ALFRED P. SLOAN FOUNDATION
Industry Studies
2008
Annual Conference | May 1 - 2, 2008 | Boston, MA
http://web.mit.edu/is08/program

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Abstract:

The Boston Area Advanced Technological Education Connections (BATEC) is a STEM education (Science, Technology, Engineering and Math Education) and workforce development partnership created in 2003 to improve technological education and the supply of information technology (IT) workers for the knowledge-based and high-tech industrial sector of the Greater Boston Area. It is funded by the Advanced Technological Education (ATE) initiative of the National Science Foundation (NSF). BATEC has accomplished its educational goals but wants to expand and regionalize more broadly its workforce development functions as a labor-market intermediary. This case study suggests that such an adaptation must be informed by and analysis of the structure, growth and geography of the regional IT labor market and of the human resource development practices of employers. Conceptual and strategic insight is drawn from workforce and regional development literature. Initiatives such as BATEC can promote "high-road" approaches to workforce development and help other NSF-funded ATE centers seeking to enhance their workforce development functions.

To be presented at: Alfred P. Sloan Foundation Industry Studies 2008 Annual Conference, May 1-2, 2008. Boston, MA.

1 Introduction

The **Boston Area Advanced Technological Education Connections** (BATEC) is a workforce development partnership created in 2003, funded by the Advanced Technology Education (ATE) program of the National Science Foundation (NSF).[1] BATEC's main objective is to improve science, technology, engineering, and mathematics (STEM) education in high schools, community colleges and state baccalaureate institutions, and to increase the supply of workers with expertise on information technology (IT) for the knowledge-based and high-tech industrial sector of the Greater Boston Area. BATEC has performed commendably, meeting its goals in curriculum and professional development, improving access for populations that are underrepresented in the IT sector, and improving the connections between employers and educational institutions (BATEC 2007).

BATEC's leadership, however, continues to face persistent problems, also cited in other literature, related to the IT workforce development infrastructure of the state. Early on in the decade, several reports emphasized that Massachusetts, especially the Greater Boston Area, has competitive advantages in knowledge- and technology-based industries clustered around natural sciences, engineering, and cutting-edge interdisciplinary research and institutions. Despite these advantages, the relationships among innovative industries and the large number of public and private academic centers, teaching hospitals, research labs and institutes are not very harmonious (BCG and ICIC 2001; Forrant et al. 2001; MassInsight 2004; MassInsight and Battelle 2004). In fact, the reports identify serious weaknesses in the university-industry connection and in the workforce development infrastructure (public and private) that could seriously hamper the region's competitiveness. These weaknesses are low talent retention, poor regional workforce development coordination, misaligned technical workforce development programs, and a debilitated state university system. The reports add that Massachusetts is good at graduating PhDs but falls behind other states in the generation of technicians and technologists with associate degrees (2-year degrees) that are more essential in maintaining leadership in key technological sectors (MassInsight 2004; MassInsight and Battelle 2004).

These complex problems of (institutional and regional) development cannot be solved by BATEC alone, by the free action of markets, or any other single agent. What is called for are collaborative strategies that connect multiple kinds of organizations working under a general vision of regional development.

BATEC has accomplished its goals in STEM education by establishing and maintaining basic connections with employers. It can improve its workforce development functions and remain a relevant actor in the industry by gaining a deeper understanding of the competitive pressures and practices of employers, and by helping educators create programs that benefit students, workers and employers navigating the knowledge-based economy. Without losing its status as an 'honest broker', BATEC can consolidate a regional outlook that focuses on emerging interdependencies between IT and all other knowledge-based sectors and reaches out to populations beyond Boston's employment core.

BATEC's challenges cannot be tackled by improving STEM education alone. Three elements are critical for the organizational and programmatic shift. First, BATEC has to rely on a more granular analysis of the geography of the local and regional IT labor market, the occupational dynamics within it, and the emerging human resource development practices in the broad variety of corporations in the region, ranging from small entrepreneurial firms to large global companies. Second, BATEC could benefit from a measure of conceptual and strategic renewal, drawing from practical fields beyond the scope of STEM education (and the ATE program).

The workforce and regional economic development fields may be the logical locus for this renewal. BATEC can assume a stronger role as a labor market intermediary (LMI). In many kinds of regional and labor market settings, LMIs have demonstrated organizing and coordinating capabilities required to integrate regional workforce development systems. BATEC needs to continue to draw lessons from its initial "take-off" stage as an ATE center while it examines the kinds of adaptations needed to remain a relevant contributor in the regional knowledge-based milieu .

The remainder of this paper will provide a description of the research protocol employed in this study, the characteristics and scope of the NSF's ATE program and BATEC's accomplishments in STEM education, the potential for LMIs to address workforce development problems in the IT sector, and a discussion on the complexity of Greater Boston's IT labor market, its occupational and geographic characteristics, and current human resource development practices affecting employment in a variety of corporate settings. This paper will also identify areas of strategic adjustment that BATEC may focus on in order to improve its workforce development functions and consolidate a regional outlook. A summary of the study and its lessons will be provided in the final section.

2 Method

The first of this case study's three components draws from recent empirical and theoretical literature on workforce and regional development to discuss what LMIs are and what role they could play in improving workforce development in knowledge-based industries, particularly the IT sector. These studies provide the foundation of this case study.

