REPORT OF THE
STATE COUNCIL OF HIGHER EDUCATION
FOR VIRGINIA

STUDY OF THE DEMAND FOR COMPUTER SCIENTISTS, ENGINEERS, AND OTHER TECHNOLOGICALLY SKILLED WORKERS IN VIRGINIA

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

SENATE DOCUMENT NO. 22

COMMONWEALTH of VIRGINIA

COUNCIL OF HIGHER EDUCATION

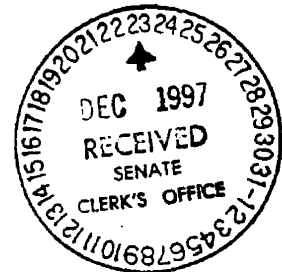*James Monroe Building, 101 North Fourteenth Street, Richmond, VA 23219*

(804) 225-2137
FAX (804) 225-2604
TDD (804) 371-8017
http://www.schev.edu

December 22, 1997

Members of the General Assembly
Commonwealth of Virginia
Richmond, Virginia 23219

Dear Members of the General Assembly:

Senate Joint Resolution 218 and House Joint Resolution 659, from the 1997 General Assembly session, directed the Council of Higher Education to study the demand for computer scientists, engineers, and other technologically skilled workers in Virginia industry and to report its findings to you, the Governor, and the Joint Commission on Technology and Science. This study accordingly offers research and a series of recommendations to help address this issue.

I am pleased to transmit to you this report, which the Council of Higher Education approved December 19, 1997.

Sincerely,

J. Michael Mullen

J. Michael Mullen

Enclosure

Preface

Senate Joint Resolution 218, sponsored by Senator Stephen D. Newman, and House Joint Resolution 659, sponsored by Delegate David B. Albo, requested the Council of Higher Education to study the demand for computer scientists, engineers, and other technologically skilled workers in Virginia industry and to report the findings to the General Assembly by November 15, 1997.

Implicit in assessing this demand is answering two questions: (1) is there a shortfall between the demand for technologically prepared workers and the supply; and (2) if there is, what actions can the Commonwealth take through its institutions of higher education to reduce this shortfall? This study accordingly also offers research and a series of recommended actions that address these questions.

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Executive Summary

The General Assembly requested that the Council of Higher Education study the demand for computer scientists, engineers, and other technologically skilled workers in Virginia. Implicit in assessing this demand is answering two questions: (1) is there a shortfall between the demand for technologically prepared workers and the supply; and (2) if there is, what actions can the Commonwealth take through its institutions of higher education to reduce this shortfall?

This report accordingly offers the results of the study's research and a series of recommended actions that address these questions. It notes that these recommendations deal with the current circumstances. They are not meant as complete answers to issues related to the long-term and significant shifts in the character of the national work force and the ability of the educational system to anticipate and respond to these changes. However, they do provide an infrastructure for dealing with future—and as yet unknown—work force educational needs.

The report provides a brief summary of national statistics that indicate a nation-wide shortage of technologically competent workers. It then delves into a more extensive examination of the shortage in Virginia. Studies done by a variety of agencies and private organizations in the state indicate that Virginia will need at least 22,000 new technology workers each year over the next five-year period. Although it is well understood that Northern Virginia will need the bulk of these workers, other regions of the state will also need a portion of them. Until a study done by the Center for Innovative Technology is released, the exact breakdown of work force needs by region is unavailable.

The next section of the report discusses the current efforts at providing technologically competent workers. Research done at the State Council of Higher Education shows a fairly steady-state production in Virginia of engineering and computer science degree program graduates of around 5,000 per year. The report cautions that although this figure is only one-quarter of the projected need of 22,000, not all of the 22,000 will actually require a technology-related degree. Again, the CIT study will shed more light on the exact nature of the jobs for which workers will be needed, and consequently on the appropriate education for them.

As it is, it is very hard to determine the true educational needs of the 22,000, since some will require the full 4-year—or more—degree for their jobs, some only a 2-year degree, and many will probably only need training in specific skills.

An associated question of what is being done in the educational system concerning the technological preparedness of the general working public is also of concern. While there will be a given number of individuals in technological jobs, most of the work force in the state need to have a set of basic technological competencies to function in the modern work environment. It is important to identify those basic needs and incorporate them into the educational system at all levels.

In spite of the information gaps on the exact extent of the need, much is already being accomplished to prepare technologically competent workers, both in the specifically technological disciplines and at the level of general need. The report details these efforts.

The last section before the recommendations discusses the areas where there are obvious shortcomings in the Commonwealth's efforts to prepare the work force for the jobs of tomorrow. It points out that there does not exist a good definition of the skills that will be needed by the various points of the work force spectrum (ranging from "general work force" through "technician" to "technology researchers and managers"). This leads to a fragmented, uncoordinated effort to instill technological skill development into the educational experience. This lack of accepted definitions is leaving some students without adequate technology skills upon graduation, and causing others to obtain more education than they need in preparing for their careers.

There is also a basic lack of coordination between demand (the work place) and supply (the educational arena) in technological skill development. While there are many efforts in place to address work force development needs, the lack of coordination within the education community may result in unnecessary duplication of effort by program providers, and confusion on the part of those in need of educational services.

The bureaucratic nature of program development and recruitment hampers the responsiveness of the state's higher education institutions in dealing with the issue of technological competence. The institutions need regulatory flexibility as well as entrepreneurial drive to initiate faster curriculum changes in response to the turbulent rate of change in business and industry.

Finally, there still are barriers imposed upon developing a technologically prepared work force by the cost of education, the lack of adequate post-secondary preparation in the K-12 system, and socioeconomic factors related to specific regions of the state.

In response to the needs determined by the study, the report provides eight recommendations to the Commonwealth, the institutions of higher education, and the private sector. The recommendations identify several important policy issues. For recommendations needing specific financial support during the 1998-2000 biennium, figures are noted in the body of the report. Other recommendations require further analysis for long-term implications, feasibility, and cost. For these recommendations, the Council offers no specific budget figures at this time and reserves the right to review the recommendations as more information about fiscal impact becomes available.

1) Provide a variety of mechanisms to develop and communicate the requirements for a technologically prepared work force to all involved parties.

2) Provide financial incentives and regulatory flexibility for the state's colleges and universities to respond faster to the needs of the marketplace.

3) Continue and expand new approaches to instruction in the state's higher education system (both public and private), with an emphasis on collaboration, distance learning, and innovative use of technology.

4) Ensure that the graduates of Virginia's colleges and institutions have the tools and instruction to leave them with the general and specific technological skills they will need in the work place.

5) Set up technology and other academic programs with the view that educational needs no longer exist in a succinct, one-time event in early life environment, but are part of a life-long process of learning.

6) Ensure that students have access to work place experience during their education so that they may fully understand their own educational needs.

7) Fund the financial aid and tuition assistance programs that help the citizens of Virginia obtain needed education.

8) Work closely with the K-12 system to ensure that both K-12 teachers and students have required technological competencies.

Acknowledgements

Background

Senate Joint Resolution 218, sponsored by Senator Stephen D. Newman, and House Joint Resolution 659, sponsored by Delegate David B. Albo, requested the Council of Higher Education to study the demand for computer scientists, engineers, and other technologically skilled workers in Virginia industry and to report the findings to the General Assembly by November 15, 1997.

