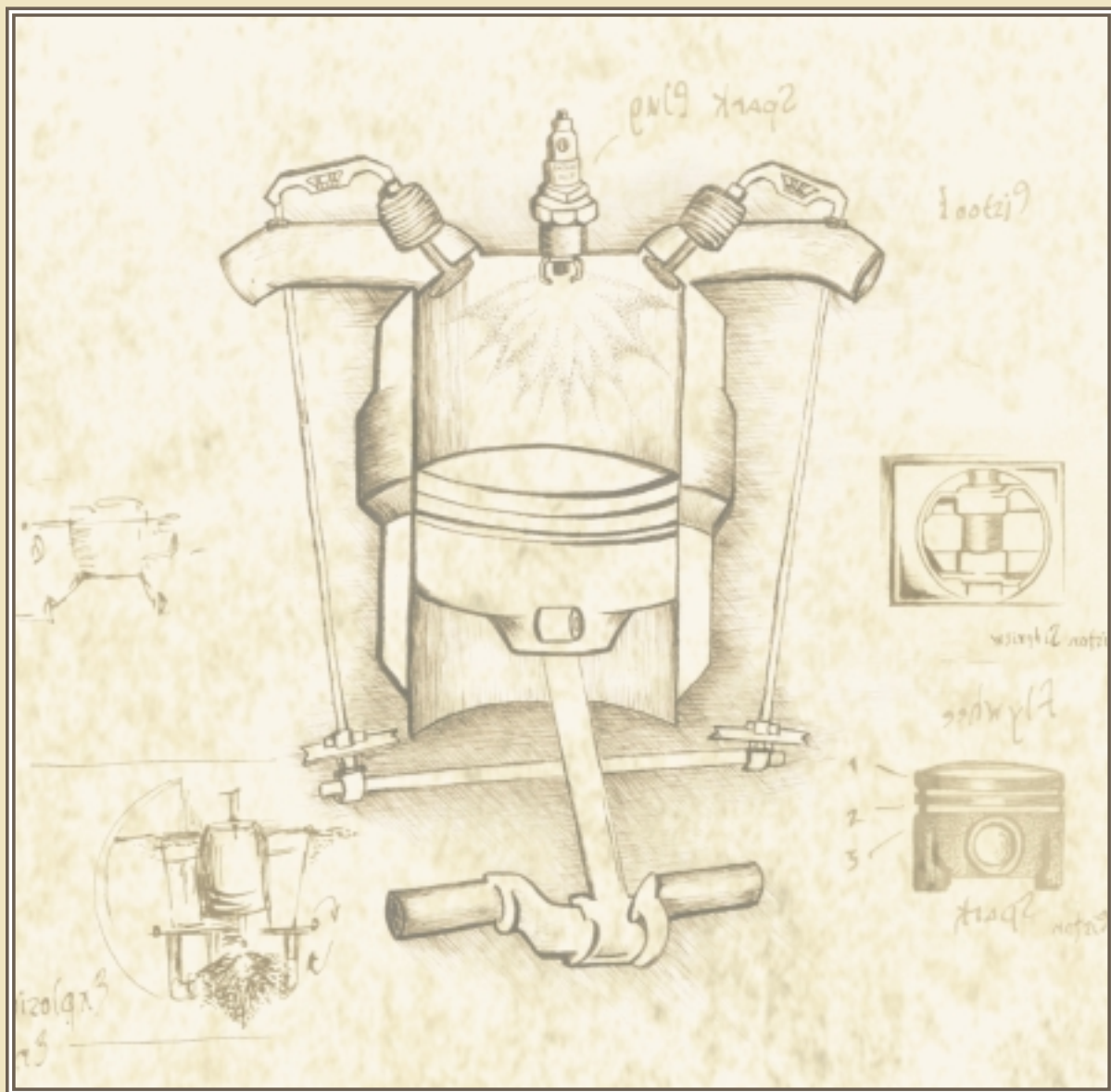


GRADUATE EDUCATION IN VIRGINIA



The Spark for Virginia's
Knowledge-Based Economic Engine

“Virginia cannot be second best in the 21st century; rather, we must strive for preeminence as a Commonwealth. Our institutions of higher learning will be the vehicle, partnering with state government and generating the spark through graduate education, to carry us forward with economic and social prosperity.”

The Honorable John Hager
Lieutenant Governor
Commonwealth of Virginia

Executive Summary

IT IS ASSUMED THAT SOCIETY AND ITS INSTITUTIONS ARE COMPOSED OF INTERDEPENDENT PARTS that work together to contribute necessary activities to the functioning of the whole society. Specifically, education has been defined as the process by which knowledge—both information and skills—is transmitted to members of a society. With technology at the helm, the new society may not only have one of the most vital *economies*, but also may be one of the most remarkable *societies* ever. Graduate education plays a vital role in the Commonwealth as we prepare to enter the new millennium.

