BEYOND THE NUMBERS

Rethinking Technology Classification: An Alternative Approach to Discussing Texas Technology Skills Shortages:

By Marc Anderberg and Richard Froeschle

"Here we are - - the world's leading economy and the leader in technology and innovation. We are creating the jobs of the future - but we are not preparing our own children to fill them."

George W. Bush, campaign speech at De Anza College

By most conventional measures, a booming economy brought widespread prosperity to Texas during the 1990's. The gross state product increased from $424.5 billion in 1992 to over $610.3 billion by the close of 1999. During this same period, *per capita* personal income rose from $19,146 to $26,858. The state's civilian labor force grew from 9,088,839 in 1992 to 10,331,234 by the end of the decade or an average of 177,485 new workers per year. Meanwhile, the statewide unemployment rate fell from 7.7 percent in December 1992 to 4.7 percent in December 1999 and has continued to drop to 4.3 percent in September 2000. (http://www.twc.state.tx.us/customers/rpm/rpmsub3.html) This expansion of the civilian labor force of over 2.0 percent per year still failed to keep up with the business side of the Texas economy which added 1,288,848 net new workers during the same seven year period. In other words, more than 100 percent of available new labor force entrants were absorbed through net job expansion. As "help wanted" signs dotted the Texas landscape, it seems as if anyone sixteen or older who wants to work can find a job.

Such gross indicators of general prosperity, however, mask disquieting undercurrents in the new Texas economy. First, amidst positive publicity about the net increase in jobs, little attention was paid to industries that went into decline and to occupational fields where demand went flat or virtually disappeared. A major question is how can we redirect existing, but displaced, human capital and create employment opportunities through marginal retraining and skill acquisition? How can workers with outmoded skill sets be upgraded to contribute to the productivity critical to the success of Texas business? And, how can be make sure that students already in the education and training pipeline continue to make that investment in themselves so that they are prepared to take on the jobs of the future?

Secondly, the process of *"creative destruction"* has transformed many jobs, which have been performed in the same way with the same skill sets for decades, into occupational opportunities only for those who have mastered the application of digital technologies. This concept is best illustrated by the following example. Mr. Baker, 46, was a draftsman with the construction firm of Foster, Miller and Killian. Since 1975 he had used a t-square and other conventional tools to design bridges under the supervision of Red Killian, the chief engineer. When the Department of Transportation adopted a rule requiring all firms bidding on state-funded highway improvement projects to attach electronic copies of their designs to their bids as exhibits, Killian and his partners purchased and installed an AutoCAD system. Mr. Baker was replaced by a recent associate degree-earner--a whiz in AutoCAD. The newly hired AutoCAD operator commands the same pay as did Mr. Baker with all of his accrued seniority. The whiz's job title, despite the markedly different hiring requirements for the position, is still "drafter." What can be done to either ensure that Mr. Baker had access to new skill training *before* he lost his job, or to help him adapt his existing knowledge base into more marketable skills?

Third, the fruits of prosperity--increased employment opportunities and higher earnings--have not been shared equally across all segments of the state's population. This "*digital divide*" has begun to separate our more prosperous citizens from those with meager earnings opportunities. As importantly, too many women and minorities find themselves on the lower end of the digital divide with significantly fewer avenues to prosperity that do not include mastery of mathematics, science and related technologies.

Current research on technology and employment focuses on the identification of employment growth in specific industries. Logically, those employers and industries that manufacture wireless telephones and computers or develop the software that makes them productive can be termed "high tech." But these firms also employ janitors, cooks, secretaries and mail clerks who don't need to master digital technology. Similarly, a "low tech" business like *Lands End* (http://www.landsend.com/) retail clothier would be struggling today without their information technology concentration and skilled, computer-savvy workforce. Thus it makes sense to think of high technology not in terms of just industry sectors but in the occupational skill sets they employ.