Implicit in assessing this demand is answering two questions: (1) is there a shortfall between the demand for technologically prepared workers and the supply; and (2) if there is, what actions can the Commonwealth take through its institutions of higher education to reduce this shortfall? This study accordingly also offers research and a series of recommended actions that address these questions.

The research shows an acute–but perhaps short-term–shortage in the number of engineers and computer scientists in Virginia. This circumstance has been a catalyst for innovation and new partnerships within the business and education communities. However, the urgency of the immediate problem should not overshadow the essential longer-term transformation of society and the work place that is underway, and the ways both citizenry and elementary, secondary, and post-secondary education must respond. It is imperative to equip all students and workers with a life-long commitment to learning and with the technical skills needed to advance their own education and careers.

The recommendations provided in this report specifically deal with the educational aspects of work force development in the Commonwealth for the short-term. However, by their very nature they also at least partially address the longer-term issues. The major problem with providing exact answers to these issues is the element of the unknown concerning the Commonwealth's—and nation's—future economy.

As the global economy and information age continue to unfold, the character of the American work place is undergoing what some would call a "seismic" shift. Predicting that character and consequent educational needs beyond a five-year window is extraordinarily difficult in the current turbulence. The recommendations do offer a solid foundation on which to build the educational infrastructure of the future.

Study Design

During the last several years, many public and private organizations have studied and advanced specific recommendations on preparing qualified workers for technology-based employment. They include: The Commission on the Future of Public Education, the Center for Regional Analysis at George Mason University, the Virginia Technology Summit, the Joint Commission on Technology and Science, The Northern Virginia Technology Council, The Virginia Center for Innovative Technology, the Virginia Business Higher Education Council, the Weldon Cooper Center for Public Service at the University of Virginia, the State Higher Education Executive Officers, the Council for

Aid to Education (an independent subsidiary of RAND), and the National Science Foundation. The Council closely studied the work of these organizations and has used their findings and recommendations where appropriate in this study. A complete listing · of all information sources researched for this study is contained in the Bibliography beginning on page 23.

In addition to reviewing existing studies and recommendations, the Council staff met with over two dozen people who are knowledgeable in demographics, labor markets, and technology businesses and industry. The staff is also participating in meetings of the Virginia Technology Summit, the Joint Commission on Technology and Science and its advisory committees, and the Virginia Educational Technology Advisory Committee, among others, all of which have experience and interest in technology and work force issues.

The Demand Side: The Need for Technology Workers in the Nation

The US Bureau of Labor Statistics has projected a substantial growth in the need for information technology employees during the period 1994 to 2005. Jobs for computer scientists and engineers will grow 90 percent; jobs for systems analysts will grow 97 percent; computer programmer jobs will grow 11 percent.

A report done by the Information Technology Association of America (ITAA) predicts a labor shortage of over 190,000 technology jobs in mid- and large-sized U.S. companies by 1999. The actual number of technology openings is thought to be even larger since ITAA's survey did not include small companies, not-for-profit organizations, or government agencies—all highly dependent on such workers. The study also expects this number to *double* in five years. This study (Help Wanted: The IT Work Force Gap at the Dawn of a New Century) was extensively cited in a recent Department of Commerce publication, America's New Deficit, the Shortage of Information Technology Workers. It makes it very clear that a general shortage of technologically competent workers is evident in every state and region.

The Demand Side: The Need for Technology Workers in Virginia

In exploring the demand for technologically competent workers in Virginia, developing truly reliable statistics on future demand is a questionable enterprise at best. Julia Martin of the Weldon Cooper Center observes that "over 10 years of interviewing experience at the Center indicates that employers are incapable of projecting their employment needs beyond a year or two in an environment where rapidly changing social, economic, political, and technological developments all combine to influence future demand."

Within Virginia, the George Mason University's Center for Regional Analysis and Virginia's Center for Innovative Technology (CIT) estimate that in 1997 there are

2,450 technology firms in Virginia employing 290,000 workers. Their study found that technology firms are growing at a rate of 9.2 percent a year compared to a growth rate for all other companies of 3 percent a year.

In spite of the difficulty in estimating future demand, the Northern Virginia Technology Council, the George Mason Center for Regional Analysis, and the CIT project that, with an adequate supply of workers, there will be 4,000 technology-based companies in Virginia by 2002, employing approximately 400,000, and generating at least $22 billion in wages. Using a Virginia Department of Taxation rule of thumb for state and local tax revenue per $1,000 in wages, Virginia and its local jurisdictions could expect from $2.1 to $2.8 billion in annual tax revenues from technology wages by 2002. If realized, this revenue could equate to a significant return on the investments that are needed in order to increase the number of graduates with the requisite technological expertise

To find applicants with adequate technological competence, employers are looking for students with four-year college degrees for some but not all of the technology-related positions. A 1997 survey of firms conducted by the Northern Virginia Technology Council and CIT found that 50 percent of employers required a bachelor's degree for many of their technology positions but also felt that an associate's degree, some college work, or technical training below the bachelor's degree was adequate for other positions. About 25 percent of the firms surveyed felt that training below the bachelor's degree was adequate, while on the other end of the spectrum 22 percent of the firms required post-graduate education for positions.

The need for technologically competent workers varies by geographic region. For example, in Tidewater the recent downsizing in the military's presence has softened the need for technology workers to some extent. Unemployment levels vary throughout Virginia so that in some regions low unemployment levels result in a scarcity of workers, while in other regions there is a scarcity of jobs. In partnership with regional technology councils from throughout the Commonwealth, the CIT is sponsoring a new survey that will establish a "snapshot" of experience levels needed and projected vacancies statewide. Slated for completion in late 1997, the results of this study should provide a better picture of the specific competencies and numbers of workers required by region in Virginia.

Given the figures provided by the various organizations studying the need, the immediate challenge facing the Commonwealth is to add approximately 110,000 new technology workers over the next five years, which translates to 22,000 each year. The reader should realize that the jobs these workers will take are directly technological in nature. The 22,000 figure is but a minor fraction of the overall number of workers that will be needed each year who possess at least some level of technological proficiency for their work. It also does not consider current employees who will need continuous upgrading of their technological skills.

In the overall sense there is compelling evidence that economic growth in Virginia can be accelerated or constrained depending on the availability of a technologically competent work force. Business leaders stress that Virginia faces a · "once-in-a-lifetime" opportunity to capture a large share of technology-based industry. However, if qualified workers cannot be recruited within or brought to Virginia, technology-based businesses will seek other geographic regions to locate, and Virginia will not realize the associated wages and tax revenues.

The Supply Side: Current Efforts in Technology Education in the Commonwealth

Given the annual demand figure provided in the previous section (22,000), the obvious next question is how many technology workers are produced each year within the Commonwealth. The Council staff queried the SCHEV Virginia students' database for engineering, computer science, and technology-related degrees conferred (from Associate to Doctorate) for the academic years 92/93 through 96/97 for all institutions—public and private. The results of the query, showing the total number of technology degrees conferred for the period, are shown in Table 1.

