Session #: 3249

GIS and Undergraduate Engineering Recruitment, An Exploratory Study at DeVry University, Pomona.

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Abstract

Enrollment in undergraduate engineering programs in the United States (U.S.) has declined over the past two decades. Studies have shown that the number of bachelor's graduates in engineering has declined since 1985, while the number of ABET accredited engineering programs has increased by approximately one-third during the same time period. This suggests greater competition among new and old engineering programs for the same dwindling supply of students. To more effectively identify and target graduating high school students interested in pursuing higher education in an associates program in Electronics and Computer Technology (ECT) or bachelor programs in Electronics Engineering Technology (EET) or Computer Engineering Technology (CET), DeVry University, Pomona campus has evaluated the use of geographic information systems (GIS) to synthesize, analyze, and display relationships between spatial data and database attributes to reveal hidden patterns and trends that are not readily apparent using basic spreadsheets or statistical packages. This paper is an exploratory study of the early use of GIS at DeVry University, Pomona, to data mine using freely available California state educational data and DeVry University historical student data to identify high schools within a defined geographic radius for targeted recruiting efforts of its undergraduate programs. Early results indicate positive new student enrollment potential. While this paper discusses one California university and its use of state educational data, the research methodology and its outcomes discussed in this paper can be generalized and adopted at most colleges and universities in the U.S.

I. Introduction

DeVry University, with 24 campuses throughout the United States and Canada, serves some 52,000 students annually. In Southern California, three campuses exist and are located in the cities of Long Beach, Pomona, and West Hills. Each offers undergraduate and graduate curricula in technology, business and management. The Pomona campus has approximately 2,300 students in five bachelor degree programs and one associate degree program, with each being offered during the day, evening, and/or weekend, dependent upon the selected program.

Opportunities for higher education have increased over the past several years with schools such as DeVry University emerging to fill a market void for students looking for alternatives to attending a traditional university. Such for profit institutions are driven to promote high

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educational outcomes while ensuring that profit drivers are maximized. Typically, these profit drivers include a strong student attrition/retention component that attempts to maximize student graduation levels, while minimizing student interrupts or program dropouts without impacting educational quality standards. Although retention/attrition studies have been done at DeVry University, they have typically been limited to statistical analysis of attendance versus dropout rates. No internal study to date has been done that evaluates spatially referenced data (e.g., student residence/driving distance) against retention/attrition constructs to determine if patterns of program completion exist.

In addition to monitoring the graduation rates of its current students, DeVry University must continually analyze market changes and capitalize on strategies and technologies that will allow it to more effectively target new students. While demand for higher education has increased, as is currently seen with the increasing number of impacted programs at many colleges and universities in Southern California, existing enrollment in electronics and engineering technology programs has declined in recent years at DeVry University, Pomona.

II. Historical Growth of Engineering-Based Programs

Enrollment in engineering-based programs has been declining over the past two decades. Figure 1. illustrates the growth of engineering schools and accredited engineering programs over time [1]. Data of the historical growth of accredited engineering programs collected from the Accreditation Board for Engineering and Technology (ABET) over a period from 1936 to 2000 shows relative growth rates since 1940 [2] with the number of engineering-based programs offered outpacing the number of institutions by a factor of 2.6.