CLASSIFYING HIGH-TECH OCCUPATIONS

Turn on the nightly news or pick up a newspaper: everywhere you look there is talk about "high-tech" occupations and the lack of qualified workers to fill these positions. In response, federal, state and local governments are passing legislation and instituting special programs to ensure that there are enough workers with the appropriate skills to fill high-tech job openings. Training institutions are racing to offer courses to prepare workers and career counseling services are more than ready to help anyone enter the high-tech field.

But, what exactly is a high-tech occupation? How are researchers defining the term? And, how are they gathering data on these occupations?

The federal government has devised methodology to classify *industries* as high-tech. So, most researchers conduct employment studies based on these industries. To date, however, there is no common methodology to classify *occupations* as high-tech. (http://www.bls.gov/opub/mlr/1999/06/art3abs.htm) The Career Development Resources (CDR) unit of the Texas Workforce Commission has undertaken this task. In this *Beyond the Numbers* article we will describe the process that we used to classify high-tech occupations and how we plan to use it for further labor market analysis.

CREATING AN ALTERNATIVE APPROACH FOR CLASSIFICATION

While one result of our study was classifying occupations as “high-tech”, our objective was **to establish a relationship between job duties and the use of advanced technology**. We defined advanced technology as systems that incorporate complex electronics (digital or sophisticated analog devices) as found in computers, lasers, robotics and satellites, as well as biomedical instruments and avionics. With regard to computer software, we did not include basic word processing nor spreadsheet programs within the definition of advanced technology. We did include information management systems that are built upon relational databases. We then classified usage levels and labeled them according to level of technology. (See Table 1.)

Table 1
Occupational Technology Classification

Rank	Technology Classification
1	Job duties driven by advanced technology
2	Job duties require significant use of advanced technology
3	Job duties rely on moderate use of advanced technology
4	Job duties involve occasional use of advanced technology
5	Job duties do not rely on the use of advanced technology

To derive the level of usage, we asked two questions:

1) How often does an employee use advanced technology?
2) Why does the employee need to use advanced technology to perform his or her job duties?

We then developed a rubric to calculate and rank the level of usage for each occupation using three variables: the time spent using advanced technology; the type of job duties in which advanced technology is used; and the purpose for using the advanced technology. (See Table 2.)

Table 2
Technology Use Requirements Metric

Rank	Amount of time spent using advanced technology	Type of job duties in which advanced technology is used	Purpose for using the advanced technology
1	Constantly	Research & Development	Program/Design Technology
2	Intermittently	Install/Repair/Set-up/Test	Run other advanced technology
3	Daily	Operate	Perform specific function or Process information
4	Occasionally	Monitor	Extract Information
5	Never	Input/Extract Information (Load/Unload Materials)	Input Information

Time Spent Using Advanced Technology

The “time spent” variable captures “how often advanced technology is used on a daily basis to perform regular job duties?” A rating of 1 through 5 was assigned to each occupation based on this criterion.

Constantly = advanced technology is used (in general) more than six hours per day
Intermittently = three to six hours per day (not necessarily in one sitting)
Daily = one to three hours per day (not necessarily in one sitting)
Occasionally = no more than once per day (for less than an hour)
Never = used only on rarest occasions -- virtually never

Purpose, and Job Duties of an Occupation Using Advanced Technology

There are actually two parts to the question of "why," or for what reason, does an occupation interface with advanced technology. The first variable for "why?" indicates the job duties for which the employee, functioning within a unique occupational classification, needs to use advanced technology. The second "why?" variable indicates the function or purpose that the advanced technology performs which contributes to occupational productivity. For example, a review of job functions for a Computer Scanner Operator reveals that they generally operate advanced technology (scanner) to perform a specific function (scan documents). Thus this occupation received a rank of 3 on the variable "type of job duties in which technology is used", and a rank of 3 in regards to the "purpose for using advanced technology." Note that under this rubric both the job duties and purpose variables are ranked from highest skill level to lowest.

