what they learn immediately following instruction, unlike standard GIS courses that are divided into lecture and laboratory components.

Outreach Activities

The GIS program's outreach activities are consistent with the university's mission to provide support to tribes from around the country. As such, Haskell serves as a meeting place for various conferences, symposia, and workshops attended by tribal members, staff, and leaders.

Tribal Outreach

Free, periodic GIS workshops entitled GIS Applications for Tribes are offered at the university to tribal environmental specialists and others from the tribes. The workshops, typically three to five days in length, serve multiple purposes. Tribal members learn basic GIS skills that are valuable for daily operations on their reservations. The workshops also provide a venue for Haskell faculty and students to learn about existing and potential applications of GIS in Indian Country from workshop participants, which may then be used to fine-tune the specific content and applications presented in the GIS courses. In addition, advanced GIS students at Haskell are encouraged to assist with instruction at the workshops, thereby providing the unique experience to teach in a classroom-like setting. A recent workshop was cosponsored by the Sac & Fox Nation of Missouri in Kansas/Nebraska and included eleven participants from eight tribes. An added component to the workshop was guest speakers from the University of Kansas and various federal agencies who presented applications of GIS and remote sensing in their respective fields.

A related aspect to the GIS workshops is site visits to tribal reservations by Haskell students and faculty. The site visits facilitate two goals: to provide additional on-site GIS support to the tribes and to observe GIS operations on tribal lands firsthand. For example, faculty and students recently visited one GIS workshop participant, the Deputy Manager for Environmental Protection for the Winnebago Reservation in Nebraska. The visit provided an opportunity to renew connections, discuss challenges the participant encountered when implementing workshop material into his daily workflows, and elicit suggestions for improvements to Haskell's GIS curriculum. The official stressed the importance of surveying skills in the implementation of GIS on his reservation as most of the publicly-available spatial datasets did not have sufficient accuracy or precision for tribal use. As a result, he found it necessary to complete a substantial amount of survey-quality field mapping using differential GPS equipment. He also advocated the importance of teaching CAD skills to GIS students, given the widespread use of CAD among engineers and surveyors with whom tribal governments must exchange data. As a result of his suggestions, we are working to adjust the curriculum to increase the modest exposure students receive to surveying techniques and CAD software.

Campus and Community Outreach

In addition to the activities directed at tribes, additional outreach activities are also aimed at the campus and the broader community. Occasional GIS workshops are offered for Haskell faculty and staff to introduce introductory GIS concepts and showcase a variety of applications. The goal of the faculty and staff workshops is to explore ways in which GIS may be integrated into faculty courses and research, as well as campus projects completed by staff. For example, a workshop was offered for staff in the campus facilities department in order to integrate GIS into future campus development and management projects. Such workshops have also proved to be an excellent avenue for promoting GIS and geography on campus and for developing collaborative relationships with other departments in the university, including natural sciences, American Indian studies, and business.

A GIS open house was another outreach activity that elevated the exposure of the GIS program on campus. The aim of the open house was to promote GIS to the university as well as to the government and university-affiliated research institutions, environmental advocacy organizations, and the broader community. Since Haskell is a small university situated in the shadow of the much larger University of Kansas, it is easy for the work of the Haskell GIS laboratory to be overlooked and for students to feel isolated from the broader academic world given the tremendous amount of research generated at the University of Kansas and its affiliated organizations.

The open house was designed to accomplish two goals: to showcase current GIS research and projects by Haskell students and to demonstrate to the students that their work is of interest to the public beyond the Haskell campus. The event was organized around several displays of student projects, each including a computer display (e.g., GIS software demonstration) and a poster describing the project. Students also were available to demonstrate or discuss their work with attendees. Another event included an informal contest in which participants were challenged to identify locations around the world as displayed on satellite imagery. The open house was well attended, with visitors including faculty from Haskell and the University of Kansas, graduate students, undergraduate students, and nonacademics from within the community. The Haskell GIS laboratory buzzed with conversation for the four hours of the event, communicating clearly to the students that their work was appreciated by senior members of the geography and environmental policy community.