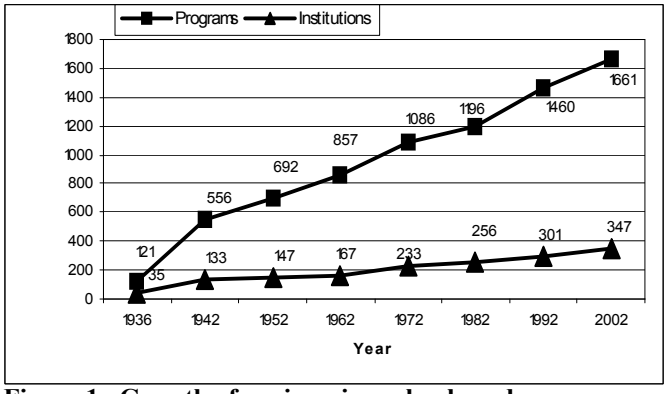

Figure 1. Growth of engineering schools and accredited engineering programs

Undergraduate engineering enrollment in the United States reached a peak of about 790,000 in 1985 and a low of approximately 590,000 in 2000 with electrical engineering bell ringing the declining enrollment trends about two years earlier [2, 3]. The number of students graduating from an engineering program has declined since 1985 while the number of accredited engineering programs has grown by approximately one-third during the same period. The data suggests that in the last two decades, new engineering disciplines such as environmental engineering and biomedical engineering are competing with older engineering disciplines for the same and decreasing supply of students [2].

Since the 1970's there has been a reactive to proactive shift for many universities and colleges to market their individual programs and educational offerings. Increased competition and demographic changes in student population have placed considerable pressure on many institutions to adopt "customer driven" strategies to compete more effectively in the educational

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market space. The idea of marketing an institution for some colleges and universities has been viewed as revolutionary. Until the 1980's, university administration at The Ohio State University did not use the word "recruitment," as recruiting students was not considered a function of a publicly supported institution. Due to pressures to change its race/ethnic mix, compounded with the decline in new student enrollment in the 1980's and early 1990's, The Ohio State University needed "to not only actively recruit, but also to very quickly undertake more sophisticated marketing techniques [4]."

With decreases in new student enrollment in engineering-based programs, institutions such as DeVry University are utilizing computer-based technologies to extract knowledge that will allow them to identify students with high probability of recruitment potential and to better serve new students throughout the recruitment process. Geographic information systems are one such technology that can support knowledge discovery and decision-making.

III. Geographic Information Systems

Geographic information systems (GIS) are specific computer-based systems that can be used to retrieve, analyze, synthesize, store, and represent graphical data for decision-making support [5]. "GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and graphical analysis benefits offered by maps [6]." GIS can be used to display relationships between spatial data and database attributes to reveal hidden patterns and trends that are not readily apparent using basic spreadsheets or statistical packages and can be used to answer questions involving [6]:

- **Location**—Where is it? A location can be described by place name, postal or zip code, or geographic references such as latitude and longitude.

- **Condition**—What is it? This question is the converse of the first question and requires spatial analysis to answer.

- **Trends**—What changes have occurred? May include both of the first two questions. Seeks to determine the differences of locations and conditions within an area over time.

- **Patterns**—What spatial patterns exist? This is a more sophisticated question that draws upon spatial statistics.

- **Modeling**—What if …? GIS leverages geographic and non-geographic information to formulate and test models linked by one or more spatial coordinates.

GIS allows spatial information to be arranged as a set of layered thematic maps with each layer or map overlaid on a bottom layer that represents a locational reference system (e.g., latitude and longitude) to which all maps are registered. Once registered, information on different layers can be algebraically manipulated and analyzed singularly or in comparison to each other. Layer information must include spatial but can also include non-spatial information. The ability to separate, manipulate, and visually display information into layers illustrates the potential of GIS as a research and decision-making tool [7].

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GIS has primarily been used to solve business related problems in non-educational domains. Limited studies have been done where GIS has been used to help educational institutions better understand their student population and improve operating efficiencies. Marble et al. [4] detailed an extensive pilot study carried out at The Ohio State University to analyze, both visually and statistically, the spatial structure of approximately 80,000 inquires and applications from 1993 and 1994 admissions streams and to use the results to better target external requirement activities.

Tang and McDonald [8] integrated GIS and spatial data mining techniques to target marketing of university courses. Their study explored the associations between students enrolled in a specified course and their demographic characteristics such as proximity to university campus, socio-economic status, and ethnic background. Their study concluded that student enrollment patterns in specified courses tended to be located in defined spatial areas with certain demographic settings. While low external validity may exist (i.e., the study was for a relatively young regional university in Australia and their conclusions may be limited in generalizing to other educational institutions), their study highlighted the power of GIS to support the knowledge discovery of hidden patterns and relationships between spatial and non-spatial variables.