The second component briefly discusses the geographic and occupational characteristics of the IT labor market in the Greater Boston Area between 2000 and 2004, and the occupational dynamics pertaining to a variety of enterprises in the region. Statistics from the Massachusetts Department of Workforce Development are used in the discussions. This approach is perceived to provide a better appreciation for the complexity of the IT labor market in which BATEC operates because the geographic location of jobs, international competitive shifts, and short- and long-term shifts in employers' attitudes much more frequently affect the IT labor market. This component also draws from 12 open-ended interviews with human resource managers and other corporate personnel from various corporate settings that served to document rapid changes in the human resource development practices of employers that heavily influence the types of workers and skills required by employers. The challenge is for BATEC to

understand human resource development practices and develop more appropriate programs.

The third component draws from lessons from BATEC's accomplishments, using data from: (1) interviews with BATEC's executive director and some members from its advisory board; (2) internal documentation of the organization; (3) national evaluations of the NSF-sponsored ATE program; and (4) the author's participation in some of BATEC activities, including industry summits, career fairs, and educational conferences. These lessons can support BATEC's effort to become a stronger regional LMI.

3 BATEC and the ATE Program

3.1 Description and Goals

BATEC was created in 2003 and, from its base at the Boston campus of the University of Massachusetts (UMass-Boston), has grown into a partnership between three community colleges, the Boston Public Schools, nine Boston rim school districts. Its geographic coverage roughly extends west to the city of Worcester, and north to Route 128, Massachusetts' dynamic high-tech corridor.[2] BATEC receives its major funding from the ATE program of the NSF.

The ATE program was funded by Congress under the aegis of the Scientific and Advanced Technology Act of 1992 (PL 102-476) to promote systemic reforms in STEM education centered on community colleges across the nation. Various sources identify the ATE grants as the largest federal commitment to community college curricula and programs (AAAC 2003; Bailey et al. 2004; AACC 2005).

Initially, the ATE program created two main tracks of funding: ATE projects and ATE centers. ATE projects have a limited scope and are mainly focused on the development of curriculum and educational materials, professional development of teachers in high school and community colleges, laboratory development, and development of expertise for the adaptation and implementation of new technologies (The Evaluation Center 2006). The average project grant is approximately $400,000, given over a period of two to three years. The ATE centers serve as regional and national clearinghouses of the materials and lessons from the projects. In early 2000, the funding and promotion of the first generation of national and regional centers were reshaped to increase the coverage and impact of their activities, to further encourage partnerships with industry, and to create resource centers, which are more focused and more visible (The Evaluation Center 2006). National, regional and resource centers receive about $5 million, $3 million, and $1.5 million, respectively, over four years (AACC 2003). Two other smaller tracks: (1) a workshops track that sponsors conferences, symposia and activities on advanced technological education; and (2) an articulation partnerships track that promotes collaborative efforts to increase the capability of middle and high school technology teachers, and partnerships between community colleges and universities (The Evaluation Center 2006).

During its first decade (1993 to 2004), the NSF awarded a total of $260 million through 600 ATE grants for projects and centers. By 2003, about 20 % of the nation's 1,132 community colleges had received an ATE award (AACC 2003). Based on various surveys, the contributions of the ATE program include: (1) the creation of more than

5,000 materials on technology education; (2) the publication of 500 modules on technology education that align workforce needs and industry standards developed by ATE programs; (3) the provision of assistance to 320,000 students at two-year colleges, 48,000 high-school students and 6,000 baccalaureate students; (4) the creation of 2,000 two-year college programs and 16,800 courses at community colleges, baccalaureate institutions and secondary schools; (5) the development of 2,000 articulation agreements; and (6) the successful involvement of approximately 80,000 educators in ATE-related activities. In 2006, 238 active grants were awarded within 41 states, the District of Columbia and Puerto Rico (AAAC 2005; Patton 2006). Most recently, eleven ATE resource centers formed the ATERC Network to promote collaboration between ATE Resource Centers. Level funding of the program has continued, and in 2007, 258 active grants received $45.4 million in funding (AACC 2007).

ATE program activities have primarily been in STEM education but have also contributed to shape workforce development partnerships between industry, employers, educational institutions, and consumers in several technological areas such as agricultural technology, biotechnology, chemical and processing technology, engineering, environmental technology, informatics, manufacturing and nanotechnology. The flexibility of the grants has allowed participants to develop a wide variety of collaborative arrangements to meet local and regional development needs and grow new synergies for economic growth. Numerous case studies document the ample success of these initiatives and suggest that some are becoming international examples of collaborations for technological development (AACC 2005; Patton 2006; AACC 2007).

Within the objectives of the ATE program, BATEC has identified four major goals: (1) developing curriculum that is relevant to the regional knowledge-based economy; (2) providing professional development experiences for educators so they can deliver standard-based programs that model the reality of the workplace; (3) attracting and advancing a diverse population of technology students; and, (4) connecting education, industry and community to promote partnerships that support career development, lifelong employment and regional economic growth (BATEC 2007).

3.2 BATEC's Accomplishments

As with the rest of the ATE program, BATEC has been primarily focused on STEM education. It utilizes a collaborative and networked systemic approach, focusing on curriculum development, professional development, outreach and diversity, and connectedness for workforce development. Accomplishments in these various program areas are detailed below.