PROJECTS

As a third supportive leg in Haskell's GIS program, involvement in projects provides invaluable professional experience to students by giving them an opportunity to apply their GIS and mapping skills to a variety of geographic topics. Each semester and during the summer months a number of Haskell students are funded by various federal grants as hourly paid interns for their work on GIS projects, which include formal research projects, campus mapping projects, and tribal projects (Haskell Indian Nations University 2006).

Research Projects

In several cases, Haskell has served as a partner institution with the University of Kansas in order to assist in the accomplishment of research and outreach goals for federally funded grants. Two such examples are Haskell's involvement in the Polar Radar for Ice Sheet Measurements Program (PRISM) and the Center for Remote Sensing of Ice Sheets (CReSIS). PRISM, a National Science Foundation (NSF) and NASA-funded grant at the University of Kansas, seeks to increase the scientific understanding of how changing ice sheets are affected by global climate change through remotely-sensed measurements of ice sheets in Greenland and Antarctica. Haskell students and faculty, for example, contributed to PRISM research through the use of GIS for data processing and visualization of ice sheet thickness measurements in Greenland. The data processed by Haskell students is being used by polar researchers to establish a base elevation (i.e., the surface under the ice) dataset for the region. A Haskell student involved in this work presented his work at the American Indian Science and Engineering Society's annual meetings in 2007. In addition, Haskell has assisted in PRISM outreach activities by coordinating GIS workshops (PRISM 2003). The partnership with PRISM was instrumental for nurturing the early GIS program at Haskell.

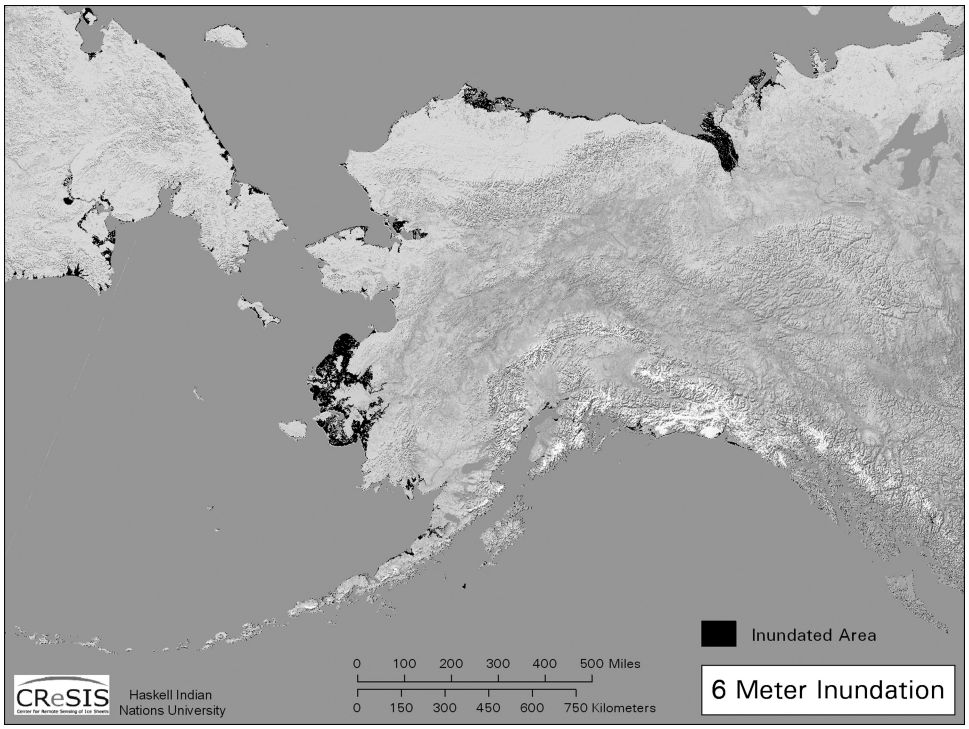

Figure 3. Inundation from sea-level rise of six meters for Alaska. (Shaded relief and land cover map from Natural Earth, Tom Patterson, U.S. National Park Service. Original map in color.)