DeVry University, Pomona carried out two studies using GIS and an application program from Environmental Systems Research Institute, Inc. (ESRI) [9] with one study used to evaluate enrolled students in one program to determine if a relationship between retention and off campus residence distance existed. This study was used to determine a distance boundary around the Pomona campus that would be used in a second study to determine school districts and high schools that met defined criterion for marketing and recruiting purposes. The research questions for this study are listed below.

IV. Research Questions

Student Retention vs. Distance From Campus:
What impact does residence/driving distance have on student retention in the Associate of Applied Science in Electronics and Computer Technology (ECT) program at DeVry University, Pomona, CA?

Market Analysis of Southern California Unified School Districts and High Schools:
What unified and secondary school districts and associated high schools, within a defined distance from DeVry, Pomona, promote marketing attention for its undergraduate programs in Associate of Applied Science in Electronics and Computer Technology, Bachelor of Science in Electronics Engineering Technology, and Bachelor of Science in Computer Engineering Technology?

The questions represent two perspectives with the first question representing a "historic" viewpoint intended to use past university data to understand dropout rates within four ethnic groups—Hispanic, Caucasian, Asian, and African American—in one degree program and the second question representing a predictive exemplar that attempts to provide information that might be used to formulate strategy and focus marketing efforts. Since both questions leverage

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spatially referenced data sets—i.e., data reference by location in space, described in terms of shape, place, and relationship to other spatial data, and contains attribute information—ArcMap 8.2 from ESRI [9] was used to analyze and present the results of the study.

V. Research Methods and Datasets

This paper is a descriptive and exploratory study of the early use of GIS at DeVry University, Pomona, to data mine using freely available California state educational data and DeVry University historical student data. Data or information needed to complete the project was identified from several sources. The student data needed to answer the first study question was obtained from DeVry University [10] for five new student class groups from 7/99 to 11/00 and totaled 344 students. These class groups were selected since the 7/99 class meets the federal mandate of 1.5 times a program length for consideration of financial support and the 11/00 class was the most recent group to have a graduation date during the study period of interest.

Table 1. lists the information that was collected from an AS/400 repository and stored in a standard Excel spreadsheet format and later converted to a database format (*.dbf) for uploading into the GIS application software for the five class groups identified.

Table 1. DeVry University Student Data

Data Element Collected	Description and Usage of Data Element in Study
Student Identification Number	Unique identification number assigned to each student. Used to define and track a student in the study.
Start Class Date	New student start date. Used to track the start date of a new student.
Current Class Date	Date of current enrollment status. Used to determine a student's last enrollment date and how long he/she remained in the university until he/she graduated or dropped out from the university.
Interrupt Code	Internal code used to classify the interrupt status of a student. Includes graduation and non-program completion codes.
Start Curriculum	Classification code of the start curriculum of each student in the study.
Current Curriculum	Classification code of the current curriculum of each student in the study. Used to track student program changes.
Entrance Placement Category	Enrollment classification based on entrance placement scores. DeVry classifies all incoming students as standard (STD) or developmental (DEV) in mathematics and/or English, dependent upon the outcomes of a set of college placement tests administered locally at each campus.
High School Code	Unique identification code assigned to each high school by the State of California. Used to track "feeder" schools to DeVry University and allow external California State data to be linked to internal university data in the GIS application software.
Ethnicity	Ethnic group specified by each student on their university enrollment application. The four largest ethnic groups on campus are Hispanic, Caucasian, Asian, and African American.

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Street Address including City and Zip	Address of student residence at time of current class date. Used as spatial information set by the GIS software to link student information to Southern California geographic coordinates.

To formulate a conclusion with respect to the second question of analyzing the optimal school districts and associated high schools for marketing of new undergraduate programs, the required data sets were freely obtained from three sources: 1) the 2000 U.S. Census [11] that provided geographic shape files of the Southern California school districts (obtained for Los Angeles, San Bernardino, Riverside, Orange, Ventura and San Diego counties but limited to the first four counties listed since the focus of the study was bounded to the DeVry University, Pomona campus), 2) data provided from the California Department of Education [12], and 3) summary data of the Southern California school districts from greatschools.net, a non-profit organization that provides information about public, private, and charter schools in the United States [13].

