AC 2011-2899: CULTIVATING GEOSPATIAL ENGINEERS IN A POPULATION UNDERREPRESENTED IN STEM INDUSTRIES

Diana Papini Warren, Maui Economic Development Board

Diana Papini Warren is a Project Manager with the Maui Economic Development Board's Women in Technology Program. She develops and manages several statewide STEM education initiatives, including the GeoTech for Hawaii Schools initiative. She facilitates the professional development courses for teachers throughout Hawaii, supports events for students, and is the webcast facilitator for the state's annual GIS Day celebration. She holds a Master of Science in Education and has fourteen years experience working as an educator, a curriculum developer, and a professional development specialist.

Leslie Wilkins , Maui Economic Development Board

Leslie Wilkins has served as the Vice President of the Maui Economic Development Board since 1999. She was hired to design, launch and direct the Women in Technology Project with a mission to engage girls/women and under represented populations into the Science, Technology, Engineering and Math (STEM) pipeline. In its tenth year, the program serves annually more than 14,000 students, educators and industry members throughout the state of Hawaii from elementary school to job placement.

Cultivating Geospatial Engineers in a Population Underrepresented in STEM Industries

Introduction

The field of geospatial technology has exponentially grown and significantly impacted multiple aspects of our global society, especially the engineering industry. Geospatial technology is an umbrella term for Geographic Information Systems (GIS), Global Positioning Systems (GPS), and Remote Sensing. This paper discusses one model for reaching students throughout the state of Hawaii to prepare them for a future in geospatial technology and engineering careers.

The model was developed and implemented by the Women in Technology Project (WIT) which is funded in part by the U.S. Departments of Labor, Agriculture, and Education, as a workforce development project. Its mission is to encourage females and other under-represented groups to pursue education and careers in science, technology, engineering and math (STEM) in the state of Hawaii. WIT successfully creates systemic change by building awareness among educators and employers of the return on investment in recruiting and retaining a diverse and inclusive skilled technical workforce that is homegrown.

Geospatial Technology in Engineering

While there is a specific field known as 'geospatial engineering,' the impacts of geospatial technology reach a wider spectrum of the engineering industry. There is a growing number of engineering firms are integrating broad scale uses of GIS. Projects include "large architecture/engineering and construction projects that include infrastructure design, environmental planning, facilities management, corridor planning, residential and commercial development master plans, and natural resource management."[1]

Colonel Hooper of the United States Army comments on the effect of geospatial technology within engineering in the military: "Exploitation of geospatial information is revolutionizing business, science, and government. Aerial and satellite remotely sensed imagery, Global Positioning Systems, and computerized Geographic Information Systems (GISs) are increasingly becoming the driving force for decision making across the local to global continuum. "[2]

The growth of the geospatial industry creates a demand for a skilled workforce. In 2004, the US Secretary of Labor named geotechnologies (along with nanotechnologies and biotechnologies) as one of the three fields most in demand for 21st Century workforce skills. Subsequently, in Summer 2010, the Department of Labor published the Geospatial Technology Competency Model which outlines in detail the skills and the knowledge base required in the various geospatial industry careers. According to this model, geospatial careers may require the "knowledge of the practical application of engineering science and technology. This includes

applying principles, techniques, procedures, and equipment to the design and production of various goods and services."[3]

Geospatial Education Needed to Fuel the Workforce Demand in Hawaii

In alignment with national trends, the number of job opportunities in Hawaii that require training or experience in geospatial technologies has dramatically increased in the last decade. Employers of all types are looking for skilled GIS technicians, remote sensing analysts, and geospatial engineers. However, the local workforce is not able to meet this demand. Many employers end up recruiting and relocating hires from outside of the state. In addition to the extra expense this entails, employers also experience turnover in hires without island ties due to difficulties in adjusting to the island's isolation, high cost of living, and unique culture.

In order to train and cultivate the local workforce in Hawaii, education programs are needed at all levels along the workforce pipeline, from K-12 to post-secondary certification programs to higher education degree programs. These education programs must also target the populations underrepresented in engineering and technology fields. In response to this need, in 2008, WIT established the GeoTech for Hawaii Schools statewide initiative to specifically target the K-12 public schools, helping them to integrate the use of GIS, GPS, and Remote Sensing.