CReSIS was established at the University of Kansas in 2005 as one of two science and technology centers funded by NSF that year. An expansion of PRISM activities, CReSIS continued the existing partnership with Haskell in order to accomplish its mission "to understand and predict the role of polar ice sheets in sea-level rise" (CReSIS 2006). CReSIS supports instruction of the introductory GIS course as well as a variety of other GIS activities at Haskell. In turn, Haskell's contribution to CReSIS is to provide GIS-related polar research by processing, analyzing, and mapping CReSIS-derived data products such as ice thickness measurements. Haskell's role as a Native American institution also provides a unique perspective to CReSIS research. For example, Haskell is currently leading a CReSIS-supported collaboration of tribal scholars that is examining the role of climate change on indigenous communities, which has resulted in an ongoing series of symposia hosted by Haskell and the American Indian & Alaska Native Climate Change Working Group.

A recent CReSIS-related research project spearheaded by Haskell involves the use of GIS for modeling global sea-level rise due to climate change (Fig. 3). The goal of the project was to integrate GIS datasets and methods into a global analysis to determine at-risk population and land area from sea-level rise. Inundation zones were calculated using a series of complex algorithms that analyzed a global digital elevation model (DEM) to identify areas adjacent to the current ocean and below a certain elevation (i.e., one meter above sea level). Once inundation zones were calculated for one to six meter increments in sea-level rise, these maps were used to calculate the total surface area and number of people affected according to LandScan (Dobson *et al.* 2000), a global population dataset (see Rowley *et al.* (2007) for discussion of the GIS methods and results. Project results are also available at *http://cresis.ku.edu/research/data/sea_level_rise/index.html*). Various methods of visualization, such as map animations and static maps, were created to display the progression of the inundation at global and regional scales. Two Haskell students, with advanced GIS experience and under the mentorship of Haskell faculty and graduate students from the University of Kansas, were integral to the project from start to finish. Both students assisted in all stages of the project, including data processing, analysis, and visualization tasks. Follow-up work has included application of the principles and methodologies for further analyses at local scales.

In addition to PRISM and CReSIS research, Haskell students have applied their GIS skills to research funded by other grants. Some students have worked on research projects at the Kansas Applied Remote Sensing (KARS) Program at the University of Kansas, which has sponsored GIS and remote-sensing student interns through the America View Program. A NASA-funded Curriculum Improvement Partnership Award (CIPA II) at Haskell supports research that integrates project management principles with GIS. Additional GIS-related research projects, student travel and presentations, laboratory equipment, and faculty salary at Haskell are funded by an NSF Tribal College and University Program (TCUP) grant. Support for GIS at Haskell is one of the main components in the proposal for the TCUP award, which seeks to improve the curriculum at Haskell in the science, technology, engineering, and mathematics (STEM) fields.

Campus Projects

The GIS laboratory at Haskell also provides support to the university through numerous campus mapping projects. Ideas for a number of the campus mapping projects derive directly from student class projects, which offer the unique opportunity for students to expand on their work and lead further development of the project. The carry-over from a class project to a research endeavor outside of class