Application of this Approach to Occupational Data

The next step of the research design was to apply the rubric to 691 occupations classified by Occupational Employment Statistics (OES) codes in Texas. The OES survey program is administered by the Texas Workforce Commission's Labor Market Information Department. The occupations selected represent 99.2 percent of total 1998 employment. Statistically reliable data for employment projections and wages are made available by TWC/LMI to facilitate this research initiative. Occupational descriptions in the federal Occupational Information Network (O*NET) database and research from the Emerging and Evolving Occupations in Texas Project were used as resources. The O*NET (http://www.onetcenter.org/) is a database of occupational data developed by the U.S. Department of Labor to replace the *Dictionary of Occupational Titles*. Although Occupational Estimates Statistics (OES) codes were used, the OES and O*NET structures are similar enough for cross-reference.

Using a scale of one to five, we selected the appropriate rank within each variable – one being the highest use of advanced technology and five being the lowest -- for each occupation. The Computer Scanner Operator, for example, resulted in ratings of 1,3, and 3 respectively. This code indicates that an employee in this position is constantly (1) operating (3) advanced technology to (3) perform a specific function. We then derived the average rank by summing the three ratings and, assigning equal weight to the three variables divided the result by three. The final occupational ranking was determined by rounding the score to the closest whole number. In the example above, the ranking for Computer Scanner Operator was 2 (1+3+3 = 7 and 7/3=2.33, 2.33 rounded according to the rules set forth in Table 3 result in a score of 2).

For those occupations in which “never” was the answer for “time spent”, the other variables were not considered. For example, Taxi Driver resulted in a code of 5, X, X and automatically was assigned a final rank of 5, indicating that Taxi Drivers virtually never use advanced technology in their job duties.

Table 3
Rounding Table for Technology-Intensity Ranking

Digit total	Average rank	Rounded rank	Technology Classification
3 -- 4	1.00 -- 1.49	1	Job duties driven by advanced technology
5 -- 7	1.50 -- 2.49	2	Job duties require significant use of advanced technology
8 --10	2.50 -- 3.49	3	Job duties rely on moderate use of advanced technology
11 -- 13	3.50 -- 4.49	4	Job duties involve occasional use of advanced technology
14 -- 15	4.50 -- 5.00	5	Job duties do not rely on the use of advanced technology

Documenting the Assumptions

Various assumptions were made to determine the rank within each variable. First, we assumed that the highest level of technology that is readily available is being used. Since the application of advanced or emerging technology is universally seen as a cornerstone of productivity and profitability, it is apparent that this assumption is true for most large firms, manufacturing plants, repair shops, etc. The adoption of advanced technology in smaller establishments, and in some service sectors, tends to occur at a slower and less uniform pace.

With regard to machinery used in manufacturing (e.g. conveyors), we assumed that the equipment is programmed by some form of computer system. In municipal services such as Police and Fire Departments and in Urban Planning, we assumed the uniform usage of Global Positioning Systems and Geographic Information Systems. The use of spreadsheets or word processing software was not defined as advanced technology. The use of relational databases however, such as those required in management information systems and computer programming, were included at a higher level of technology.

Other examples of our “highest technology available” assumptions include:

--elementary through post-secondary teachers occasionally use the Internet to search for information;
--supervisors use the technology of other workers as well as personnel information management systems; and
--automobile repair workers use computer diagnostics tools.

Case Study Illustration

The Printing Industry is an excellent example of how digital technology is transforming occupations. Putting the image on photographic film and developing "mechanicals" (layouts of the final product for customer approval) are no longer necessary. Instead, digital cameras and photo editing software can be used to manipulate images on computer screens. Once editing is completed, the images can be transmitted to the customer via e-mail. For final production, orders are processed through computer-to-printer, computer-to-copier, or computer-to-plate technology.

> National Association of Printers & Lithographers. "1997 And All That: Choice, Choice, and More Choice." *Tech Trends Report* 1, no. 6. (1998)

While there are still many small print shops throughout Texas that may not be using digital technology currently, we assume that they will in the near future (or else be driven out of business by competitors). As a result, most of the printing occupations (OES 89702 – 89719) received a rank of two. The printing occupations that (based on the job descriptions) we assumed were still not using digital technology are Hand Compositors and Typesetters (OES 89702), Job Printers (OES 89705) and Film Strippers (OES 89717). Not surprisingly, these occupations also are facing low to negative growth in demand.