Curriculum Development

BATEC's curriculum development program rests on a methodology that incorporates a new cognitive and pedagogic approach for IT teaching and learning. Until recently, most teaching in IT was very didactic, oriented towards testing, and with little or no connection to workplace environments and real problem-solving opportunities for students (BATEC 2007). The new approach integrates emerging industry needs and workplace-driven problems, emphasizes higher-order thinking skills, active learning and teamwork, and makes an explicit emphasis on employability skills and industry

standards. BATEC has introduced and promoted this new approach through various industry summits that bring together high schools, community colleges, employers, and the state university—stakeholders that traditionally do not exchange perspectives on mutual educational and workforce development interests. In addition, BATEC has helped create 89 courses at participating educational institutions and has facilitated the creation of formal certificate and academic programs in areas, such as systems architecture, web development, computer forensics, and radio frequency identification (BATEC 2007). These programs have been closely planned and developed with current employers and potential new technology enterprises.

Professional Development

BATEC's professional development program has concentrated on creating a more holistic approach to faculty development. The approach has four major components: "futures forums", summer institutes, externships, and specific training programs (BATEC 2007). Quite often, community college and high school faculty (as well as other important professional staff, such as career counselors) have little opportunity to upgrade their knowledge about emerging technologies and observe knowledge applications in actual industry settings.

BATEC has organized industry experts and strategists to lead futures forums that serve to map the local technology landscape, demonstrate new applications, and identify future technology trends. The forums, beyond the immediate networking opportunities they provide, have helped create a community of learners who share a common workforce development language in the local knowledge-based industrial milieu. The forums also serve as venues for identifying the topics for summer institutes, which are more formal opportunities for faculty to attend workshops and courses in relevant technology areas. Both the forums and summer institutes have served as building blocks for an externship program that provides educators the opportunity to work in a business setting (BATEC 2007). When necessary, BATEC also sponsors local educators to attend or access specific training programs, such as Oracle certification (BATEC 2007).

Outreach Activities

BATEC's outreach programs are executed through various channels and address information needs of underprivileged and/or underrepresented students (e.g., women or members of racial minorities) from the high school to the baccalaureate levels. These activities vary in depth and intensity and include simple information sessions in schools, day-long college fairs, internships, technology apprenticeship opportunities, student technology-leadership "ambassadorships" (peer groups that spread information in schools), preparation and distribution of outreach manuals for community colleges, college placement test review programs, after-school programs, and a bridge program from high school to community college. The success of all of these activities has earned BATEC praise from the National Visiting Committee, a seven member group from across the US that provides advice to BATEC (BATEC 2007).

Connectedness for Workforce Development

BATEC has contributed successfully in connecting education, industry and community groups to form mutually beneficial partnerships. Its success is most evident in

making industry participate in organizational governance, content specification and skills emphasis, which in turned has resulted in various large employers – such as Raytheon, Health Partners, Blue Cross Blue Shield, AVNET and Staples – championing internships, apprenticeship and externship programs, as well as providing monetary and "in-kind" resources to assist programs and organize education / industry summits.

Most recently, BATEC brokered various projects in which educational institutions, employers, producers, and consumers can collaborate to develop new products and applications for the health industry. This project revolves around the use of radio frequency identification technology to modernize information delivery and retrieval within health care systems and between healthcare delivery units.

BATEC has primarily been dedicated to technician and technologist education. In seeking to strengthen its workforce development role in the region, BATEC would benefit from a better understanding of the local and regional IT labor market, its occupational dynamics, and the human resource development practices within a variety of corporations.

4 Workforce Development and Labor Market Intermediaries in the Knowledge-based Industrial Milieu

4.1 Workforce Development and LMIs

Workforce development broadly describes the collaborative and networked practices of or services provided by various organizations for the improvement of labor market access and employment opportunities for workers with all kinds of socio-economic, demographic or educational background and skill (Giloth 2004; Meléndez 2004). LMIs can serve as the organizers of such practices and deliver the services. In the most common definition, LMIs refers to organizations that try to connect workers to employment opportunities, and employers to workers. As such, ATE centers partially perform as LMIs (Servon 2004).

Some LMIs focus on short-term "work-first" strategies for welfare recipients, staffing services, or long-term career-ladder development strategies (Giloth 2004; Meléndez 2004; Benner, Leete, and Pastor 2007; Meléndez and Borges-Mendez, 2007). Some LMIs show distinct levels of organizational complexity that can effectively let them establish relationships with actors on both the demand and supply sides of the market (Benner 2002; Giloth 2004; Borges-Méndez and Meléndez 2004; Takahashi and Meléndez 2004; Benner et al. 2007; Meléndez and Borges-Méndez, 2007). In some cases, LMIs have been created or promoted by employers in order to pursue specific strategic objectives, such as searching for various kinds of labor flexibility, which is a key aspect of preserving competitiveness (Harrison and Weiss 1998; Benner 2002; Giloth 2004).

4.2 LMIs in the Knowledge-Based Industrial Milieu

LMIs, as strategic partners in workforce development, are significant to the IT sector for several reasons (Servon 2004; Stoll 2004; Wolf-Powers 2004; Chapple 2006; Garmise 2006). As the National Academy of Sciences (2003) observed, "rapid IT diffusion and business transitions reduce the effectiveness of the market in reconciling

supply and demand and the effectiveness of many putative policy solutions". Poor communication between IT stakeholders in workforce development has led to allocation and coordination problems in strategic partnerships (US Department of Commerce 2003). On the supply side, the workforce is very heterogeneous, comprising individuals engaged in a wide range of activities in the IT industry, potentially causing turmoil in the labor market (Wentling et al. 2002; National Academy of Sciences 2003) along with discrimination based on age, race and gender (National Academy of Sciences 2003*)*. On the demand side, rapid *open innovation* is creating difficulties for stakeholders (industry, government, community, academe) in defining the scope of their workforce development efforts (MassInsight 2004).[3] LMIs can address these issues by supplementing the "invisible" allocation and coordination mechanisms of the labor market on both the supply and demand side.