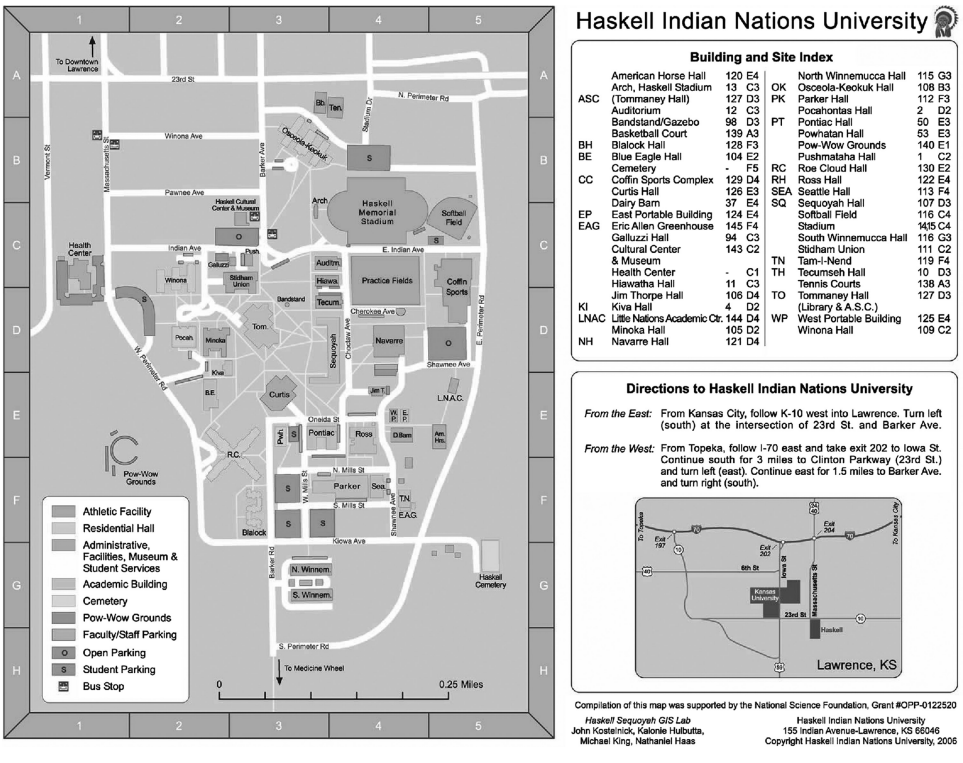

Figure 4. A new campus map of Haskell Indian Nations University, an example of a campus project with much student involvement. (Original map in color.)

also illustrates the integrated relationship between legs of the stool that support the GIS program. One example of such a campus project includes the production of a new campus map for the university, in which two students participated in its compilation and design (Fig. 4). Another project involved the development of a 3-D visualization of campus (Fig. 5) that was led entirely by a Haskell student from start to finish with assistance from three other students. The resulting 3-D visualization may be viewed in either Google Earth© or ESRI's ArcScene©, and has served numerous purposes in student recruitment, daily campus maintenance projects, acquainting potential visitors with the university prior to arrival, and planning for future development of the university's facilities. The students presented this work at KU's annual GIS Day symposium and at the annual meeting of the Association of American Geographers (AAG) in 2007. A third campus project, also directed by GIS students, is a historical GIS that utilizes historical maps to tell the story of the university from its earliest days to the present through photographs, maps, and aerial photographs. The students presented this work at the 2008 annual meeting of the AAG in Boston, Massachusetts. In addition to serving as opportunities for students to polish their GIS knowledge and skills for a place they know well, such campus mapping projects often result in useful products available to the university community.

Tribal Projects

In addition to the campus projects discussed above, a number of tribal projects have been developed that apply GIS techniques to issues on Native American reservations. These projects are intended to provide opportunities for students to apply their GIS skills to questions faced by tribal communities far from the Haskell campus and to provide new understandings of cultural and environmental problems that tribes encounter on the reservations.

One such project is an analysis of the impact of sea-level rise on the Pleasant Point Reservation of the Passamaquoddy Nation in eastern Maine, which builds on the global sea-level rise modeling research described above. The reservation is subject to very high tides (it is at the mouth of the Bay of Fundy) so a model of sea-level must account for both long-term changes in general sea level and short-term tidal fluctuations. The project also provides an opportunity to consider questions involving loss of tidal flats, economic and cultural impacts associated with that loss, as well as the more traditional analysis of destruction of coastal infrastructure. Global models, of necessity, cannot account for local environmental conditions such as extraordinary tidal ranges. An important goal of the project is to demonstrate the value of connecting local understanding and indigenous knowledge with global processes. The pilot project provided the basic methods for the two local sea-level rise impact studies described later in the article. Such tribal projects often provide an opportunity to collaborate with other faculty in disciplines such as American Indian studies. For example, the sea-level rise efforts have been aided substantially by the involvement of Dr. Daniel Wildcat, a prominent native scholar with expertise in American Indian education (Deloria and Wildcat 2001) and the impact of environmental change on indigenous communities.