The primary data elements selected for the study included:

- 2002 Stanford 9 (mathematics and reading) scores
- Percent of families within a school district to receive Aid to Families with Dependent Children (AFDC)
- Percent of California community college attendance (CCATT) within a school district
- Percent of high school graduates completing a course sequence for admission to a University of California or California State University

Each data element was selected based on external studies that evaluated student exemplars related to student success and persistence in college. The Stanford 9 is a standardized, norm-referenced and national achievement test that assesses reading, mathematics, and language skills of students in grades K-13 [14]. Studies have shown that variables including standardized test scores (e.g., Stanford 9, SAT/ACT, etc.), high school GPA, and high school percentage ranking can serve as predictors of collegiate student success [15]. Waugh and Micceri [16] showed that retention and graduation rates were positively correlated to high school GPA.

Kroc et al. [15] concluded that "High school grade point average was the best predictor of graduation rate, followed by test scores and gender; ethnicity and domicile had smaller, but appreciable effects." Their results gathered from 53 land grant and research universities on more than 160,000 students showed that the four year graduation rate for women was 12% higher that the men's rate (36% compared to 24%) and the graduation rates of underrepresented minority students (African American, Hispanic, and Native American) was approximately 17% lower than the Caucasian students.

VI. Results

Using the data sets previously discussed and the ArcMap 8.2 GIS software, one map for each study was generated. Due to the size of each map, they have been placed immediately following the results summary of each study summarized below.

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Student Retention vs. Distance Study

Standard and developmental students in the ECT program were academically followed through analysis of enrollment, interrupt, and graduation dates to determine if conclusions could be inferred between travel distance and attrition patterns. Student retention patterns versus student residence/driving distance from campus were evaluated separately for each ethnic group, which resulted in a different map for each group created to support the analysis and presentation of results. For each ethnic group, a gradient breakdown of percent population per unified school district was first determined and used as a base layer in the GIS application software. This layer, which used a manual breaks classification scheme with four levels optimized statistically for representation of the population gradient, was overlaid with student interrupt and graduation data (both developmental and standard classified students). To support distance comparisons, a 30-mile maximum, three-ring buffer around DeVry, Pomona was used.

Table 2. summarizes the results of the ECT student retention versus residence/driving distance from campus study.

Table 2. ECT Student Driving Distance vs. Percent Program Completion
(Program completion = Number of degree-conferred students /Total program starts)

	Hispanic		Caucasian		Asian		African Amer.	
Distance (Miles)	Standard	Develop.	Standard	Develop.	Standard	Develop.	Standard	Develop.
0-10	9/22 = 41%	6/19 = 32%	6/22 = 27%	1/5 = 20%	5/17 = 29%	3/11 = 27%	0/4 = 0%	1/5 = 20%
10-20	9/28 = 32%	2/8 = 25%	2/15 = 13%	0/2 = 0%	6/12 = 50%	0/1 = 0%	0/0 = NA	0/3 = 0%
20-30	1/7 = 14%	0/7 = 0%	3/9 = 33%	0/4 = 0%	0/1 = 0%	2/5 = 40%	0/6 = 0%	0/0 = NA
> 30	5/10 = 50%	0/0 = NA	6/12= 50 %	0/1 = 0%	2/3 = 67%	1/1 = 100%	2/3 = 67%	0/2 = 0%

Based on the outcomes of the study, higher drop out rates were seen for developmental students over a standard classified reference group. While this supports past attrition studies done by DeVry University, the identification of an inverse relationship between student driving/residence distance and student retention was unexpected but, before comments on validity and reliability can be made with respect to an inverse retention/distance relationship, further study with an expanded sample size is required and planned.