Another reason why LMIs are significant to the IT sector is that they can compel human resource (HR) managers to adopt "high-road" labor flexibility strategies (Harrison 1994; Harrison and Weiss 1998; Garmise 2006) to help mitigate the impact of a wide range of factors including rapid technological change, decomposition of internal labor markets in corporations (Osterman 1998; 2001), proliferation of dead-end forms of flexible work (Carre 2003), and the globalization and offshoring of economic activity (Kroll 2005; Ernst 2006; Saxenian 2006*)*. In some service industries (IT included), these factors have contributed to institutionalize "low-road" strategies of flexibility that deny workers opportunities for upward mobility (Harrison 1994; Carre 2003; Hyde 2003; Smith 2001*)*.

In knowledge-based industrial sectors, the HR functions of accounting, hiring, compensation, and conflict management no longer satisfy the demands of the current technological environment of rapid *open innovation* and competitiveness. A dramatic shift has taken place from traditional HR to the more proactive "human resource development" (HRD), which anticipates human resource needs, sees training as a core value of the organization, promotes commitment to learning, facilitates self-management and self-learning, and values skill flexibility and teamwork (Wentling et al. 2002). The shift from the old model to the new has not been swift, and often workforce development practices remain focused on short-term placement and remedial interventions. When almost all kinds of workers and professionals require periodic upgrading of skills and new knowledge, the "low-road" approach might be wasteful because it does not contribute to building strong and durable skills to navigate the ever-increasing volatility of labor markets.

Finally, preserving competitiveness in knowledge-based industries, and promoting innovation and adaptability has been attributed to a host of factors. Among them is the geographic and organizational clustering of various research and development activities taking place in universities, corporate and publicly-funded labs. These actors network with other entrepreneurial agents (e.g., venture capitalists, inventors, etc.) to produce dynamic externalities or feedback effects that enhance new product design and create other positive economic outcomes (Porter 2000; Martin and Sunley 2006; Maskell 2006; Porter et al. 2006; Bresnahan et al. 2006*)*. Although the agglomeration effects of the clustering tend to be primordial, innovation seems to be enhanced by the collaborative and networking practices (culture) within the cluster (Saxenian 1994). Some scholars emphasize that IT industries during the early stages of entrepreneurial take-off seem to

benefit a great deal from the flexibility and fluidity of informal and horizontal relationships in meeting its human resource needs (Sellers 2002).

However, as sectors mature, these relationships require some degree of institutionalization, although not to the point of becoming rigid arrangements that run against the characteristic dynamism of the IT sector. Collaborative arrangements between numerous public, private and non-profit actors are essential in order for positive labor/human resource externalities to take hold and benefit both emerging and mature IT/high-tech (or bio-tech) clusters. LMIs can improve industrial governance and organizational cohesion in such scenarios.

Insights from studies on workforce development and LMIs can reinforce BATEC's strategies. These studies, however, are only beginning to develop a regional workforce development outlook. Few emphasize that traditional political jurisdictions (town, county, municipality) are not necessarily the most adequate geographic unit of analysis in order to address equity problems in the labor market and competitive pressures in a number of industrial sectors (Harrison and Weiss 1998; Benner 2002; Chapple 2005; Pastor, Benner, and Rosner 2006; Benner, et al. 2007; Meléndez and Borges-Méndez, 2007). The regional outlook can take into consideration geographic patterns of occupational, income and educational exclusion experienced by ethnic minorities even during of periods of economic expansion (Borges-Méndez, et.al. 2007).

5 Growth and Change in the IT Labor Market and Knowledge-based Milieu of Grater Boston and the Commonwealth.

5.1 Growth, Structure and Geography of the IT Labor Market in the Greater Boston

Some analysts portray IT labor markets in the US as tight labor markets experiencing continuing shortages. This characterization often serves as an expedient excuse for hiring foreign-born, highly skilled programmers at low wages (Matloff 2002; 2003*)*. However, the labor shortage tale is too simple to capture the structural complexity of these labor markets and the occupational dynamics within them.

In the US, IT jobs more than tripled between 1983 and 2000, from 719,000 to 2,498,000 at the peak of the sector's expansion, but unemployment in core IT occupations increased in 2000 and almost reached 6 % during the first half of 2003 (STEM Workforce Data Project 2004*)*. Nationally, such decline in employment was recognized as the "dot-com burst." Given the tendency of IT firms to cluster in some geographic locations, the effect of the decline was particularly felt in areas such as Silicon Valley in California and Route 128 in Massachusetts, and it was attributed to the September 11, 2001 terror attacks on the US, growing outsourcing and offshoring of IT services, and streamlining and restructuring due to product-cycle and market dynamics (Matloff 2002; 2003; National Academy of Sciences 2003; US Department of Commerce 2003; MassInsight 2004; MassInsight and Battelle 2004).

By 2005, the employment trend improved. Governmental sources say that five in the top fifteen growing occupational categories for 2004 to 2014 are IT-related ones, and all will be expanding more than 38% (Bureau of Labor Statistics 2005*)*. Although news of the recuperation were welcomed, industry sources say that, between the downturn and the recuperation, the IT sector underwent a dramatic transformation that changed

occupational content and performance requirements and pushed managers to reevaluate the human resource function in companies (ITAA 2004; NWCTE 2004).