Recognizing that the application of GIS in business and government settings typically involves teams of experts from a variety of disciplines, we recently expanded work supported by the CIPA project management grant to explore the integration of project management techniques with GIS as it relates to tribal projects. Over the course of a summer, a group of students attended project management training, then designed a team-based research project to expand the local sea-level rise studies at locations in or adjacent to reservation lands in Maine and Washington.

Figure 5. A portion of a 3-D visualization of the Haskell campus as displayed in Google Earth.

Students presented the final research results at a NASA-sponsored symposium as well as the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) national convention in 2007. The students and faculty mentors also authored a paper describing the project that has been accepted for publication in ESRI's *GIS Educator*©.

Another tribal project includes a cartographic analysis of cultural and environmental trends in Thurston County, Nebraska, an area that includes two reservations (the Omaha and Winnebago) and substantial non-native land holdings. The analysis was designed to illustrate the relationships between physical geography, historical settlement patterns, and land use on the reservations. A Haskell student developed maps in the GIS laboratory, which was followed by a day-long site visit arranged with the Winnebago tribal government to compare the analysis with field observations on the reservation. As we had hoped, the meeting with tribal officials and some fieldwork on the reservation made the issues that were depicted on the maps come alive for the students. They left with an increased appreciation for the importance of combining geographic fieldwork with GIS analyses. Subsequently, a student from the Winnebago tribe has taken a GIS course and is now working on a project to identify the best locations for wind power.

Project Benefits

Such research, campus, and tribal projects provide several advantages for students as they develop their GIS skills in a hands-on, project-oriented atmosphere. Added benefits include the excitement of contributing to important and necessary research as well as an opportunity to earn a modest paycheck for the hours they contribute to the project work.[2] More advanced students have the opportunity to lead and develop projects, which provides valuable leadership and project management skills. We also have found, as others have (e.g., Chen 1998; Benhart 2000), that teaching GIS through a project-oriented approach itself yields benefits such as an increased knowledge that comes through application of classroom material and theoretical concepts to real-world problems. The sea-level rise project—having direct relation to problems and questions that PRISM and CReSIS seek to answer—is a good example of how Haskell students have become involved in researching an important societal issue while at the same time gaining experience with complex GIS methods and datasets discussed in the courses. At the same time, the sea-level rise project shows how Haskell students can make a crucial contribution to a research project of the same caliber as those projects in which their fellow students at the University of Kansas are commonly involved. In fact, a benefit of small colleges and universities such as Haskell is that they may offer these project opportunities to students while they are undergraduates, opportunities that are often reserved for graduate students at larger institutions.

Students have presented the results of their research and projects at regional and national professional conferences, which have provided networking opportunities with professionals in the field as well as representatives from graduate schools. Collaborative project work with other students, instructors, mentors, and faculty advisors may be an invaluable training asset as a student develops skills and prepares to enter the workforce (see Chen 1998), or pursue graduate studies. Finally, the projects themselves have benefited from student insights and perspectives about how to approach a problem.