It was noted that Hispanic and Asian students were predominately clustered in pattern areas within a 20 miles radius from campus. Caucasians, in comparison, appeared to be diffused over a larger distance with higher graduation rates seen over other ethnic groups when distances of 20 miles or greater were marked. African American students, which represented the smallest ethnic group with a sample size of 36 students, showed the lowest graduation rate of all the groups studied (3 graduates out of 36 starts). While a small sample size is acknowledged, the results support further evaluation into the possible causes of high attrition among African American students. Once identified, corrective administrative actions or student support mechanisms could be adopted to help improve student retention in this already underrepresented student population.

Figure 2. details the conclusions of this study and presents the results from the GIS software.

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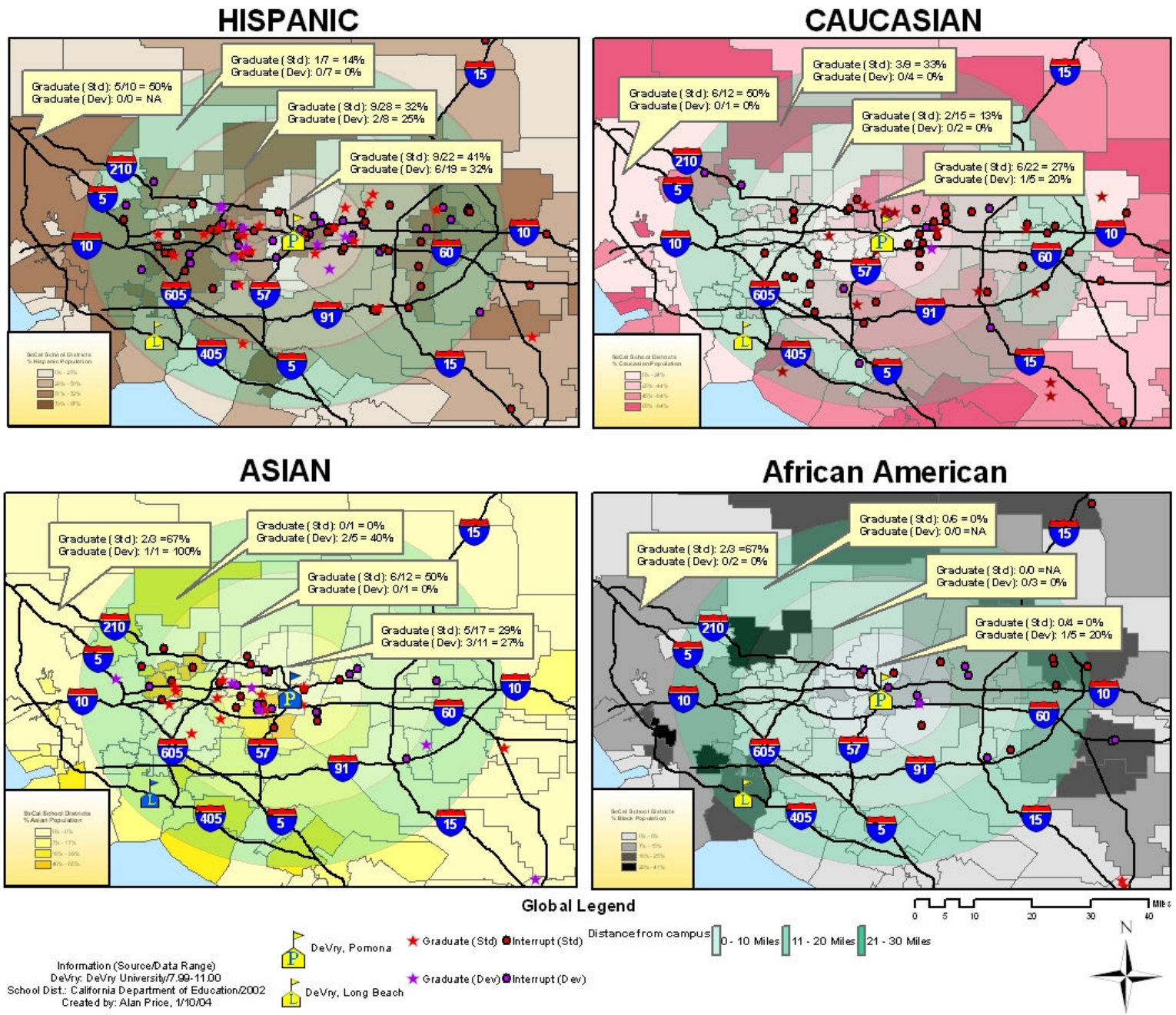
Figure 2. DeVry University, Pomona Campus
ECT Student Driving Distance vs. Program Completion
7/99 to 11/00 Standard and Developmental Class Groups