In Massachusetts, 2001 to 2004 was marked by job decline with payroll employment falling steeply and steadily for three years (Sum et al. 2006), but the IT sector did not suffer as much. Massachusetts is known to have a disproportionately high-tech economy. Yet, of the 3.2 million jobs in the state in 2000, only 125,000, or 3.9%, were in high-tech occupations. That share remained virtually unchanged in 2004. Table 1 disaggregates the share of IT in total occupations in Massachusetts, and Table 2 offers a breakdown of the occupations which gained or lost ground.[4]

Table 1 Jobs in High-Tech: Massachusetts; Greater Boston; Boston.

	Total jobs		**HT jobs**		**HT/Total**
2000	3,204,490		124,820		0.039
2004	3,159,740		128,660		0.041
	GB jobs	**GB/Total**	**GB HT jobs**	**GB HT/HT Total**	**GB HT/GB Total**
2000	2,446,040	0.763	114,810	0.920	0.047
2004	2,454,000	0.777	118,950	0.925	0.048
	B jobs	**B/Total**	**B HT jobs**	**B HT/HT Total**	**B HT/B Total**
2000	1,854,760	0.579	99,650	0.798	0.054
2004	1,816,430	0.575	98,830	0.768	0.054

GB: Boston-Lawrence-Worcester CMSA (Consolidated Metro Statistical Area)
B: Boston PMSA (Primary Metropolitan Statistical Area)

Source: Commonwealth of Massachusetts. Massachusetts of Workforce Development. Regional Labor Market Information Series, Report #3, September 2005.

Table 2 shows growth for the clearly IT-driven occupations among the high-tech occupations. More specifically, some IT-driven occupations grew dramatically, such as computer hardware engineers (75.19%); computer and information scientists (59.76%); network systems and data communications analysts (46.11%); computer software engineers, systems software (36.82%); database administrators (7%); and, multi-media artists and animators (6.48%). Computer software engineers (applications) and computer programmers declined by 2.79% and by a dramatic 45.52%, respectively (Massachusetts Department of Workforce Development 2005).

Table 2: Occupations in High-Tech, Massachusetts, 2000 and 2004

	MA			GB		
Occupational Title	**N, MA 2000**	**N, MA 2004**	**Change**	**N, GB 2000**	**N, GB 2004**	**Change**
Physicists	140	580	314.29%	140	580	314.29%
Epidemiologists	70	220	214.29%	70	220	214.29%
Nuclear Engineers	100	180	80.00%	100	180	80.00%
Computer Hardware Engineers	2,700	4,730	75.19%	2,700	4,730	75.19%
Computer and Information Scientists, Research	820	1,310	59.76%	770	1,310	70.13%
Biological Technicians	1,690	2,560	51.48%	1,620	2,430	50.00%
Network Systems and Data Communications Analysts	3,730	5,450	46.11%			
Computer Software Engineers, Systems Software	13,470	18,430	36.82%	13,070	17,260	32.06%
Electronics Engineers, Except Computer	3,220	3,810	18.32%	3,000	3,740	24.67%
Database Administrators	3,570	3,820	7.00%	3,200	3,340	4.38%
Multi-Media Artists and Animators	1,080	1,150	6.48%	1,000	1,080	8.00%
Chemical Engineers	880	920	4.55%	770	860	11.69%
Chemical Technicians	2,220	2,310	4.05%	1,800	1,890	5.00%
Computer Systems Analysts	16,280	16,410	0.80%			
Medical and Clinical Laboratory Technologists	4,670	4,690	0.43%		3,760	
Electrical and Electronic Engineering Technicians	7,250	7,250	0.00%	6,510		
Computer Software Engineers, Applications	21,520	20,920	-2.79%			
Biomedical Engineers	590	570	-3.39%	590	570	-3.39%
Microbiologists	690	600	-13.04%	640	600	-6.25%
Electrical Engineers	8,080	6,930	-14.23%	7,670	6,760	-11.86%
Radiologic Technologists and Technicians	5,900	4,840	-17.97%		3,440	
Electro-Mechanical Technicians	2,270	1,740	-23.35%		1,740	
Chemists	3,350	2,370	-29.25%	2,940	2,270	-22.79%
Geoscientists, Except Hydrologists and Geographers	270	150	-44.44%	270	150	-44.44%
Computer Programmers	19,200	10,460	-45.52%			
Nuclear Medicine Technologists	730	330	-54.79%	620	240	-61.29%
Medical Scientists, Except Epidemiologists		4,220			4,220	
Biochemists and Biophysicists		800			800	
Aerospace Engineers		590			590	
Aerospace Engineering and Operating Technicians	330			330		
Nuclear Technicians		250			250	
Geological and Petroleum Technicians						
Astronomers		70			70	
Atmospheric and Space Scientists						
Petroleum Engineers						
Mining and Geological Engineers						

Source: Commonwealth of Massachusetts. Massachusetts of Workforce Regional Labor Market Information Series, Report #3

Job reclassification, in the sense of splitting a single occupation, may help explain the precipitous decline in "computer programmers" over this period. Qualitative evidence from interviews with computing science academics and IT professionals also suggest that a combination of organizational restructuring in IT industries and innovation in programming resulted in the shedding of a whole segment of programmers. Jobs were eliminated, fused with other jobs, or standardized into "lower value products", or were simply sent offshore. In general, the Greater Boston Area, relative to the state, has experienced larger gains and smaller losses in almost every high-tech occupation.