Hawaii Public School Demographics

Hawaii public schools are reflective of the diversity of the island chain's population. Less than fifteen percent of Hawaii's K-12 student population is white or Caucasian, while the majority consists of Asian, Native Hawaiian or Pacific Islanders and mixed races. (See Table 1 Below.)

Table 1. Ethnicity of Students and Teachers in Public Schools of Hawaii

Ethnicity	Students	Teachers
African-American	2.3%	0.4%
Caucasian	14.7%	22.8%
Chinese	3.2%	3.9%
Filipino	20.5%	5.7%
Hawaiian/Part-Hawaiian	27.6%	9.4%
Hispanic	3.2%	0.2%
Japanese	9.2%	28.9%
Korean	1.3%	0.8%
Native American	0.6%	0.0%
Samoan	3.4%	0.3%
Other	13.9%	27.4%

(Hawaii Dept. of Education Superintendent's Report 2/2/09) [4]

These numbers confirm the efficacy of specifically targeting public schools in order to reach those populations traditionally underrepresented in engineering and technology fields. In the

GeoTech for Hawaii Schools initiative, the primary component of program offerings consists of professional development for teachers. The goal is to reach the student populations listed above by first reaching teachers.

In doing so, we remain cognizant of the fact that these teachers do not themselves reflect the same degree of ethnic diversity found in the student population. Where 27.6% of students are Hawaiian or Part Hawaiian, only 9.4% of teachers are Hawaiian. Similarly, 20.5% of students are Filipino, and only 5.7% of teachers are. This is significant for us as we seek to develop effective professional development events for teachers. In addition to training teachers on necessary geospatial technologies skills, we integrate themes and methods that recognize cultural diversity within the student population and the need for equity of opportunity.[5] In addition, all events incorporate a gender equity awareness session, a pillar of all WIT programs. Articles on best practices in the classroom for encouraging gender equity are distributed, and participants engage in related activities and discussions.[6]

Industry Connections

Raising awareness of career pathways and local industry connections is a feature of all our events, and we accomplish this by bringing in local professionals from the geospatial technology industry to interact directly with participants. Professors and PhD candidates from the University of Hawaii at Manoa, consultants from geotechnical engineering firms, and planning professionals from the county government and private industry are a few examples of the sources of guest presenters we have engaged. We seek out presenters that are female and/or are of ethnicities that correspond with student demographics.

Presenters are asked to share their personal educational and professional career pathways, and to share the uses and applications of geospatial technology in their current occupations. For example, teachers learned first-hand from a female GIS specialist at a geotechnical and hydro-geological firm how she uses the technology to predict and model landslides. Another female professional from an environmental consulting firm discussed an island-wide project to assess dams and ditches. A mixed-race, locally raised and educated geologist shared how he uses GIS software to predict lava flow from the active volcanoes on Hawaii Island.

Part of preparing teachers to implement geospatial technologies into the classroom involves exposing them to real world applications of the technology. Participants in our events have expressed appreciation of these industry connection components of our offerings and, in some cases, followed up to invite speakers into the classroom to present to their students.

GeoTech Initiative Events and Outcomes 2008 – 2010

From Summer 2008 to December 2010, the GeoTech for Hawaii Schools initiative facilitated a total of fifteen training events for educators over a 29 month period, engaging 260 teachers from

schools statewide. The table below lists the events and the participant enrollment figures. (See Table 2.)

Table 2. GeoTech Initiative Events for Teachers: Descriptions and Total Enrollment

	GeoTech Initiative Event	Description	Participants
A	Introduction to GIS Workshop Series – Summer 2008	A Series of Five Two-Day Workshops, one on each of main Hawaiian islands	48
B	Introduction to GIS Workshop Series – Summer 2009	A Series of Five Two-Day Workshops, one on each of main Hawaiian islands	108
C	Introduction to GeoTech – Spring 2009	An eight week online course offered to teachers statewide	27
D	Global Positioning Systems 101	A one day workshop on Kauai	18
E	Mapping Our Future: Using GIS and GPS for Place-based Inquiry – Fall 2009	An intermediate level, three month hybrid course (face to face with live online follow up sessions) offered to teachers statewide	17
F	ArcGIS in Education – Fall 2009	An intermediate level, two-day workshop on Oahu.	21
G	Introduction to GeoTech – Fall 2010	An eight week online course offered to teachers statewide	21
		Total	260