Presentation of Findings

The methodology worked well. It resulted in logical ranks that square with the public's intuitive grasp of the "technology-intensity" of the various occupations. Engineers that design technology ranked higher than engineers that design structures. In manufacturing, set-up crews who program the computers to run the machinery ranked higher than operators who simply use the machinery. The same held true for pattern-makers as opposed to those who then use the pattern to cut, mold and shape a product. Likewise, in the health care industry, technologists ranked higher than technicians.

An interesting finding was that the use of information management systems places most clerical and financial occupations at a rank of three (i.e., the job duties rely on some use of advanced technology). Similarly, increased reliance on "enterprise resource planning systems" raise inventory, shipping and transporting occupations to a rank of three. Such examples emphasize the importance of using a KSA-based approach at the occupational level. **Without such detailed and careful empirical analysis, it is too easy to underestimate the technology-intensity of many common occupations.**

We were not able to rank Sales and Purchasing occupations because the level of advanced technology used depends upon the product. For example, a Vacuum Cleaner Product Demonstrator never uses advanced technology and would rank as a five while a Computer Server Product Demonstrator would have a code of 132 and rank as a two (i.e., the job duties rely on significant use of advanced technology).

High Technology and Labor Market Disparity

The CDR's research on technology-driven occupations also was applied to a master database of occupation-specific variables to ascertain whether there were any unique groupings correlated with occupations falling within the five technology-driven definitional subsets (http://socrates.cdr.state.tx.us/isocrates/occprofiles/profile_select.asp).

Of the 638 total occupations with useable data for assessing technology-intensity, only 18 were classified as being "driven by advanced technology" and another 49 "required significant use of technology" (see Table 4). Although digital technology has become quite pervasive in consumer goods and services, from an occupational standpoint, over 40 percent of all occupations, and 43.3 percent of all 1998 occupational employment "do not rely on technology." However, technology-driven occupations exhibited all the characteristics one might imagine. Those that rely on technology are projected to expand by 33. 7 percent between 1998 and 2008; a rate almost double that for all occupations. For occupations driven by technology, 65.9 percent of projected job openings will be due to growth, as opposed to replacing existing jobs.

By contrast, occupations that do not rely on technology will have only 38 percent of total openings due to growth whereas the Texas job market as a whole will have 42.2 percent due to growth. Not surprisingly, those occupations which are either driven by technology or require significant use of technology will represent an increasingly greater percentage of total employment in the Texas economy; while those which do not rely on technology will decrease as a percent of total employment by 2008. It is important to note however, that despite these percentage changes, occupations in the top two technology categories will represent just under seven percent of total employment by 2008. The flip side is that 43.2 percent of total Texas employment is projected to be in occupations which do not rely on advanced technology in 2008 (this assumes that duties, tasks, and skills for this subset of occupations are not substantively changed by technology between 2001 and 2008--an assumption that may be heroic).

This research also substantiated several noteworthy hypotheses about technology and occupations. The amount of education required to practice effectively in occupations driven by technology is slightly above a bachelor's degree. On the other hand, occupations which do not rely on advanced technology averaged an educational preparation period that only slightly exceeded less than one month of on the job training (OJT).

There are also monetary returns waiting for those who become employed in technology-driven occupations. The weighted average hourly wage for all occupations in Texas was $13.40 in 1998. (http://www.twc.state.tx.us/lmi/lfs/type/wages/wageshome.html) In contrast, those occupations that rely on technology averaged $23.37 per hour and even those that required significant use of technology averaged $21.58. The weighted average hourly wage for occupations that do not rely on technology was only $9.03. Clearly, there are financial rewards to those investing both in education as a whole and particularly in educational programs associated with technology-driven occupations. Lastly, this same research demonstrates a significant under-representation of women and minorities in the occupations that rely on advanced technology and an over representation in those occupations that do not rely on technology or only occasionally use technology. Despite the fact that women comprise over 44 percent of the Texas workforce, they represent less than 22 percent of persons in occupations that are driven by technology. Similarly, while over 43 percent of the Texas workforce are categorized as non-white (including Hispanics), only 28.6 percent are employed in occupations driven by technology. Non-whites are found in the lower two technology occupation categories at rates exceeding 50 percent. Given the projected demographics of the state of Texas and the growth of these population subgroups, this under-representation of women and minorities in technology-driven occupations portends a serious stress on the economy of the future--not to mention how the self-selection of low-tech careers will impact their individual economic self-sufficiency.