Despite the downswing earlier in the decade, growth in the IT occupational cluster remained robust. In fact, it is projected to continue expanding to 2010. None of the other 22 occupational clusters considered by the Division of Unemployment Assistance shows expected comparable growth (Commonwealth of Massachusetts 2004). Using 2000 as a base year, the computer specialist occupational cluster is projected to grow by 53% by 2010. Specific occupational categories are expected to grow faster, such as computer support specialists, network and computer system administrators, and network systems and data communications analysts, which are expected to grow by 73 %, 59 % and 60 %, respectively (Commonwealth of Massachusetts 2004).

Because changes in the concentration and location of jobs, in addition to occupational shifts, affect workforce development strategies significantly, this study tries to assess the spatial character of IT/high-tech jobs in the Greater Boston Area and the state. Table 1 shows some approximation of the geographic concentration of such jobs within Massachusetts and breaks down IT jobs in Greater Boston and the Boston Primary Metropolitan Statistical Area (PMSA).[5] Greater Boston, home to more than three fourths of Massachusetts's total jobs in both years, is shown to have more than 90% of the high-tech jobs in the same period. Tightening the focus even more, the Boston PMSA held 58% of the state's jobs and 80% of its high-tech jobs.

Based on Table 1, geographical movements of high-tech jobs in this period seem to have taken place in the Boston PMSA. Examination of Table 1 shows that the number of high-tech jobs grew in this period even as the total number of jobs in the state declined. Virtually all of that growth, nearly 5,000 jobs, occurred in the parts of Greater Boston outside of the Boston PMSA.[6]

Based on Table 3, which shows the distribution of high-tech jobs among the state's metropolitan statistical areas in both years, Boston PMSA's share of the total declined by three percentage points. In the same period, some 2.5 of those percentage points can be accounted for by growth in Lawrence and Worcester. For the period under consideration, this relocation is marginal. Readers familiar with Boston will recognize this movement as one from the area encompassed by the metropolitan subway system to that within striking distance of the commuter rail. In any case, the Boston PMSA remains the dominant location of high-tech work. Regionalization strategies to open further opportunities for people not integrated into knowledge-based industries must consider such high degree of spatial concentration.

Table 3: High-Tech Jobs by MSA and PMSA, Massachusetts

MSA Name	HT Jobs, 2000	Share	HT Jobs, 2004	Share
Barnstable-Yarmouth, MA MSA	0	0.00%	340	0.26%
Boston, MA-NH PMSA	99650	79.83%	98830	76.81%
Brockton, MA PMSA	620	0.50%	1440	1.12%
Fitchburg-Leominster, MA PMSA	170	0.14%	80	0.06%
Lawrence, MA-NH PMSA	3730	2.99%	5820	4.52%
Lowell, MA-NH PMSA	6660	5.34%	7220	5.61%
New Bedford, MA PMSA	210	0.17%	230	0.18%
Pittsfield, MA MSA	380	0.30%	170	0.13%
Providence-Fall River-Warwick, RI-MA MSA	7240	5.80%	6450	5.01%
Springfield, MA MSA	2390	1.91%	2750	2.14%
Worcester, MA-CT PMSA	3770	3.02%	5330	4.14%
Total	**124820**		**128660**	

MSA (Metro Statistical Area); PMSA (Principal Statistical Metropolitan Area)

Source: Commonwealth of Massachusetts. Massachusetts of Workforce Development. Regional Labor Market Information Series, Report#3, September 2005.

5.2 Diversity in Human Resource Development (HRD) Practices

Interviews with IT employers in the Greater Boston Area revealed the heterogeneity of HRD practices. For instance, HRD practices depend on firm size and corporate structure.

Large firms have adopted some of the elements of the "small-firm model", hiring workers for short-term employment through staffing agencies. However, they also have created extended job ladders (internal labor markets) that focus on job stability and upward mobility through a more credential-driven path, which is structured by human resource professionals. This concept of extended job ladders is largely nonexistent in smaller firms.[7]

On one hand, small and medium-sized IT firms (from 100 to 150 employees) tend to make heavy use of contract work or seek to hire young and flexible workers. Small firms are strongly constrained by labor costs, causing them to take advantage of the relatively lower cost of young workers. Their turnover rates are strongly linked to atypical product-cycles and fluctuating project durations, which can range from one to three years. Small firms tend to terminate employment with great ease when projects are completed.

Young workers with limited credentials are seeking for exposure to a broad range of production processes from programming to project design. As observed by some small firm managers and owners, young workers seem willing to favor exposure to a variety of work experiences over the prospect of short-term employment.

Both small firms and workers are well aware of this dynamic and take advantage of it. Small firms benefit from the flexibility of young hires, and workers gain from exposure to a variety of experiences. High turnover and low job attachment are common features of the job culture of small IT firms.[8]

Another important variation in HRD practices is based on approaches to workplace learning. Some employers emphasize self-learning, selecting workers who have or can develop a broad mix of standard skills (hard skills), experience, personality traits (soft skills), and teamwork capabilities, placing less emphasis on school certification or formal degrees. Other employers are developing customized teaching/learning partnerships with multiple kinds of educational organizations, whereas others are internalizing the creation of pedagogic tools for workforce development. Employers have created "corporate universities" that, for instance, develop virtual case studies, which simulate conditions that workers are likely to encounter in their line of work. These case-studies are changed regularly, seeking to convey the idea of continuous workplace learning. More traditional employers, like public agencies, continue combining traditional cumulative learning and training with emphasis on promoting equity in IT jobs.