Outcomes: A & B -- Introduction to GIS Summer Workshop Series – 2008 & 2009

In each of these two day workshops, teachers learned the basic concepts of GIS, received curriculum and Hawaii geographic data sets, and viewed presentations by local geospatial professionals. In addition, participants learned to use GPS handheld devices, and, in 2009, funding allowed us to provide a GPS handheld to every participant to take home. A total of ten two- day workshops took place, five each summer.

There was a significant increase in enrollment from 2008 to 2009: from 48 to 108. This could be attributed to a variety of factors, including the increased awareness of geospatial technology in general, the awareness of the GeoTech for Hawaii Schools initiative itself, the increased incentives (GPS handhelds), and/or improved scheduling or accessibility for teachers.

According to pre-assessment surveys given to every participant at the start of each workshop, 94-95% rated themselves as having "Never Used GIS". In 2008, 94% reported having never used GPS handhelds, and in 2009, 90% rated themselves as either "Never Used GPS" or "Novice

User". This confirms the need for this introductory level of workshop. In addition, 82% reported never having participated in any similar training.

Fifty percent of participants taught at the high school level, and 41% taught at the intermediate school level. The remaining 9% taught at the elementary level. The average number of students a typical intermediate and high school level teacher has is 150 and for an elementary teacher, 25. Thus, multiplying an average of 75 students by 240 teachers, we can propose a potential impact of reaching approximately 22,144 public school students. For this particular workshop series, a follow up assessment of teachers was not conducted to compile actual numbers of classroom implementation events and impact on students. In addition, we had a small group of teachers who did attend more than one event, and this has not been factored into these estimates.

At the end of the two-day workshop, a post-assessment survey was conducted. Ninety-four percent of participants said they are more likely to integrate the technology, websites, and resources introduced at the workshop into their classrooms. Ninety-one percent said they would be interested in participating in similar workshops in the future. Most telling is the qualitative data we received, which shows participants' new understandings of the relevance of geospatial technology, in particular GIS. The following table displays direct quotes from teacher participants.

Table 3. Intro to GIS Workshop Participant Descriptions of GIS Capabilities

"GIS software is almost incomprehensible in its ability to map geospatial relationships of natural features, human influences and beyond. It is a very direct graphic way to condense LOTS of data into a smaller visual format for comprehension and usage."
"GIS has limitless possibilities for interpreting data in a more 3-dimensional/spatial point-of-view. GIS can give a very detailed and accurate visual representation of a given geographical area that we would have not otherwise been able to see."
"Puts spatial data in the hands of the students allowing them to layer information, compare data, synthesize, and analyze information."
"It is possible to do many things using the GIS. One important feature is the ability to assist all students in understanding what numbers represent. In this case, the maps and layers are powerful visual representations that can assist students in their conceptual understanding. Another feature is the ability to use local data in defining communities in which students live."
"Creating layered labeled maps. Incorporating our own tracks and waypoints from our own GPS system. Can add color, information tools, and scroll over labels to our maps. Can also create three dimensional or relief maps."

These introductory workshops have resulted in a cadre of 156 educators throughout the state empowered to provide opportunities for students to engage in the use of geospatial technologies. In addition to these summer workshop series, two other GeoTech for Hawaii Schools events

were introductory level in nature as well: the Intro to GeoTech online course and the GPS 101 one day workshop.

Outcomes: C & G – Intro to GeoTech Online Course

The Introduction to GeoTech online course was offered to teachers statewide in Spring 2009 and again in Fall 2010. With twenty-seven teachers in the first course and twenty-one in the second course, a total of 48 teachers participated from all five of the main islands. This was an eight week course which consisted of weekly assignments and a weekly live, interactive webcast event. Introductory level information on GIS, GPS, and Remote Sensing was introduced and skills were demonstrated at each live session. Most of the sessions involved guest experts. These guests included two women from the University of Hawaii at Manoa Geography and Geosciences Departments, a female professor from the University of Southern California, two experts in GIS in education from the Environmental Systems Research Institute (ESRI), and a data manager from the U.S. Geological Survey.