Challenges and Lessons Learned

A number of challenges have been encountered and subsequent lessons learned from the development of the GIS program at Haskell. Perhaps the greatest challenge has been to develop ongoing streams of funding for the program. In a time when colleges and universities stress the importance of external funding to supplement operating budgets, grants and contracts have become an important source of support for GIS programs. Several GIS educators (e.g., Foote 1997; Lloyd 2001; Mannel and Winkelman 2005) have discussed how GIS education development and integration into the core curriculum of geography has required funding to address hardware and software obstacles. In the development of the program thus far, GIS activities at Haskell have been supported entirely by external funding sources, which have provided the only funds for teaching and research faculty salaries, student pay, travel to conferences, and laboratory equipment (computers, printers, software, and GPS equipment). The continued pursuit of external funding will be critical to the future sustainability of GIS at Haskell until university funds may assist in supporting the program. This remains a particular challenge in the wake of yearly cuts to the university's operating budget by the BIA, which severely limits the addition of new programs. Fortunately, numerous funding opportunities are available to support the development of GIS programs at colleges and universities, including TCUs, and the pursuit of external funding with additional partners may prove valuable to success. Although not an emphasis of the existing program, future planning also may include the possibility of developing additional partnerships with GIS and remote-sensing corporations in the private sector.

Another successful strategy for the development of Haskell's GIS program has been partnerships with other universities as well as federal (e.g., USGS), state (e.g., Kansas Biological Survey), and local agencies (e.g., Western Air Maps, a geospatial technology company in the region, and the Kansas City Area Transportation Authority). Such partners provide numerous benefits including collaborators for the pursuit of grants, a source of guest speakers for the classroom, sites for class field trips, and internship and employment opportunities for students. In addition to partnerships with other universities, strong ties with tribal offices are particularly important for TCUs, yet this remains a logistical challenge for Haskell which, unlike most TCUs, is not located in close proximity to an Indian reservation.

Although such partnerships sometimes may be perceived as providing benefits primarily to the smaller institution, we have found such relationships to be equally beneficial to both institutions, albeit in different ways. For example, Haskell has benefited from many quality instructors who are graduate students at the University of Kansas. In turn, Haskell has provided a unique environment full of many opportunities that would otherwise not be available, and these opportunities have greatly enhanced the professional careers of these instructors. Students also have reaped many benefits through the opportunities afforded by such partnerships, and in fact have been sought out by those partners for their unique experience and skills in GIS projects. In other words, the benefit has been mutual and not, as one might presume, a situation of the larger institution saving the smaller.

The benefits garnered from Haskell's close partnership with the University of Kansas have been crucial in the development of the program, and undoubtedly the close proximity of the two schools has been very beneficial to the partnership. However, based on our observation of other partnerships that CReSIS successfully maintains with universities a great distance from Lawrence, Kansas, building collaborative partnerships is a realistic possibility regardless of geographic location and should be pursued by an institution that would like to build its own GIS program. The ability to effectively communicate through teleconferencing, e-mail, and Intranets minimizes the impact of distance and is beneficial for furthering such relationships.

The development of a curriculum within a broader cultural context is another important consideration for TCUs and other minority-serving institutions, particularly for topics such as GIS that are multidisciplinary and applicable to societal issues. Although not all Haskell students will seek employment with their tribes following the completion of their degrees, it is nonetheless important that they understand the geographic dimensions of issues that confront the tribes and the applications of GIS for addressing such issues. To achieve this goal, lectures and computer laboratory exercises may integrate case studies and examples from tribal lands into classroom instruction. At the same time, such situations prove to be a delicate endeavor in cases where culturally sensitive data must be respected and treated with confidentiality, yet these situations expose students to another important issue related to the use of GIS in Native American affairs.

Another beneficial activity for the development of any GIS program is promotion throughout the campus. Many faculty, staff, and administrators who are nongeographers are not aware of recent advancements in GIS and the discipline of geography in general. Campus activities such as an open house, participation in student orientations and career fairs, workshops, presentations at faculty meetings, course advertisements (e.g., flyers posted around campus), and campus projects have become important and necessary activities at Haskell for stressing the importance of geography in the college and university curriculum. Such activities also may prove useful for recruiting students from other fields. Initially, GIS courses at Haskell were filled largely with students from the environmental science degree program, yet recent enrollment trends indicate an increase in students from other fields such as business and American Indian studies. As another example, an employee in the university's facilities department recently completed the introductory GIS course with intentions of incorporating GIS within that department.