Finally, HRD practices are strongly embedded in the IT organizational model of employers. For example, a large health care insurance and service provider has a centralized IT division — lead by a Vice-President for IT — that is in command of most of the IT functions of the company. IT workforce development needs are centrally assessed and implemented. The centralized model, however, can respond with flexibility to the demands of taking on new large institutional clients, such as hospitals or universities, which require harmonization of IT practices and customization. In such cases, the company relies on outsourcing some IT needs to a joint team, which comprises private subcontractors, the client's IT personnel and the company's IT personnel. By contrast, HRD practices might be also embedded within a decentralized IT environment. In this scenario, workforce development serves the needs of a conglomerate of semi-autonomous projects or divisions, each with their own IT requirements. Large defense contractors tend to operate this way.

Qualitative knowledge about the human resource practices in employers can complement conventional labor market assessments that primarily focus on the number of job vacancies. Accounting for vacancies alone fails to grasp the transformation occurring in workplaces in the knowledge-based and high-tech industrial milieu.

6 BATEC: Lessons Learned and Adaptations

Labor markets in Greater Boston's IT sector are influenced by both the positive and negative forces of innovation: job growth, employment volatility, uncharted occupational change, human resource development practices, etc. These forces do not always work in harmony to produce the best outcomes for workers and employers. Employers require various kinds of occupational and labor flexibility to respond to speedy changes at multiple levels of activity, ranging from research to production. Workers and public institutions often struggle to keep apace.

In this scenario, the search for flexibility can be organized collaboratively by public, private and non-profit actors to prioritize human capital investments on incumbent

and future workers with emphasis on continuous upgrading, as well as investments on the local/regional educational infrastructure, which is considered a "high-road" strategy of workforce development (Harrison 1994). Conversely, corporations, the main drivers of the labor market, may opt for a "low-road" strategy (Harrison 1994) that seeks to minimize investments in human capital and workforce development, encourages short-term, insecure or unprotected employment, off-shoring, and does not promote relationships with other institutional actors in the governance of the local/regional labor market.

Currently, BATEC is trying to promote a "high-road" strategic approach by becoming a stronger LMI within the high-tech, knowledge-based industrial milieu. BATEC is seeking to address emerging sectorial interdependencies between traditional high-tech and biotech, finance and health sub-sectors, as well as the persistent equity gaps in IT labor markets. In order to be effective, BATEC needs to take stock of lessons learnt from its experience as an ATE center and make some necessary adaptations in four key areas.

First, BATEC has successfully maintained **stakeholder engagement** beyond the initial grant writing stage. It was able to assemble a team of committed stakeholders in order to obtain a $3-million anchor grant from the NSF for a series of concrete activities over a period of three years. UMass-Boston and individuals from BATEC's design team were important protagonists in the process. Afterward, BATEC managed to keep the momentum through intensive dissemination of results at the national and local level to show stakeholders the value-added contribution of the partnership.

Entering into a new phase of regionalization will require a shift in the geographic scale of the strategies to maintain stakeholder engagement. The new strategies would have to attract the participation of regional organizations such as regional industrial and economic development councils, workforce investment boards (WIBs) that are in charge of managing the state's workforce development funding, and consortiums and initiatives promoting the development of specific industries.

The challenge for BATEC is to propose a vision for a regional workforce development system that finances, regulates, serves, maintains, and links the core functions and activities that support workers and respond to the human resource needs of employers on a wider geographical scale (Author 1 & Author 2, 2007). BATEC may also have to attract funding for regional development programs, such as the Workforce Innovation and Regional Economic Development Program (WIRED) of the US. Department of Labor.

Second, to elicit the sustained participation of stakeholders in the partnership, BATEC has developed an **open network-building philosophy** that promotes flexible, nonhierarchical, inclusive practices that do not try to impose "one-size-fits-all" activities on the potential pool of institutional participants. This philosophy simply concentrates on creating opportunities for further building on their own strengths and interests in the IT field.[9] The openness and flexibility serves best the variety of institutional participants because most of them choose to participate that they may address specific equity issues or socioeconomic disadvantages experienced by some of their constituents. In this regard, BATEC also sees itself as an agent of knowledge diffusion that connects some disadvantaged institutional agents to the flow of knowledge resources in IT.

BATEC will have to continue promoting this philosophy, but it will have to strengthen its system netting functions (Meléndez and Borges-Méndez, 2007). System netting refers to activities that concentrate in developing a regional outlook or vision for the system as a whole, develop policies and programs that structure collaborations among stakeholders, and focus resources where needed to satisfy the needs of both workers and employers.

Third, along with securing basic funding and organizing primary system-building activities, BATEC has established **a form of governance** for the whole partnership. The process was, to say the least, not linear. At first, BATEC created a very organic representative structure with members from the main stakeholders in the initial grant layout (high schools, community colleges and employers*)*. However, BATEC soon realized that this structure was too rigid and was easily overwhelmed by the multi-tasking and frantic pace of activities in the "micro-arenas" (curriculum and professional development, etc.) that were forming within and around the primary actors. This encouraged BATEC to maintain a general "leadership team", comprising those who managed BATEC's activities, and to expand its "advisory board", including executives from local businesses, leaders from industry organizations, representatives from state and local government, and heads of community-based organizations.

The Advisory Board is divided into four "leadership subgroups" in education, industry, business, and underrepresented groups. They provide substantial feedback about BATEC's proposed activities, help identify industry trends and workforce needs, and provide BATEC with some of the evaluation metrics required by the National Science Foundation.

Regionalization may require making adaptations to BATEC's governance bodies, although they already have considerable regional diversity. These adaptations would have to focus, for example, on improving the geographic representation of communities in various parts of the state that are disconnected from the knowledge-based economy (Borges-Méndez, et al. 2007*)*.