TABLE ONE
Engineering and Computer Science Degrees
Conferred by Virginia's Public and Private
Colleges and Universities
Academic Years 92/93 Through 96/97

Academic Year	Number
92/93	5,050
93/94	5,128
94/95	5,279
95/96	5,083
96/97	5,209

From Table 1 it is clear that in terms of formal educational credentials from Virginia's institutions of higher education, the Commonwealth is generating less than a quarter of the technology workers needed each year in the state (22,000). Furthermore, the trend for the aggregate figures shown in Table 1 is flat, indicating the future number

of technology graduates will not increase significantly without a specific long-term intervention. While specific disciplines are showing increases in the number of graduates, and there are increases in the number of new students enrolling in certain of these programs, the numbers involved are not dramatic. As examples, General Computer Information Sciences had 5,504 students who were majoring in degree programs in the state's public and private institutions in the 96-97 school year, versus 4,202 in 92-93. Computer Engineering had 454 majors in 96-97 statewide compared to 270 in 92-93. On the other hand, Electrical Engineers went from an enrollment of 2,617 in 92-93 to 2,100 in 96-97. Additional information on major enrollment and graduates is in Appendix B.

However, it is not a correct conclusion to view the gap between the Commonwealth's production (approximately 5,000 annually) and the demand (22,000 annually) as "the" shortfall. Many of the technology jobs of both the present and the future as determined by the various studies do not require formal degrees. Due to this, a large number of the available jobs will go to individuals who have only taken specific preparatory courses, and the number of such individuals is virtually impossible to determine. Also, many employers offer their own training to acquire needed skills. A large percentage of the jobs will be filled by individuals who obtain their formal educational credentials from out of the state. And finally, there is no guarantee that all or any particular number of the 5,000 annual graduates will stay in Virginia to fill positions.

It bears repeating that the estimate of 22,000 annually needed workers does not take into account job vacancies that will need people with at least some technological competency. but whose jobs aren't completely technological in nature. Certain people who work in banks, insurance companies, retail stores, and so forth may well have to possess superior computer and system analysis skills. This pool is vastly larger than the 22,000, and will draw from all levels of education. Here it becomes important to see that those with liberal arts degrees can be on the same footing as technology program graduates, if they possess the basic technological competencies required for the position.

Thus, it is inaccurate to say that the Commonwealth's public and private institutions are producing less than one-fourth the number of needed graduates with technology credentials. There is. in fact, no way to determine the exact magnitude of the shortfall without an extensive (and expensive) survey of the entire state population's level of technological competency in concert with a full-scale survey of employers needs. This latter survey need will be addressed in part by the CIT study previously mentioned.

Nonetheless, the work of the CIT and Northern Virginia Technology Council so far shows that there is a need for 19.000 technology workers in Northern Virginia alone at present. So there is undoubtedly some extent of shortfall. Their and other studies indicate that the state's public and private institutions should help prime the pipeline so that technology graduates (engineers. computer scientists, etc.) double or even triple in number beginning in five years. While the Council's staff found no specific figures that definitively set the shortfall at a number that would justify such measures, it did find a compelling body of evidence supporting this view.

Closing the Gap between Demand and Supply: What's Getting Done

The Commonwealth's colleges and universities, regional technology councils, and government bodies appear to understand that there is a shortage of at least some extent of technologically competent workers and are responding positively. In the 1995 report The Commitment Grows: Higher Education Support for Economic Development in Virginia, the presidents of Virginia's public and independent colleges and universities expressed their collective intent to listen more closely to what business and industry has to say. This, the restructuring reports submitted on October 1, 1997, the ongoing dialogues facilitated by the Virginia Business Higher Education Council and other groups, and the number of business and industry advisory boards to higher education institutions created within the last several years all indicate that attempts to resolve the shortage are underway.

The work done to date indicates that the problem can be addressed most effectively by partnerships among Virginia's businesses, the public and independent colleges and universities, secondary education, the various work force development and training programs within the state, the relevant state agencies and policy boards, and the Governor and General Assembly. During the past year, these groups have met in various configurations to discuss the problem and explore solutions.

One of the problems in closing the gap between demand and supply is the difficulty in developing a clear picture of the skills and competencies required for a continuously changing work force. The technology industry is both growing and churning. It is clear that "skills" are not necessarily limited to a degree program, such as engineering or computer science, but also require a new attitude about thinking, learning, and working.

While technology-based industries require workers with specialized knowledge, these workers also must have the same skills needed in a wide range of today's businesses: communication, negotiation, and conflict management; adaptability, flexibility, and entrepreneurship; creative thinking and problem solving; leadership and management; positive attitude; and commitment to work and to life-long learning. Many employers appear to be less concerned about specific technology skills, recognizing that they constantly change as technology changes. Still, there is general agreement that the work force is in a better position to respond to employer demands if it possesses a base level of technological competence and a willingness to upgrade its skills as needed.

Employers understandably want to know why Virginia's colleges and universities did not anticipate a labor shortage and take steps earlier to increase the number of graduates with degrees in computer science, engineering, and other technological fields. The reasons are complex and deserve further analysis. To some extent, a lag time between a labor shortage and an increase in the supply of qualified workers is a normal part of the market place. Once a shortage is identified, it takes a few years for students to become aware of job opportunities and to enroll in and complete the required educational programs. Another factor to consider is that much of the demographic growth in recent

years in both the work force and the student population has been from women and minorities, who historically have been less likely than others to pursue science and technology fields. Finally, low unemployment rates in the state mean a reduced pool of potential workers to fill vacant jobs. The unemployment rate in Northern Virginia is 2.6 percent according to recent figures from the Virginia Employment Commission.

Collectively and individually, Virginia's colleges and universities are taking steps to address the shortage of technology workers. They have proposed new programs and enhanced existing activities to provide graduates with the knowledge and skills needed for technology-related work. The reader is referred to Appendix C, "Work Force Preparation Initiatives at Virginia's Colleges and Universities," for a by-institution listing of some of the efforts that are underway. The information in Appendix C is a compilation of data provided by the public institutions in their restructuring reports. Some of the highlights of Appendix C are mentioned in the paragraphs below.

Many of the institutions, especially the VCCS colleges, have increased adult education programs and modified the curriculum in degree-granting programs to foster skill development relative to work force needs. These efforts include courses of study delivered directly to students via desktop computers; on-site training and workshops for businesses; market research on the needs of technology firms; a statewide cooperative program in microelectronics materials, devices, and circuits; certificate programs in computational science and electronic commerce; internship programs with area businesses; an increased emphasis on experiential and service learning in the curriculum; and efforts to stimulate enrollment in high-demand disciplines.

Furthermore, many of the colleges and institutions have established business and industry advisory boards at the school or academic program level, have initiated strategic partnerships with specific employers, or have used regional surveys and focus groups to learn what knowledge and skills employers want graduates to have and to obtain their assessment of the capabilities of recent graduates who they have hired.

Virginia's colleges and universities, both public and independent, also are making strong progress in infusing technology into the curriculum and raising the general technological competence throughout their institutions. In accordance with House Bill 1848, enacted by the 1997 General Assembly, the public colleges and universities are working to "ensure that all graduates have the technology skills necessary to compete in the 21st Century." As documented in their 1997 restructuring reports, all of the institutions have strategies designed to achieve this goal. The state's institutions are generally taking measures to make the use of computers so widespread that students will naturally encounter and use them.

It is important to note that the recently revised Standards of Learning for K-12 education (see Appendix F) include a requirement that students should be proficient in the use of technology by the eighth grade. As progress is made toward that goal, there will be less of a burden on the colleges to train students but more of an expectation on the part of students that technology will be deeply integrated into their college education. The

<u>Standards of Learning</u> for K-12 education also emphasizes a solid understanding of math and science by all students as a prerequisite for obtaining a high school degree. A strong background in these areas is a fundamental requirement for many technology-related jobs. Additionally, training in technology needs to be a standard part of both in-service and pre-service education for our Commonwealth's teachers.