Table 4
Occupations Identified as Driven by Advanced Technology

Occupational Title	Percent Growth	Education required	Average 1998 wage
Computer Science Teachers	49.0%	Doctorate	$34.40
Nuclear Engineers	23.7%	Bachelors	$34.28
Electrical and Electronic Engineers	25.6%	Bachelors	$29.55
Aerospace Engineers	.40%	Bachelors	$29.31
Mechanical Engineers	21.5%	Bachelors	$28.67
Computer Engineers	48.1%	Bachelors	$27.99
Materials Engineers	14.1%	Bachelors	$25.52
Mainframe Computer Programmers	.06%	Bachelors	$25.50
Systems Analysts	66.9%	Bachelors	$24.86
Database Administrators	48.3%	Bachelors	$23.70
Marine Engineers	11.4%	Bachelors	$22.76
Computer Scientists NEC	75.3%	Bachelors	$22.44
Estimators and Drafters, Utility	-18.7%	Post-secondary Vocational	$19.80
Computer Support Specialists	67.8%	Associates	$19.63
Numerical Tool/Process Control	16.3%	Post-secondary Vocational	$19.55
CAD/CAM Drafters	18.6%	Post-secondary Vocational	$18.24
Engineering Technicians/Technologists	15.4%	Associates	$17.99
Electric and Electronic Technicians	17.6%	Associates	$17.36

This research offers the statistical evidence of the need for additional skills training in fields related to the understanding and application of technology; both for students currently in the education and training pipeline and for those, like the displaced Mr. Baker in the previous example, whose skills are rapidly becoming obsolete while he is still on the job. Regardless of whether the labor market of the future is analyzed from an industry perspective or from an occupational viewpoint, there is no denying both the tremendous need for skilled technology workers and the potential rewards awaiting those workers, and employers, willing to make the human capital investment.

Targeting Training Resources: Applying Definitions of High Technology

The diversity of definitions used when discussing high technology makes the development of targeted training initiatives difficult. As a key economic sector and emerging export industry for Texas, it is vital that we invest in the skills training and education of the workers that will drive these high technology industries in the future. But how to invite open participation while still focusing on the specific target of engaging high technology employers, stakeholding associations and other "players"is a challenge.

Since government funding is limited, any government Request for Proposals (RFP) would ideally seek to focus these monies on training situations with maximum return on investment; to the taxpayers, to the workers, and the technology-driven businesses which provide the job opportunities. To target these training monies, service the skills training needs of high technology employers, and create an optimal environment promoting local control and minimizing administrative barriers to participation for interested professional associations and individual employers, a unique construct for classifying high technology must be devised.

One approach is to revert to the use of industries as a defining construct. For example, a high technology or “technology-intensive” industry for purposes of an RFP is one whose primary focus might be on the development or application of digital technology in the production of a product or provision of a service within the state of Texas. But rather than reverting to high technology industry definitions immersed in Standard Industrial Classification (SIC) industry titles, perhaps some alternative measures for classifying high technology industries are in order. Again for example, eligible employers and partnerships might be those contributing to industry sectors which are characterized by 1) high concentrations of research and development, as measured by R&D expenditures to gross sales or a high ratio of patents to workers, 2) high concentrations in professional, technical and scientific workers within their existing workforce, 3) above average ratios of persons with postsecondary credentials or science and engineering degrees, 4) higher than average productivity per worker, as measured by average output per unit labor cost or similar measure, 5) other related measures including, but not limited to, low rates of value for intermediate products versus final products (high value-added industries), market niche which tends to be national or global in nature (net regional exporters), and higher average wages for a broader strata of workers (a well-compensated “middle class” of technology-driven workers).