Fourth, BATEC has established **a track-record for the partnership** in order to build its profile and sustain its visibility. This was not a conventional marketing exercise because the strategic objective was to attract and maintain stakeholder participation, and to increase legitimacy vis-à-vis those stakeholders.

Workforce development in IT (and in other fields) is hampered by the pervasive misconception that learning is a terminal stage in the life of workers, a "one-shot deal" or an "entry-and-exit" practice into the training or educational market. By contrast, effective workforce development depends on a longer-term commitment to learning from all stakeholders. Thus, for the partnership to remain relevant, it must regularly update its supply of products, which must also be relevant to the production function or the value-added chain of the various actors within the partnership. In this context, BATEC will have to create new projects that have regional scopes and exploit the new technological and production interdependencies that are emerging among industrial sectors, including health and radio frequency technologies, or biotech and informatics.

Finally, BATEC has established its own **research capacity** and has produced limited basic research, mostly related to its STEM education initiative. However, new research with a regional outlook will be required to plan a new regional agenda. The anticipated organizational growth and increased complexity will demand greater research

capacity for various purposes: (1) new product development; (2) strategic planning; (3) evaluation; and (4) the development of case studies to document practices and disseminate innovation and learning. BATEC's future research efforts will have to consider the geography of the IT labor market, the occupational dynamics in a variety of industry settings, and the emerging industrial interdependencies within the knowledge-based milieu.

7 Conclusion

Economic growth and competitiveness in the Greater Boston Area's knowledge-based industrial milieu will increasingly require policy makers and planners to pay greater attention to the weaknesses of the workforce development infrastructure. During the last three years, BATEC has accomplished most of its goals as an ATE center and has accumulated valuable experience from the implementation of STEM education programs and activities oriented to address said weaknesses. Increasingly, however, BATEC is seeking to improve its workforce development capabilities and to regionalize its efforts.

In line with the objective of this case study, several suggestions for BATEC's strategic renewal are specified. BATEC would benefit from adopting some of the functions of LMIs, which have proven to be an important organizational ingredient in the workforce development strategies of the knowledge-based, high-tech industrial milieu. In some corporate and government circles, conventional wisdom suggests that workforce development is primarily a localized remedial, short-term activity. In this context, BATEC can also promote "high-road" strategies to directly and indirectly mitigate some of the negative effects of various forms of flexibility in the labor market and address critical issues that devalue labor and professional resources. Furthermore, if BATEC assumes a stronger LMI role, it can contribute more forcefully to improving equity in the labor market by opening opportunities for various kinds of disadvantaged workers who have limited access to the knowledge-based economy of the Greater Boston Area.

BATEC has met its goals and has learned valuable lessons as an ATE center. However, in order to facilitate its adaptation, BATEC will have to modify some of its practices in five ways: (1) by developing new activities for promoting regional stakeholder engagement within the partnership; (2) by strengthening its open-network building philosophy with netting activities to consolidate a regional network; (3) by intensifying the incorporation into the governance of the organization of representative actors from communities excluded from the knowledge-based economy; (4) by devising with a long-term outlook on workforce development a new generation of regional products that are relevant to the value-added chain of employers; and, (5) by improving its research capabilities. These adaptations could also serve other ATE centers in the nation seeking to overcome similar challenges.

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[1] The opinions in this paper are exclusively those of the author and neither of BATEC's administrators nor of the National Science Foundation or other funding source.

[2] The same labor market area analyzed further in the paper.

[3] The rise in open innovation is led by companies not relying only on internal research and development (R& D) labs, but instead "partnering with small and large companies, as well as university and federal research centers" (MassInsight 2004, 2). Accordingly, the emerging collaborations and strategic alliances, which can also encompass production, commercialization, and even retail development, require multi-institutional approaches to workforce development and education in order to collate the needs of these multiple agents at different stages of innovation and product cycles, and often doing business with a broad variety of businesses.

[4] Here, the choice of occupations to classify as high-tech, as in the other tables, is conservative, relying on the list of thirty-six occupations that the Massachusetts Department of Workforce Development has classified as high-tech (Massachusetts Department of Workforce Development 2005).

[5] Greater Boston is defined as the Boston-Lawrence-Worcester Consolidated Metropolitan Statistical Area (CMSA). The Boston area is defined as the Principal Metropolitan Statistical Area, which includes the city proper and the first ring of surrounding towns, such as Cambridge and Somerville.

[6] The greater Boston area gained 4,140 high-tech jobs. Factoring in the 820 high-tech jobs lost in the Boston PMSA, this means that the rest of greater Boston gained 4,960 high-tech jobs. Since the state as a whole gained only 3,840 high-tech jobs in this period, simple arithmetic suggests that the remainder of the state had a net loss of 1,120 high-tech jobs over the same period.

[7] A recent article at MassBenchmarks, (2006, 8) seems to suggest that this "frugal contractual model" of HRD is making headway in the labor market as a whole, although not necessarily for the same reasons than in the IT labor market: "Non-payroll jobs appear to be growing at a significant faster rate than payroll jobs, as suggested by faster growing proprietors' income, estimated income tax payments, and self-employment counts on the Current Population Surveys. Although these jobs make up 10 per cent of total employment, there may be a trend towards greater reliance on contract work as employers try to avoid high health care and pension costs."

[8] This model could generate negative patterns of employment and human capital deterioration. For example, workers may experience job insecurity and employers can experience significant human capital losses .

[9] In the European literature on workforce development this approach has been called "open coordinated governance" (Regalia 2006).