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Marketing Areas/Schools Study

To identify school districts and high schools (within a distance concluded from the first study of 20 miles from DeVry, Pomona) that would promote marketing attention for new undergraduate programs**,** school district shape files were again used and a color gradient established to differentiate the percent of community college attendance within each school district. A five-level color gradient was used with each level selected to equalize or most appropriately represent the community college attendance distribution between each level. Using the data obtained from the California Department of Education, a query was done using the GIS software to identify school districts that met the following constraints:

- Community college attendance greater than 25 percent
- AFDC recipients less than 20 percent
- Stanford 9 (2002 math/reading scores) greater than 57/47 percent with the percentile ranking reflecting the typical student's performance at the school or district compared to students in a 1995 norming group

These variables were selected based on quantitative analysis of each variable. For example, the 20 percent AFDC factor was selected since it was determined that high school graduation rates for districts with AFDC recipients greater than 20 percent were substantially lower (e.g., 82% vs. 92%) than for districts with AFDC recipients less than 20 percent. For the Stanford 9 math and reading scores, an average was taken of all 134 school districts in Southern California. While an average may not represent the best benchmark, it provided an initial reference point for the study.

The results from the selected query yielded nine school districts that met the defined criteria. The identified districts were: Arcadia, Bonita, Brea-Olinda, ChinoValley, Claremont, Corona-Norco, Glendora, Placentia-Yorba Linda, and Walnut. From these districts, a second analysis was done using the GIS software to identify the high schools in the identified school districts that met the following conditions:

- Selected high school is a "feeder" school to DeVry University, Pomona with a feeder school defined as a school that has previous enrollment experience with DeVry University
- Stanford 9 (2002 math/reading) greater than 57/47 percent (i.e., higher than the average of all 134 school districts in Southern California)
- High school graduates completing a course sequence for admission to a University of California or California State University is less than 46 percent (selected to maximize the identification of high schools with students that show greater affinity to attending a non-state supported four-year educational institution)

Based on these constraints, four high schools were identified as potential target sites for recruitment efforts by DeVry University, Pomona. The details of this study, including the four high schools identified by the GIS software, are shown in Figure 3.