An up-to-date and pervasive technology infrastructure is critical to success in the initiative to ensure adequate competencies and numbers of workers for Virginia's economy of the future. The 1996 General Assembly appropriated substantial funds for improvements as phase one of a multi-year plan. According to a survey conducted by Council staff, these funds have enabled the colleges and universities to make significant improvements in their technology environments. However, it is clear that this process will require continuous funding and should not be viewed as a one-time event.

Closing the Gap between Demand and Supply: What's Not Getting Done

In preparing this study, the Council staff was struck with the number of agencies and organizations that are struggling with the issue of work force technology competence. While these organizations' work is of vital importance and is helping to continuously improve the picture of the Commonwealth's needs, there is still a murkiness concerning the extent and nature of training needs.

A good part of the problem, as cited in the preceding sections, is the amorphous nature of defining technological competence. Obviously also contributing to the circumstance is the unpredictable future of technology, here in the state and nationally.

On the supply side, Virginia's public and private institutions are engaged in a good-faith effort to upgrade the technological competence of their graduates, and to offer programs as work force needs are identified. Without coordination in this effort, though, several things are occurring. First, many of the public and private institutions are assembling similar or even unnecessarily duplicative programs within the same region. This is inefficient and prospectively expensive for the state. Second, an imbalance in the technological preparedness of graduates within the state is evolving as the institutions provide differing definitions of the nature of that preparedness. There is not at present a sufficient mechanism to distill the collective needs of businesses and industry for highly-skilled workers into a coherent set of conceptual plans for obtaining those workers. Such plans could guide the efforts of post-secondary educators from the public, independent, and proprietary institutions to address those needs.

In addition to the lack of coordinated planning, there are other obstacles that have hampered the ability of Virginia's colleges and universities to respond to the need for more and better-qualified technology workers. While several institutions have introduced new academic programs designed specifically to meet industry needs, the current process for initiating programs is lengthy, bureaucratic, and can be burdensome. Likewise, it may be difficult under current funding and governance structures for institutions to

increase enrollment, particularly in specific high-cost academic programs. Institutions need the regulatory flexibility as well as the entrepreneurial drive to initiate faster curriculum changes in response to the turbulent rate of change in business and industry.

Much of the current higher education curriculum is designed around specific degrees at the associate, baccalaureate, masters, and doctoral level (with the exception of non-credit courses). Numerous experts now suggest that the educational requirements of what some call "the knowledge economy" might be better met in innovative ways, outside of the confines of traditional degree awards.

For example, the Council for Aid to Education states in <u>Breaking the Social Contract: The Fiscal Crisis in Higher Education</u>: "Instead of retaining the traditional sharp distinction between the bachelor's degree and all other non-degree categories, we find it preferable to think in terms of a continuum of learning activities appropriate for attaining specific goals. In the future, the focus should be on the attainment of more specific, measurable knowledge sets, rather than on simple attainment of a bachelor's degree." As part of their restructuring efforts, many of the state's colleges and universities increasingly are focusing on the skill sets that students acquire through their coursework; however, still more work is needed in this arena.

Despite overwhelming evidence demonstrating that individuals with at least some post-secondary education have greater lifetime earnings than those with none and contribute in many ways as citizens in their local communities, state, and nation, there are still economic barriers that prevent some individuals from pursuing such education. Addressing the Commonwealth's work force development needs cannot be accomplished unless a wide net is cast.

While the focus of this study is on the role of higher education in developing a highly-skilled work force for technology-related employment, it is worth noting under the heading of "what's not getting done," that there are other barriers outside the realm of higher education. The Commission on the Future of Public Education will supplement existing plans to improve K-12 education to prepare students more adequately for work in the knowledge economy. While steps have already been taken, it will require some years before the goals that have been set forward can be achieved.

Much of the shortage of skilled workers is also tied to other issues specific to each of the regions of the state besides educational opportunity. A comprehensive examination of the shortages at the regional level should thus consider such issues as job development, transportation, quality of life, effective marketing, and the like that affect where both businesses and individuals choose to locate. For example, traffic congestion discourages some potential workers from relocating to Northern Virginia. Innovative telecommuting options might enable Northern Virginia employers to meet their work force needs by using populations elsewhere in the state.

Closing the Gap between Demand and Supply: Recommendations

While much already has been accomplished or initiated in the past year, there are steps needed to close the gap between the demand for workers ready to fill technology-based positions with Virginia employers and the supply of graduates from Virginia's colleges and universities. Following from the previous section, the primary effort needed is to establish some form of state-wide coordination of identifying technology work force needs and responding to them. The other steps—or recommendations—discussed below focus on appropriate responses the Commonwealth, the institutions of higher education, and the private sector should consider. The recommendations identify several important policy issues. For recommendations needing specific financial support during the 1998-2000 biennium, figures are noted in the body of the report. Other recommendations require further analysis for long-term implications, feasibility, and cost. For these recommendations, the Council offers no specific budget figures at this time and reserves the right to review the recommendations as more information about fiscal impact becomes available.

Recommendation One: Communication and Coordination

Mechanisms should be established that alert colleges and universities to the need to attract more students into specific majors, to modify the curriculum to keep pace with rapidly-changing industry standards, to establish standards for the general technological preparation of the Commonwealth's graduates, and to introduce new credit and non-credit courses. Accordingly the Council recommends:

a) Appointing a Work Force Planning Advisory Committee under the auspices of the Council of Higher Education, composed of representatives from the following groups: leaders of the educational institutions, leaders from the various public and private agencies and organizations that deal with work force preparation and economic development, and other appropriate business leaders. The independent colleges and the for-profit institutions should be included. The purposes of the Committee should be to exchange information about work force needs and the role of higher education in meeting those needs, to identify opportunities for higher education and employers to collaborate in meeting those needs, and to assess progress toward goals.

b) A joint meeting of the Council of Higher Education, the Board of the VCCS, and the Board of Education should be held annually to discuss efforts among the secondary and post-secondary institutions to address work force development needs, using information provided by the proposed Work Force Planning Committee and the proposed business and industry advisory council to the Board of Education.

c) In cooperation with the private sector and educational providers at all levels, the Commonwealth should explore means of communicating to students and employees the value of life-long learning and maintaining technical skills. While the educational

system has responsibilities in ensuring that work place skills are available and publicized, students and employees correspondingly have the responsibility to take advantage of educational services to ensure their own personal and career development.

d) Over the next six years, the General Assembly should fund five High Skills Work Force Development Centers each biennium. These centers would coordinate the specific high skill training needs of a particular Virginia region and industry. Further study is needed to develop this concept more fully; however, the idea, which was articulated in the Blueprint for Technology-Based Economic Growth in Virginia (See Appendix E), already has received support from the Council of Presidents, the Center for Innovative Technology, the Virginia Business Higher Education Council, and others. The estimated 1998-2000 fiscal impact of this recommendation is $3.0 million.

e) Each of the colleges and universities should be encouraged to establish one or more mechanisms to promote dialogue between the institution and a wide range of employers in the proximity of the institution around issues of work force preparation and economic development. Many of the colleges and universities already have such mechanisms in place; however, their importance cannot be overstated.