In the pre-assessment survey, the percentages of participants that reported having no experience whatsoever with geospatial technologies were as follows: Remote Sensing 58.8% , GIS 47.1%, GPS 35.3%. In the post-assessment survey, participants rated themselves as having advanced to the next levels of Novice or Proficient as noted in the table below. (See Table 4.)

Table 4. Intro to GeoTech Participants Post –Assessment Survey Results

	Novice	Proficient
Remote Sensing	52.9%	47.1%
GIS	64.7%	35.3%
GPS	47.1%	52.9%

This data helps to confirm that the course successfully provided foundational geospatial knowledge to educators. All content was delivered via a GoogleGroup and the Live Elluminate vClass synchronous sessions. With one exception, all teachers were from grades 6 -12; therefore estimated potential of the course is exposing approximately 7,840 students to geospatial technologies.

Outcomes: D – GPS 101

A one-day workshop for Kauai educators was offered to introduce Global Positioning System devices and their potential applications in education. Participants received curriculum and a GPS handheld to take home. Participants spent a good portion of the day outside in order to receive satellite signals while engaging in a variety of educational activities using GPS, such as measuring the circumference of the Earth, measuring one second of longitude, collecting

vegetation data, and more. The remainder of the day was spent uploading GPS data to the computer to a variety of GIS programs for analysis.

In the pre-assessment survey, only 33.3% reported having never used GPS prior to the workshop. Sixty-six percent were either novice or proficient. Although this was an introductory workshop, there were clearly some educators interested in furthering their existing knowledge of GPS. Sixty-one percent reported not previously owning or having access to any GPS units for use with their students.

In the post-assessment, 94.4% agreed that they were more likely to integrate the technology, software or websites introduced as a result of this workshop. When asked to describe how GPS works, their comments reflected a basic understanding of the technology. The following are examples:

"By locating 3 satellites, 2-D mapping can be achieved. With 4 satellites, 3-D mapping is possible. Triangulation generally is accurate to about 12 feet."

"Connects with satellites, pinpoints your position, gives direction of travel,speed, marks your tracks and backtracks"

This cohort of Kauai teachers is now a growing GeoTech professional learning community. Follow-up events are being planned, including a GIS workshop.

Outcomes: E - Mapping Our Future Event

In the Fall of 2009, 17 educators participated in Mapping Our Future: Using GIS and GPS for Place-based Inquiry. The participants, from four different islands, came together for a four day, face-to-face training, then continued participation via an online course during three months of classroom implementation. This was the first intermediate level course offered, and the hybrid model piloted allowed for a potentially closer examination of implementation and its impact on students.

In the pre-assessment survey, 84.2% of participants reported already having experience with GIS and being a novice user. Seventy-eight percent were novice users of GPS handhelds prior to the course. These background skills allowed the trainers to go through data collection activities at a swift pace, allowing more time for higher level spatial analysis and use of technology applications.

In the post-assessment survey, when asked to describe some capabilities of GIS, participants commented as follows:

"Organizing spatial data is a powerful tool. Recently some of my students used the GPS to map a trail they were taking data on. They were able to download their coordinates, and find the trail on a map. Given time we could have added the information on the transects in the way of

location, as well as data. Being able to store spatial data for future use is incredible for our student projects."

"Creating graphical depictions of data superimposed onto a variety of 2D and 3D maps."

"We can use GIS to document natural resources, to determine the effect that we have on the environment, to document demographics and a way of showing variation and changes and ratios of demographics."

"GIS is a tool for compiling, analyzing, and displaying all forms of geographically referenced information. It allows us to ask questions and find the answers about the world around us. We need to know the nature of our world and our place in it. GIS is capable of helping us gain a better understanding of our culture and other cultures, and our relationship between physical and human environments."

At the final live online session, participants were asked to share presentations of what they had implemented over the three month period since the face-to-face workshop. Some examples of projects include the following:

- Students used GPS units to map the entire school campus and developed thematic maps within GIS.
- Students used curriculum provided to study animals and biomes of the world by mapping and analyzing a zoo.
- Students mapped boundaries of county parks using GPS units and developed maps in GIS for eventual county use.
- Students used GPS units to collect data in the field of a valley, then studied the topography and land use of the entire watershed in which the valley lies, using high resolution imagery for analysis.