Note that the following categories, while commonly understood within the business community and the media, ***do not strictly follow the SIC coding system***. This approach is recommended purposefully to encourage maximum employer participation without the complexity or possible elimination of key employers or other stakeholders due to an excessively restrictive criterion. Industry sectors that generally address more than one of the above measures are:

1. Engineering and Scientific Services
2. Aircraft and Defense-related Manufacturing
3. Medical and Scientific Instruments Manufacturing
4. Biotechnology and Bioengineering Services
5. Telecommunications Services
6. Information Storage, Retrieval and Processing
7. Software Development and Applications Programming Services
8. Semi-conductor, Computer and Telephony Manufacturing

Industry Definitions Alone Will Not Suffice

The objective remains, however, to enhance the skill sets of workers either currently employed in, or who might become employed by, high technology employers. Thus the question remains, who really is an Information Technology worker? Definitions vary widely. The Information Technology Association of America (ITAA) uses a broad definition of IT as “any skilled worker who performs any function related to information technology, defined as the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware.” (http://www.itaa.org/)

The authors posit that the occupational approach to defining what is "high tech" is essential not only to guide further research but also in the policy arena. When letting bids, for example, to secure economic or workforce development services, state and local agencies will be unable to assess the proposals they receive in any meaningful fashion if the RFPs they publish are rooted only in an industry-oriented conception of high technology that does not fit the real distribution of skilled workers across all industries in the new knowledge-based economy.

Thus we recommend an alternative approach to classifying IT skills that was developed by the *Intersociety Study Group on Information Technology Workers* (April 1999). (http://cra.org/reports/wits/cra.wits.html) Again from a proposal perspective, an agency might require that the successful bidder must work with, or be significantly associated with, at least one of the industry sectors detailed above AND be able to fit the proposed training into one of the four IT worker skill categories below. This categorization of IT workers has a reasonably strong correlation between formal education requirement and class of worker, with Conceptualizers requiring the highest level of formal education with generally doctorate or masters degree holders.

A. **Technology Conceptualizers**--Those workers who conceive of and sketch out the basic nature of a computer system or related product; such as Systems Analyst, Research Engineer, Research Scientist, Biogeneticist or Product Designer.

B. **Technology Developers**--Those who work on specifying, designing, constructing and testing an information technology product or related system; such as Software Engineer, Aerospace Engineer, Computer Programmer, Chip Designer, Tester
C. **Product Modifiers/Extenders**--Those who modify or add on to an information technology system or related product; such as Database Administrator, Maintenance Programmer, Laboratory Research Technologists, Webmaster

D. **Product Supporters/Tenders**--Those who deliver, install, operate, maintain or repair an information technology system or related product; such as Customer Support Specialist, Network Installer, Network Administrator, Biotechnology Technician, CAD/CAM Design Specialist, Help Desk Specialist.

Future Research

In order to plan effectively for the future labor market, we must begin with sound methodology and data. Now that we have classified high-tech occupations and presented alternative approaches to discussing the high technology sector of the economy, we can begin to analyze the demand for employees with high-tech skills and the wages paid to these workers. Most of the constructs presented here are sufficiently new that data currently collected by most existing data programs are insufficient to be applied consistently. It would be a useful and necessary challenge to build a new data collection system that incorporates these notions initially at collection time. In the interim, research should continue on the re-thinking of worker skill classification.

Due to our relationship with public education, the CDR will continue to be interested not only in classification issues --but also in equity and access concerns. Such concerns include not only discovering how many women and minorities are in these positions now, but also how many currently are taking courses that will prepare them for these occupations in the future.

For those interested in a more robust discussion of labor market churning, high technology classification, high technology as a part of economic development, and the under-representation of women and minorities in technology-driven occupations, much of the foundation research has been noted in the forthcoming Career Development Resources (CDR) publication *Texas Technology Workers and the Knowledge Economy*, authored by Marc Anderberg (February 2001). (http://www.cdr.state.tx.us/)