Although the true power of GIS derives from applying it to well-defined geographic problems and issues, there is a danger in GIS instruction becoming little more than technical training in a narrow subfield of computer technology. This tendency may be exacerbated by students who have little or no background in basic geography courses, which is typical of many universities without established geography departments such as Haskell. The basic geographic principles found in introductory geography courses are helpful and necessary in an effective GIS education; yet at the same time GIS concepts and principles themselves may be good teachers of geography (Nellis 1994; Chen 1998).

We have attempted to resolve this weakness with two separate efforts. First, we integrate more basic map use principles (e.g., map scale; topographic map reading) and geographic concepts into the introductory GIS course than if the course were offered to students who had already taken an introductory course in cartography or physical geography. Second, now that a core GIS sequence has been developed, we have expanded the course offerings at Haskell to include an introductory class in physical geography, in addition to the already existing world regional geography course, in an effort to teach important geographic concepts and spatial thinking skills before students enroll in GIS courses. Although highly recommended as courses taken prior to the GIS sequence, neither of these courses is currently required. Graduate students from the University of Kansas who have taught these classes elsewhere are often readily available to provide instruction, so the costs of adding the courses to the curriculum so far have been relatively low. However, the availability of sustained funding and instructors with the appropriate teaching backgrounds continues to provide challenges to long-term curriculum planning. In the future, we hope that all of the five currently listed geography courses, and others that follow, will become a new degree program, or part of an emphasis within one of the currently existing degree programs.

Finally, whereas the GIS program has become more established at Haskell in recent years, formal methods of overall program assessment have yet to be developed, and this is an area for future work. Such measures, once developed, will provide a more objective approach to assessing the overall effectiveness and success of the program. Currently, simple measures such as the placement of graduating students in GIS-related careers[3] or graduate school, the participation of students in professional conferences, and the publication of research that has involved students are used anecdotally to gauge overall success. As these measures are developed formally over time, they may be beneficial in objectively determining the success of the program, as well as identifying areas that may be improved.

Summary and Conclusions

This article has presented a "three-legged stool" approach, consisting of courses, outreach activities, and projects, that may be utilized for implementing a GIS program at a small university. We hope that the strategies employed in the development of Haskell's GIS program, as well as the challenges encountered along the way, are useful for other colleges and universities, particularly minority-serving institutions such as TCUs, Hispanic-Serving Institutions (HSIs), and Historically Black Colleges and Universities (HSCUs), that wish to add a similar program. In summary, based on our experience such institutions should emphasize the following when building a GIS program:

- Focus should be on diversifying the program with different activities. Courses are the most crucial component, but effort should be made to develop other ways of teaching, such as project-based learning and outreach activities.
- External funding is critical to the success of a GIS program and ample funding opportunities exist for minority-serving institutions, whether independently awarded or garnered through partnerships with other institutions.
- A GIS program, particularly one that is developed independent of a geography department, should reach out to many departments and disciplines within the university. Given the universal application of GIS data and methods, such integration will likely be well-accepted and beneficial for all parties involved.
- Effort should be made to teach basic geographic principles with (or in addition to) the core GIS curriculum.

As GIS is integrated more and more into the college and university curriculum, in geography departments and elsewhere, additional models and case studies are needed to highlight success stories as well as potential pitfalls. This is particularly the case for TCUs such as Haskell, where it is critical to develop effective programs for educating and training those native students that return to Indian Country, as well as those that enter the workforce elsewhere.

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NOTES

1. Indian Country is an often-used term referring generally to Native American reservations and tribal lands within the United States.
2. Wages are supported by grant funding. Hourly rates varied by student's level of experience and involvement in the lab's work, but we attempt to keep the rates competitive to the general market for hourly wages earned by GIS professionals in the region.
3. For example, recent program participants and graduates have found GIS-related employment in tribal governments, the U.S. Forest Service, and the U.S. Census Bureau.

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