Recommendation Two: Financial Incentives and Regulatory Flexibility

The Council, General Assembly, and Governor should pursue ways to provide encouragement, including financial incentives and regulatory flexibility, for colleges and universities to adapt services and programs or introduce new services and programs in response to the needs of business and industry. The bureaucracy regulating academic programs should be kept to the minimum needed to protect the public interest. Institutions should have the flexibility to initiate and modify degree programs as quickly as possible to meet emerging needs. The Council accordingly recommends:

a) The colleges and universities should build upon existing mechanisms and put in place new mechanisms to triple the number of graduates with degrees in computer science, selected engineering programs, and other technical fields. The General Assembly should recognize that this goal will require additional financial support. It should consider capitation programs that provide incentives to students and institutions to pursue technological education, and incentives to students to remain in the Commonwealth upon graduation. This recommendation is a high priority and will require further study in order to develop an in-depth proposal. The Council should work with the colleges and universities and with other appropriate bodies to develop a recommendation in time for the 1999 budget amendment process.

b) Building on a similar program put in place within the VCCS this year, the General Assembly should establish a scholarship program for qualified students to enroll in specific disciplines at four-year institutions. These disciplines would be those in

which there are known shortages such as computer science, selective fields of engineering, and information science. In addition, the colleges and universities should be encouraged to use private funds to attract and support students in these disciplines.

c) During 1998 (as proposed in its strategic plan), the Council will work with the colleges and universities to study how best to decentralize the approval of new academic programs and to coordinate evaluation of existing programs. Recommendations should be completed in time to bring any required Code changes to the 1999 session of the General Assembly. To support this decentralization process, the General Assembly should fund the Council of Higher Education's budget proposal for 1998-2000 of $150,000 each year of the biennium. These funds would be used to hire consultants and to support travel and other associated costs to study the efficacy of specific academic disciplines each year.

Recommendation Three: New Means of Delivery

The idea that institutions have sole authority to serve a particular region of the state must give way to a recognition that technology will reduce geographic barriers and that innovation, consumer demand, and excellence should drive the market. The growth in the number and aggressiveness of alternate providers of education and training attests to the strength of this market. While it will remain important for Virginia's colleges and universities to reach out to the communities in which they are located and to meet many of the educational needs of that region, it is unlikely that any one institution could meet all of those needs. Indeed, to the greatest extent possible, institutions of higher education must become collaborators rather than competitors, building upon such successful models as the Commonwealth Graduate Engineering Program and the Virginia Microelectronics Consortium. Increasingly, the job-related education needs of the citizens of the Commonwealth will be met through a combination of on-site education and distance learning, often delivered by several institutions, rather than a single institution. Accordingly the Council recommends:

a) Capitalizing on the investment made by the Commonwealth in Net.Work.Virginia, the Virtual Library of Virginia, TELETECHNET, and other cooperative projects such as the Graduate Engineering Program, the Commonwealth should pursue opportunities to use technology to allow students anywhere in Virginia to obtain high quality education and training.

b) Support is needed to encourage public and private colleges, public and private secondary schools, and other appropriate entities to join Net.Work.Virginia. While Net.Work.Virginia already puts Virginia ahead of other states with regard to the capacity and extensiveness of a network designed to advance educational uses, there are many relevant organizations it does not yet reach.

c) Virginia should be an active partner in the Southern Regional Electronic Campus of the Southern Regional Education Board. Virginia should take advantage of courses

and programs offered by other states, and advance its own courses and programs.

d) The General Assembly should support the Virginia Microelectronics Consortium and provide financial incentives to encourage similar collaboration among institutions of higher education in other disciplines as well. These sorts of arrangements to share resources among institutions have the potential to increase productivity, as envisioned in the RAND report, Breaking the Social Contract.

e) The Commonwealth increasingly should deploy the brokerage concept in expanding higher education services. This approach is in use at the Southwest Virginia Higher Education Center in Abingdon and other such centers in Virginia, and is the proposed approach for the Roanoke Higher Education Center. In accord with this recommendation, the staffs of the High Skills Work Force Development Centers recommended in 1 (d) should function as brokers. They should first identify specific educational needs as brought forth by business inquiry. Then they should work with those institutions interested in providing programs to ensure they are appropriate in nature and cost.

Recommendation Four: Technology Literacy & Support

Consistent with the provisions of House Bill 1848 (1997 General Assembly) the colleges and universities must develop a means to ensure that graduates of all degree programs will be technologically literate. The efforts of the Work Force Planning Advisory Committee to the Council, recommendation 1 (a), should play a major role in facilitating this development by providing a consistent definition and set of standards for technological competence.

Both teachers and students in the universities, colleges, and K-12 schools should learn to use computers and other technologies. It is especially important that efforts to instill technological competency begin in the secondary school environment.

This goal cannot be addressed simply by creating one or two courses that attempt to teach the use of computers. General fund support and the financial commitment of the corporate community are needed to enable universities, colleges, and K-12 schools to replace and upgrade technology on a regular, timely basis, and to keep pace with new developments to support the use of technology in teaching and learning. Accordingly, the Council recommends:

a) Virginia's colleges and universities should explore the possibility of requiring that every student own a computer, as Virginia Tech has just done. Colleges that require students to own a computer should ensure that the cost of the computer is included in the overall cost of education when calculating financial need. The General Assembly should adopt the Council's recommendation, embodied in its 1998-2000 proposal for financial aid, that the cost of computers when required be addressed in the Student Financial Aid calculation.

b) Colleges and universities should explore means to certify to prospective employers that graduates will possess the ability to use standard office automation and to use computers to locate, organize, and analyze information. In collaboration with other organizations nationally that are working on such standards, the Work Force Planning Advisory Committee should seek to develop a meaningful way to describe to employers throughout Virginia the expected computer competencies for graduates.

c) The General Assembly should fund the Council of Higher Education's budget recommendations for the Equipment Trust Fund (ETF) and for the operating budget for technology for 1998-2000. These recommendations provide for $78 million in new equipment and $43.6 million in technology operating support and continue a four-year plan begun in the 1996-98 biennium to provide a base level of technology equipment and support at the colleges and universities.

d) Businesses within Virginia should reach out to the colleges and universities to explore ways that they could assist the institutions in providing the equipment that is needed to support teaching and learning in today's technology-intensive environment.

e) The Council should initiate a specific review of the adequacy of equipment in the colleges and universities that supports computer science and engineering disciplines and of the funding mechanism for replacing this equipment. This review might be done in conjunction with the proposed academic program review, if these disciplines are among the initial programs reviewed. A comprehensive review of the equipment in place at the colleges and universities for these disciplines was last done nearly ten years ago.

Recommendation Five: Life-long Learning

All of the literature on work force development emphasizes that it is no longer possible to acquire the skills needed for a lifetime of employment just through secondary or post-secondary education. Instead, today's workers need to become life-long learners and plan to upgrade their knowledge and skills through a combination of formal education, on-the-job training, and self-directed learning. The Commonwealth should enhance the opportunities available to its citizens for life-long learning through the following approaches.

a) Colleges and universities should pursue innovative ways to equip students with specific knowledge sets and means of documenting such competencies as well as providing the traditional degree programs.

b) While non-credit instruction can effectively deliver much of the technology training that is needed, there are financial and other disincentives for the colleges and universities to offer such training on the scale that is needed. Recommendations on eliminating these impediments to non-credit instruction by the public colleges and universities are currently being developed by the joint subcommittee appointed by

House Joint Resolution 622 and will be presented to the 1998 General Assembly. The Council should examine the findings and endorse those that are appropriate.

c) Colleges and universities should explore incentives for graduates to continue education in their field.

d) In addition to efforts to improve the technological skills of new employees, the Commonwealth should explore ways to encourage existing employees to continuously sharpen their skills. Creative program development, use of new features of the Tax Relief Act of 1997 (particularly the Lifelong Learning Credit), program discounts, and cooperative programs between business and higher education may be ways to encourage workers to keep pace with technological change.