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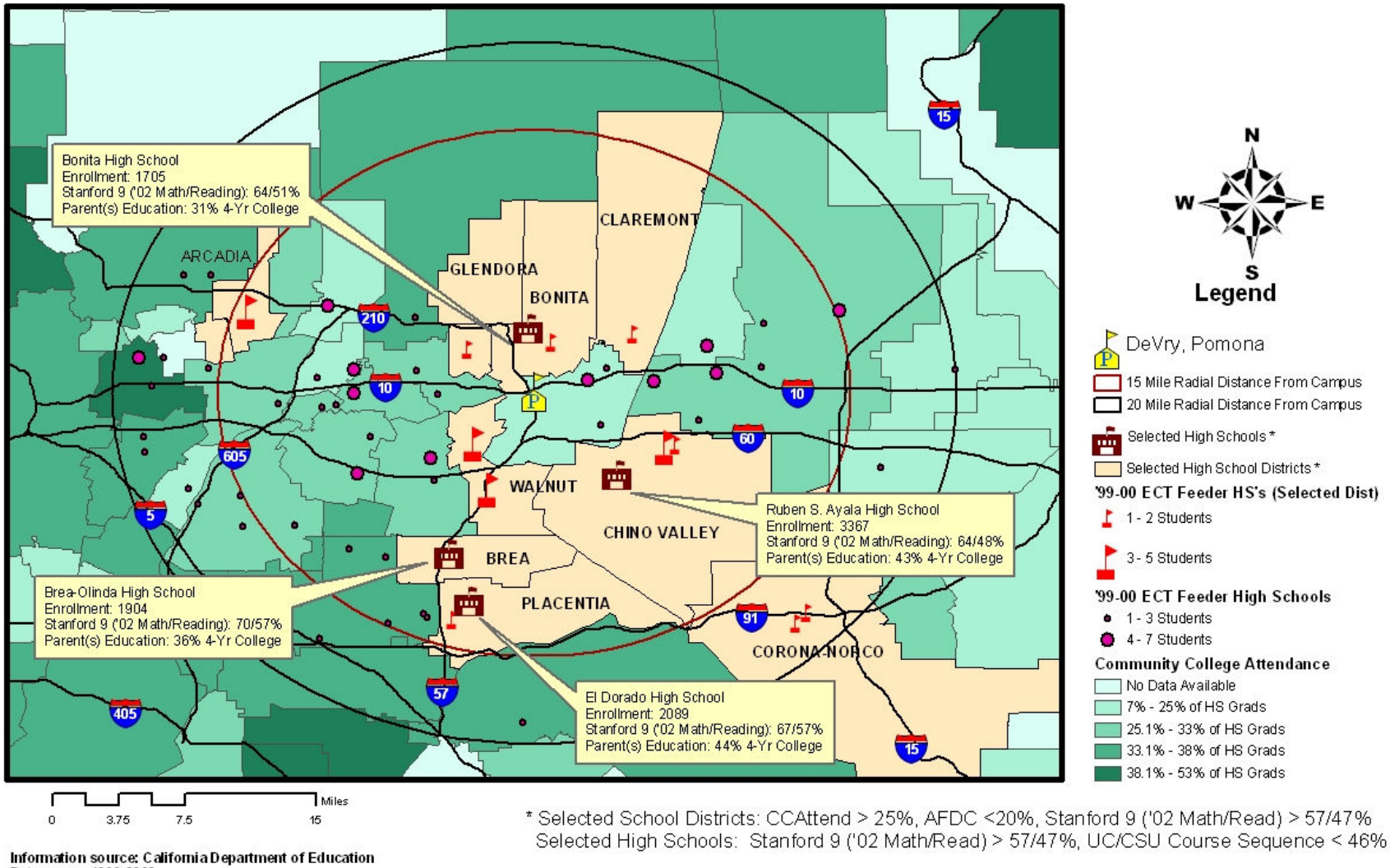
FIGURE 3. DEVRY UNIVERSITY, POMONA CAMPUS SELECTED HIGH SCHOOL DISTRICTS AND SCHOOLS FOR MARKETING OF UNDERGRADUATE DEGREE PROGRAMS



* Selected School Districts: CCAttend > 25%, AFDC <20%, Stanford 9 ('02 Math/Read) > 57/47%
Selected High Schools: Stanford 9 ('02 Math/Read) > 57/47%, UC/CSU Course Sequence < 46%

Information source: California Department of Education
Data range: 1996-2002
Web site: http://www.cde.ca.gov/
Created by: Alan Price, 1/10/04

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Discussion and Conclusion

This paper describes the results of early adoption of GIS by one university to use technology to better understand its existing student population and to more effectively target new students interested in undergraduate programs in Associate of Applied Science in Electronics and Computer Technology, Bachelor of Science in Electronics Engineering Technology, and Bachelor of Science in Computer Engineering Technology. Early results of this 2003 study indicate positive new student enrollment potential but follow up studies are needed to quantify the impact over the 2004 school year.