In this particular course, fourteen educators were from intermediate and high school levels, while three others were upper elementary level teachers. Half were science teachers, while the rest were either social studies, math, or some type of technology resource or special education teachers.

Further analysis of the effectiveness of this type of hybrid model of professional development course is underway. Of all of the events offered by the GeoTech for Hawaii Schools Initiative, this course resulted in the most cohesive professional learning community. Teachers worked with one another even at a distance and developed collaborative projects as a result of the course. In addition, there was more opportunity to view the final results of implementation. Final projects are still being submitted by teachers as the final course date is after the date of publication for this paper.

Outcomes: F - ArcGIS in Education Event

In October 2009, a two-day workshop was offered on Oahu to educators with some prior experience with GIS. This intermediate level GIS course provided curriculum, experience with GPS handhelds, and instruction on the connection between GPS and GIS.

In the pre-assessment survey, 47.6% claimed to be novice GIS users and 52.4% GPS novice users. These existing skill sets were not quite as high as we would have expected, however, the trainers reported that even the participants with the least experience did quite well with the materials. Seventy-one percent of participants reported having experience using technology, software or websites relating to geography prior to the event. Eighty-one percent of the participants were high school level teachers, with a split down the middle between science and social studies teachers. This calculates into a potential for 3,150 students being exposed to or engaged on some level with geospatial technologies.

Of the participants, 100% said they would be interested in taking additional courses in GIS and GPS, and 100% reported being more likely to integrate the technology, software, or websites introduced as a result of this workshop.

Beyond Training Events – Ongoing, Online Support

The National Staff Development Council estimates that less than 15% of teachers actually implement what they learn in typical teacher workshops which are "one time" events. Based on this research as well as first-hand experience, the GeoTech for Hawaii Schools statewide initiative built into its infrastructure a variety of venues for ongoing, online support. There is a website (blog) that is continually updated with resources for educators and students: http://geotechhawaii.blogspot.com . In addition, on a monthly basis, all GeoTech event participants and GeoTech enthusiasts are invited to attend a Geo-Tech Office Hours session which is 100% online via a distance learning tool. The tool is a LIVE Elluminate vClass which enables voice, video, and desktop sharing in a synchronous web-based venue. Each month a topic is introduced or reviewed, and time for general GeoTech "questions and answers" is allocated. Every month, each member of the growing GeoTech email list receives an email update pointing to the blog, reminding educators about upcoming events, and sharing other GeoTech resources.

Ongoing engagement is also offered via other events, including tie-ins with GIS Day, Geography Awareness Week, and Earth Day annually. In November 2009, on GIS Day, a statewide webcast event was facilitated. Seventeen schools participated by having a classroom of students (with teacher) log on to the webcast, while eight different geospatial technology professionals presented and demonstrated projects.

The GeoTech Hawaii Schools project also hosts special events and provides support directly to students upon request. In summer 2008, a GIS Camp for students was hosted. In fall 2009, GIS for Students workshops were held on various islands, and some via an online format.

A License and a Bright Future for Hawaii

The State of Hawaii has acquired a statewide license for the latest version of the GIS software from ESRI, the industry standard ArcGIS 9.3. This became official in March 2009 and the license is valid through 2014. This is the result of an agreement between Women in Technology, the Hawaii Department of Education and ESRI, and provides an incredible opportunity to schools to ramp up their use of geospatial technologies.

Hawaii is the first state in the nation to have statewide GIS access from K -16, and leads the nation in student access to GIS software. Women in Technology is the point of distribution for the software through: http://www.womenintech.com/GISDistributionCenter/ .

Conclusion

The modern engineering industry needs a workforce skilled in geospatial technologies. It has been the work of Women in Technology to help cultivate the next generation of engineers for Hawaii's workforce, and so it follows that WIT has embraced the challenge to cultivate geospatial technology skills in Hawaii's youth. The GeoTech for Hawaii Schools initiative has begun its work and will continue to refine its efforts into the future. So far, its initiatives have succeeded in increasing the GeoTech skills of a cadre of local teachers, and access to geospatial technology hardware and applications for their students.

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