Recommendation Six: Work Experience in the Curriculum

The curriculum at Virginia's colleges and universities should reflect a current awareness of the business environment where appropriate. To assist in this effort, Virginia's colleges and universities should initiate and expand collaborative ventures between faculty and employers, authorizing time spent on such endeavors by faculty as a legitimate part of their job description. This permits faculty to immerse themselves in the business environment and, conversely, representatives from the business environment to immerse themselves in the academic environment. Additionally:

a) Classroom instruction needs to be supplemented with real-life applications. More emphasis should be given to internships, Tech Prep approaches, and apprenticeship programs. Internships most often are offered by large companies; small firms also might provide useful learning opportunities and should be considered as a means to increase the number of available internships.

b) Every college and university should provide internships, service learning, or other projects to ensure all students have the opportunity to obtain some exposure to the world of work during their education.

Recommendation Seven: Access to Education

The Council, General Assembly, and Governor must ensure that economic barriers do not prevent interested individuals from attending college. Given the shortage of qualified workers for many sectors of the economy and given skill levels that for the most part can be acquired only through higher education, it is imperative that the Commonwealth make the investment in its human capital needed to support its economic development goals.

a) As a beginning, the General Assembly should appropriate an additional $62 million for 1998-2000 to support state undergraduate student financial aid. Consistent with

the Council's 1998-2000 budget recommendations, this amount would meet 50% of the unmet financial need of the students in Virginia's colleges and universities.

b) The General Assembly should also support the proposed increase of $12.9 million for the Tuition Assistance Grant program for Virginia students attending private colleges and universities within the state.

Recommendation Eight: Partnering with K-12 Education

Higher education must reach out to the K-12 educational system in developing curricula and educational standards that will improve the technological skills and abilities of their graduates. Exemplary outreach programs are already in place at many of the institutions and include such initiatives as adopting one or more public schools in the region, consulting services by faculty, students volunteering as tutors, as well as more formal programs such as dual enrollment, School-to-Work, and Tech Prep. These efforts and programs should be expanded and supported by all parties. It is vitally important that the products of the K-12 system arrive at the employment or post-secondary level with the basic academic and technological skills to successfully pursue their career or education. Towards this end the Council additionally recommends that:

a) Colleges, universities, and local school divisions should increase the technology mastery of K-12 teachers through expanded in-service and pre-service training opportunities.

b) The General Assembly should fund the Council's budget request for $4.6 million for 1998-2000 to establish no more than three institutes at Virginia colleges and universities that would provide in-service training to secondary school teachers in the effective use of technology. This proposal builds on the success of the pilot projects that were put in place in the 1996-98 biennium.

c) The colleges and universities, including the independent colleges, should move quickly to implement the "Guidelines for Technology in the Commonwealth's State-Approved Teacher-Education Programs," which were developed 'n response to House Bill 1848, 1997 Session of the General Assembly, and approved by the Council at its November 1997 meeting.

Conclusion

In the knowledge economy of the 21st century, the vast majority of workers in all employment sectors must be computer literate. The "knowledge worker" must be part journalist, part graphic designer, part librarian, and part computer scientist. While employers are experiencing a short-term problem in hiring computer scientists, engineers, and other high-tech employees, society faces a chronic long-term problem in equipping citizens with crucial computer-technology and life-long learning skills. Research and

experience indicate that a style of teaching that incorporates technology, stresses exploration, and fosters group work must supplement the lecture and reading styles that have characterized much of higher education for so long. The turbulent rate of change in business and industry also means that partnerships between the education and business communities need to remain active to keep pace with these changes.

In sum, the development of technologically prepared workers does not respond to episodic intervention. It requires an on-going commitment on the part of all parties involved to learning, first fostered through elementary and secondary education, continued through post-secondary education, and refreshed through on-the-job training. Numerous studies conducted throughout the 1980's and 1990's have documented that learning how to learn is the essential workplace skill.

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APPENDICES

Appendix A	Senate Joint Resolution no. 218 & House Joint Resolution no. 659
Appendix B	Trends in Enrollment and Degrees Awarded, 1993-1997
Appendix C	Work force Preparation Initiatives At Virginia's Colleges and Universities
Appendix D	Executive Summary, Training and Business Assistance Services Virginia Community College System Report, July 1997
Appendix E	Building a CommonWealth of Technology: A Blueprint for Technology-Based Economic Growth in Virginia Virginia Technology Summit Report
Appendix F	Standards of Learning for Virginia Public Schools, June 1995 Computer/Technology Standards by the End of Grade Five Computer/Technology Standards by the End of Grade Eight

Study of the Demand for Computer Scientists, Engineers, and Other
Technologically Skilled Workers in Virginia

1997

APPENDIX A:

Senate Joint Resolution no. 218

And

House Joint Resolution no. 659

SENATE JOINT RESOLUTION NO. 218
Requesting the State Council of Higher Education for Virginia to study the demand for computer scientists, engineers, and other technologically skilled workers in Virginia industry.

Agreed to by the Senate, February 13, 1997
Agreed to by the House of Delegates, February 11, 1997

WHEREAS, proficiency in Internet research, electronic mail, word processing, and database and spreadsheet programs is a prerequisite to becoming a technology-literate employee in the twenty-first century; and

WHEREAS, the growth of technology-based businesses has been a driving force in the growth of the Commonwealth's economy over the past decade, as particularly illustrated in Northern Virginia, where the Northern Virginia Technology Council estimates that there are now more than 1,600 high technology companies employing some 170,000 workers who earn an average of more than $40,000 annually, collectively contributing more than $7 billion in wages each year to that region's economy; and

WHEREAS, while economists have projected the creation of thousands of new high-technology jobs, data indicate that there are many job vacancies currently existing in computer science, engineering and other related fields, prompting employers to go outside Virginia and even overseas to acquire trained personnel; and

WHEREAS, while Virginia's high-technology companies recruit employees from around the nation, it is difficult for such companies to compete with companies based in other technology-intensive locations such as California's Silicon Valley; Boston, Massachusetts; and Austin, Texas; and

WHEREAS, only 2,124 of the 24,000 students who graduated with bachelor's degrees from Virginia's colleges and universities in 1996 finished with computer science or engineering degrees; and

WHEREAS, the gap between marketplace demand for high technology workers and the available supply is threatening to stall the Commonwealth's pursuit of a vibrant economic expansion; and

WHEREAS, the Commonwealth lacks a framework for state-level policy and planning related to the role of the public schools and institutions of higher education in developing skills needed in the high-technology work force to ensure Virginia's long-term leadership in an economy based on technological knowledge; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, That the State Council of Higher Education for Virginia be requested to study the demand for computer scientists, engineers, and other technologically skilled workers in Virginia industry. In pursuing its study, the State Council shall assess employment needs for these technologically skilled workers in Virginia industry and shall review and propose actions the Commonwealth, institutions of higher education, and the private sector might take to increase the number of enrollments and graduates in programs leading to technological competence, including computer science, engineering, and other related fields.

The State Council shall consult with state-supported and independent colleges and universities in the Commonwealth, the Center for Innovative Technology, the Department of Education, the Virginia Economic Development Partnership, and the Northern Virginia Technology Council.

All agencies of the Commonwealth shall provide assistance to the State Council for this study, upon request.