In this paper the exploratory use of GIS to better understand the spatial distributions and associated graduation rates of students enrolled in one educational program within DeVry University, Pomona was discussed. The study showed that residence distance from campus negatively impacted program completion rates. For a small sample of 344 students, it was noted that students typically lived within 40 miles from the Pomona campus and that students within 20 miles from campus generally showed higher graduation rates. While a larger sample size is needed to validate this premise, GIS produced the visual outcomes to support the conclusions in this paper that would have been difficult to duplicate using non-spatial analysis techniques and standard database programs.

Opportunities for further use of GIS have been identified. In the marketing areas/schools study, a limited data set of selected high schools was used. To expand target identification of possible high schools for marketing efforts, information sources—DeVry University data and California Department of Education data of all school districts and high schools in Southern California—could be integrated with the GIS application software to support more inclusive queries. While parental education levels at identified high schools were shown on the marketing areas/schools study map, they were not used as a query parameter but may be considered for future studies. Students with college-educated parents tend to receive more family support and earn higher high school GPA's and SAT scores [17]. Each has been shown to positively impact retention and graduation rates.

While this paper discusses one California university and its use of state educational data, the research methodology and its outcomes discussed in this paper can be generalized and adopted at most colleges and universities in the U.S. Education data at the district and local school level is often freely available from most state sources or from non-profit organizations such as greatschools.net [13]. This data and a college or universities own student data can be used by a geographic information system to help an institution to more effectively support and understand its current student population and to target new students interested in pursuing higher education in science and engineering-based programs.

References

1. *Science and Engineering Degrees: 1966-2000*, Susan T. Hill, NSF 02-327, National Science Foundation, Division of Science Resources Statistics, Arlington, VA, 2002.

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2. Newberry, B., and Farison, J., "A Look at the Past and Present of General Engineering and Engineering Science Programs," *Journal of Engineering Education,* July, 2003, pp. 217-224.
3. Heydt, G., and Vittal, V., "Feeding Our Profession," *IEEE Power and Energy Magazine,* January/February, 2003, pp. 38-45.
4. Marble, D., et al, "Applying GIS Technology to the Freshman Admissions Process at a Large University," http://gis.esri.com/library/userconf/proc95/to200/p182.html, accessed December 20, 2003.
5. Longley, P., Goodchild, M., Maquire, D., and Rhind, D., "Geographic Information Systems and Science," John Wiley and Sons, 2001.
6. Classnotes, Geographic and Visual Information Systems, Claremont Graduate University, Fall 2002.
7. Foote, K., and Lynch, M., "Geographic Information Systems as an Integrating Technology: Context, Concepts, and Definitions," http://www.colorado.edu/geography/gcraft/notes/intro/intro.html, accessed November 5, 2002.
8. Tang, H., and McDonald, S., "Integrating GIS and Spatial Data Mining Technique for Target Marketing of University Courses," *Symposium on Geospatial Theory, Processing and Applications*, Ottawa, 2002.
9. ESRI, Inc., 380 New York St., Redlands, CA 92373-8100, 909-793-2853, www.esri.com
10. DeVry University, Pomona, CA, 7/99-11/00, ECT Student Data.
11. www.esri.com/data/download/census2000_tigerline/index.html, accessed October, 2002.
12. www.cde.ca.gov, accessed November, 2002.
13. www.greatschools.net, accessed October, 2002.
14. "Norm-referenced Assessment (Stanford 9)," http://www.ade.state.az.us/standards/stanford9/stanford9factsheet.asp, accessed December 21, 2003.
15. Kroc, R., et al, "Predicting Graduation Rates: A Study of Land Grant, Research I and AAU Universities," http://aer.arizona.edu/AER/Enrollment/Policy_Analyses/Predicting%20Grad%20Rates.pdf, accessed December 21, 2003.
16. Waugh, G., and Micceri, T., "Using Ethnicity, SAT/ACT Scores, and High School GPA to Predict Retention and Graduation Rates," *Florida Association for Institutional Research Conference,* March, 1994.
17. "Using the SIQ to Identify Characteristics of First Generation Students at ISU," http://www.indstate.edu/oirt/briefs/2001No3.pdf, accessed December 21, 2003.

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