The State Council shall complete its work in time to submit its findings and recommendations to the Joint Subcommittee on Science and Technology, established pursuant to House Joint Resolution No. 195 (1996), or a successor joint subcommittee or entity thereof, and to the Governor and the General Assembly by November 15, 1997, as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

Go to (General Assembly Home)

HOUSE JOINT RESOLUTION NO. 659
Requesting the State Council of Higher Education for Virginia to study the demand for computer scientists, engineers, and other technologically skilled workers in Virginia industry.

Agreed to by the House of Delegates, February 20, 1997
Agreed to by the Senate, February 19, 1997

WHEREAS, proficiency in Internet research, electronic mail, word processing, and database and spreadsheet programs is a prerequisite to becoming a technology-literate employee in the twenty-first century; and

WHEREAS, the growth of technology-based businesses has been a driving force in the growth of the Commonwealth's economy over the past decade, as particularly illustrated in Northern Virginia, where the Northern Virginia Technology Council estimates that there are now more than 1,600 high technology companies employing some 170,000 workers who earn an average of more than $40,000 annually, collectively contributing more than $7 billion in wages each year to that region's economy; and

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Study of the Demand for Computer Scientists, Engineers, and Other
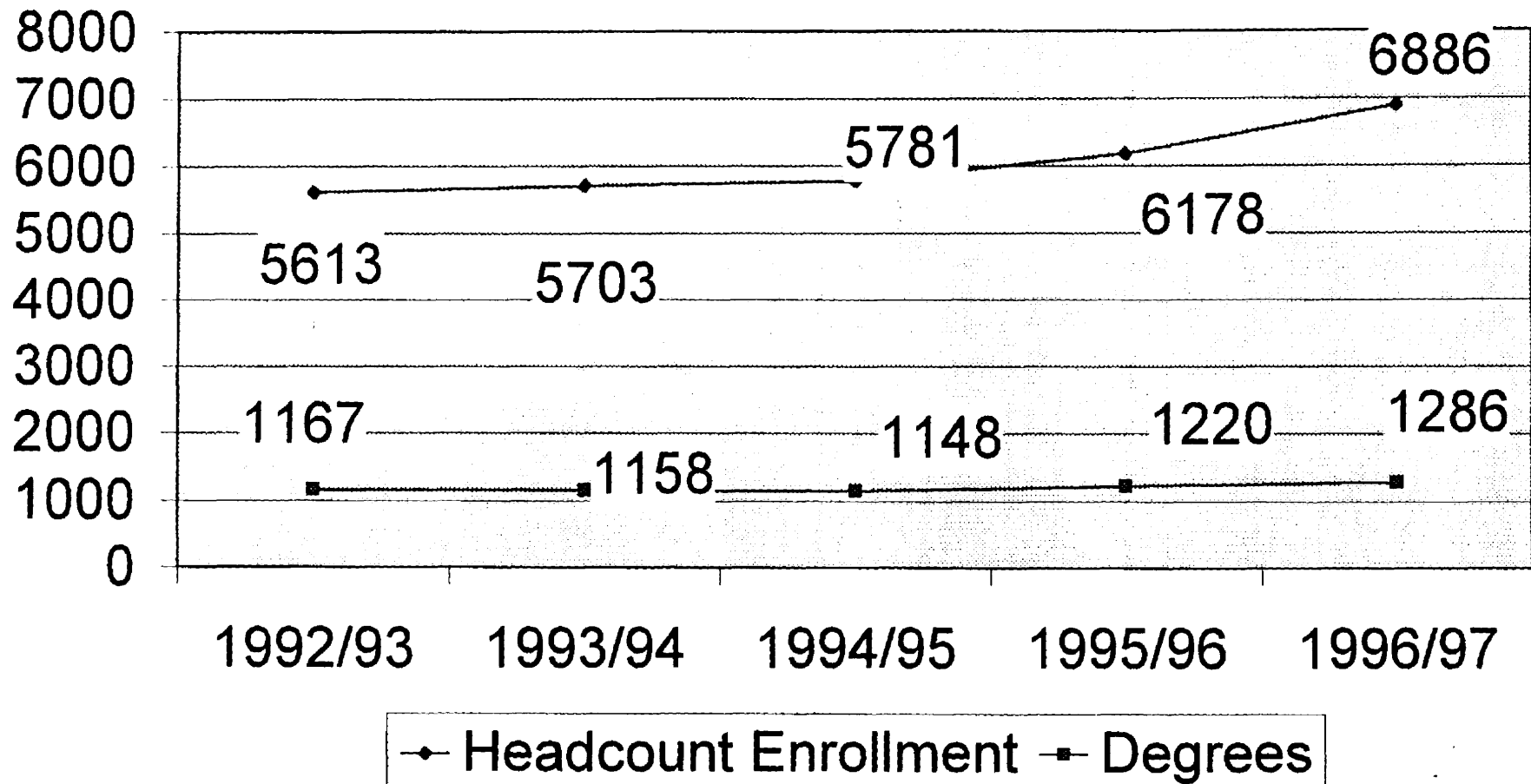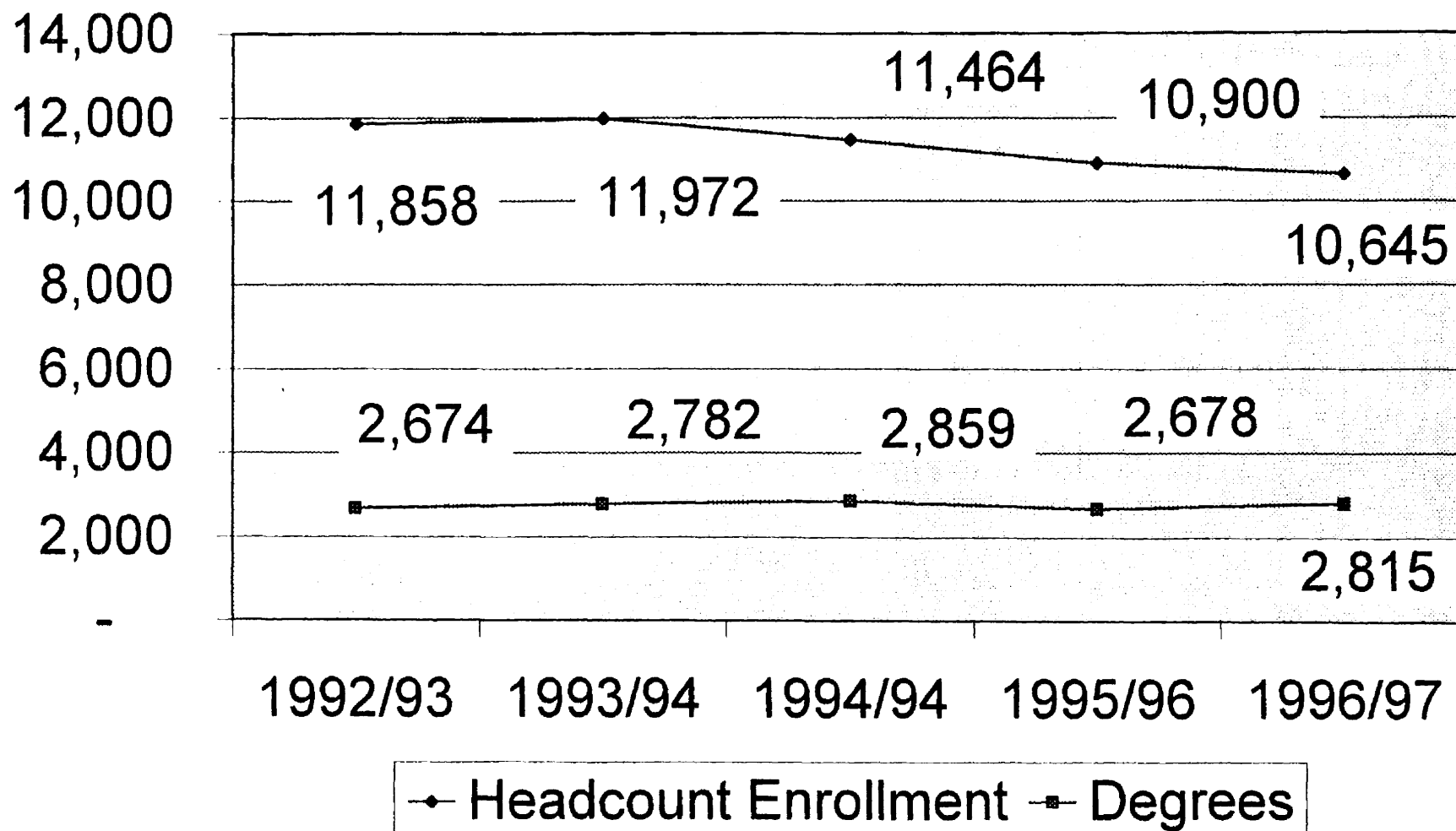Technologically Skilled Workers in Virginia

1997

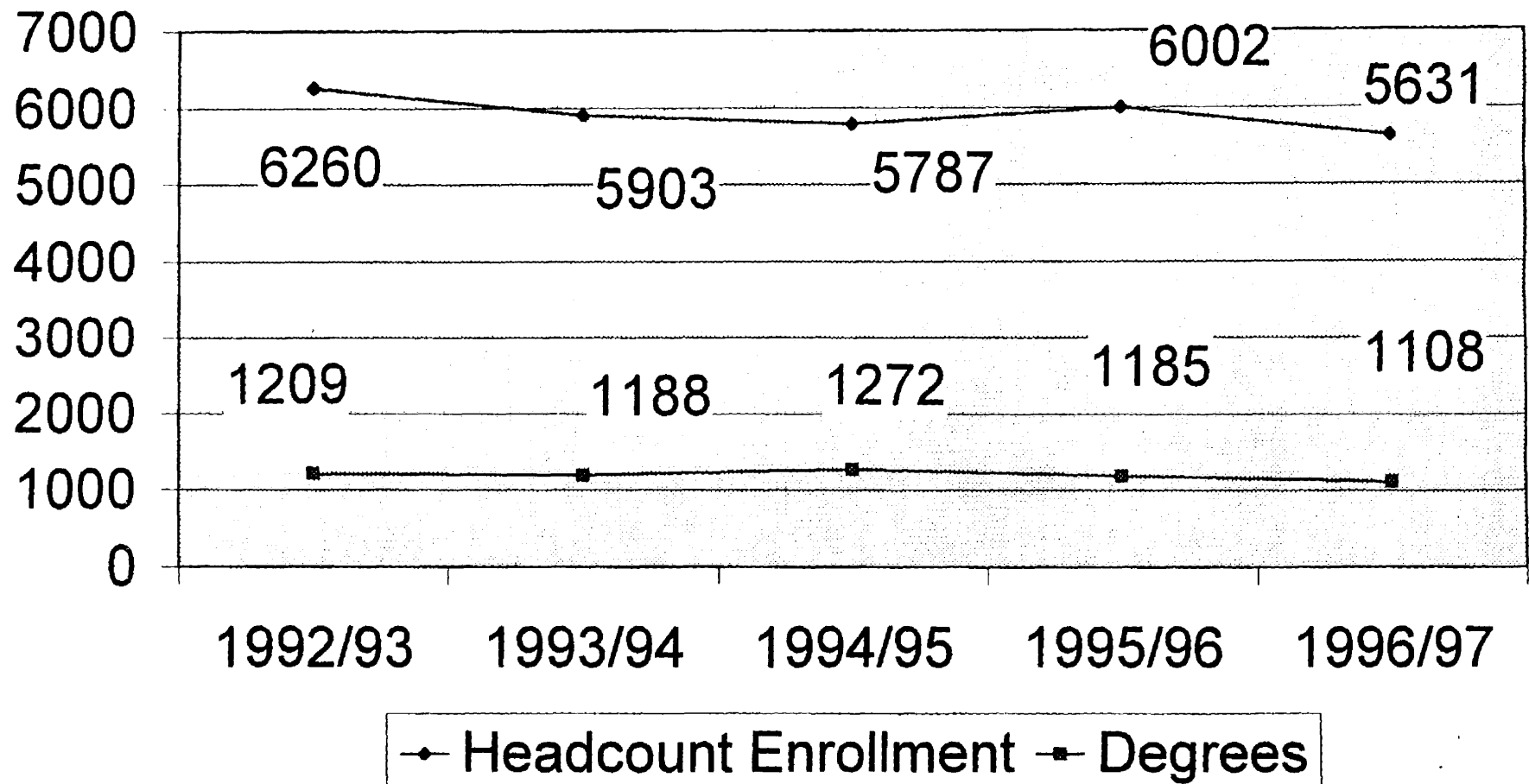APPENDIX B:

Trends in Enrollment and Degrees Awarded, 1993-1997

Computer Science: Headcount Enrollment and Degrees Awarded at Public and Private Institutions in Virginia, 1993-97

	1992/93	1993/94	1994/95	1995/96	1996/97
Headcount Enrollment	5613	5703	5781	6178	6886
Degrees	1167	1158	1148	1220	1286

Legend: Headcount Enrollment — Degrees

Engineering: Headcount Enrollment and Degrees Awarded at Public and Private Institutions in Virginia, 1993-97

	1992/93	1993/94	1994/94	1995/96	1996/97
Headcount Enrollment	11,858	11,972	11,464	10,900	10,645
Degrees	2,674	2,782	2,859	2,678	2,815

Engineering Technology: Headcount Enrollment and Degrees Awarded at Public and Private Institutions in Virginia, 1993-97

	1992/93	1993/94	1994/95	1995/96	1996/97
Headcount Enrollment	6260	5903	5787	6002	5631
Degrees	1209	1188	1272	1185	1108

Appendix C

**Work Force Preparation Initiatives
at Virginia's Public
Colleges and Universities**

**Available upon request from
Frances Bradford, (804) 225-2645**

Also available online at:

Http://www.schev.edu/acadpg/rt97a11.html

Appendix D

Training and Business Assistance Services
Of the
Virginia Community College System

Available upon request from
Frances Bradford, (804) 225-2645

Also available online at:

Http://www.so.cc.va.us/tbas9596.htm

Appendix E

Building a CommonWealth of Technology:
A Blueprint for Technology-Based Economic Growth in Virginia

**Available upon request from
Frances Bradford, (804) 225-2645**

Also available online at:

Http://www.cit.org/publications/reports/TechSummit-May97/blueprint-july.**pdf**
(Requires Adobe Acrobat viewer)

Appendix F

Standards of Learning for Virginia Public Schools, 6 and 8

Available upon request from
Frances Bradford, (804) 225-2645

Also available online at:

Http://www.pen.k12.va.us/go/Sols/home.shtml