Traditionally, college education has been broken into two stages—undergraduate education and graduate education. However, undergraduate education alone no longer assures today’s workers of the competencies and skills they need to survive in a knowledge-based economy. Unlike 30 years ago, when graduate education was generally a luxury—the intellectual pursuit of an elite few—many of today’s workers will not be able to remain marketable without an advanced degree. As a potent catalyst for knowledge, graduate education can play a pivotal role in helping Virginians and Virginia seize a leadership position in the age of information.

Protecting Virginia’s status as an emerging high-tech player has captured the attention of the Commonwealth’s stakeholders and leaders. These influential individuals recognize both the fierce competition the Commonwealth faces and the benefits of graduate education to the people of Virginia. Virginia has begun developing a strategy to ensure that the necessary resources and linkages are, in fact, in place to gain maximum advantage from its research and development assets. Partnerships among universities, private companies, federal laboratories and agencies, and the Commonwealth are the hallmark of this strategy. Central to the strategy’s success will be Virginia’s graduate education programs.

Out of a desire to ensure a first-tier position in the emerging knowledge-based economy, 12 of the Commonwealth’s colleges and universities came together to outline the role of graduate education in Virginia’s economic and social prosperity. Out of this collective effort, the following pages evolved. The case is compelling—graduate education is a means to survival and prosperity in a changed society. In order to maximize the utility of graduate education, however, its value must be recognized and supported.

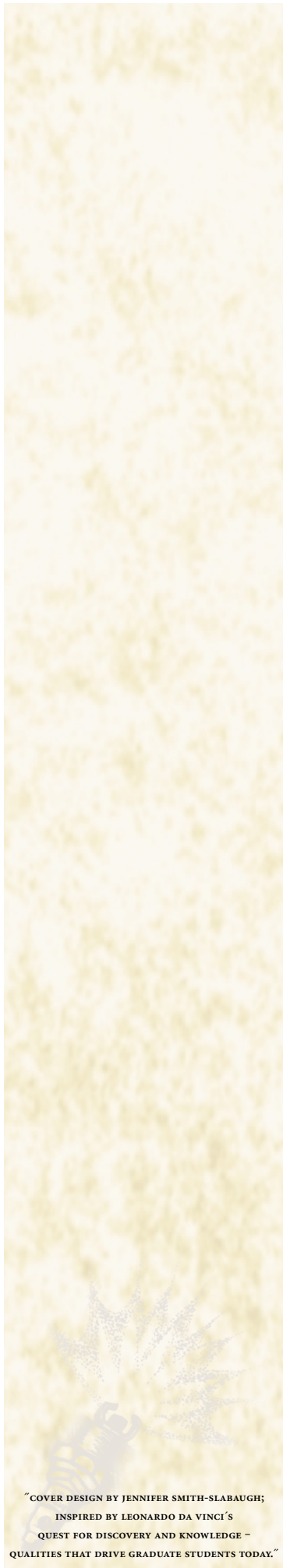
As the operating environment of society continues to become more complex and Virginia struggles to solve social and economic problems, graduate education is a means to attract new industry, educate the human resources needed by that industry, expand the research and development currently being done, and develop innovative solutions to many of our pressing social needs. This report provides an overview of the role of graduate education in the economic and social welfare of the Commonwealth of Virginia and how expanding that role can help propel Virginia forward in the coming century.

graduate education is a means to survival and prosperity in a changed society

SEPTEMBER, 1999

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“COVER DESIGN BY JENNIFER SMITH-SLABAUGH;
INSPIRED BY LEONARDO DA VINCI’S
QUEST FOR DISCOVERY AND KNOWLEDGE –
QUALITIES THAT DRIVE GRADUATE STUDENTS TODAY.”

Making the Case

THE YEAR 2000 HERALDS THE ADVENT OF A NEW CENTURY AND A NEW AGE—THE AGE OF information. Information and knowledge have become central to every aspect of our thriving society. As a forceful catalyst for the production of knowledge, graduate education will no longer be a luxury reserved for aspiring academicians. Instead, graduate education will enable our post-industrial society to deal with the occupational complexity, multi-disciplinary needs, increased specialization, and changed environment of the new century. In short, graduate education will spark the economic and social prosperity of the 21st century—globally, nationally, and right here in the Commonwealth of Virginia.

The beginning of the new millenium is an excellent point from which to anticipate the future and review the past. Looking back from the brink of the 21st century, we witnessed a rapid transition from an industrial to a knowledge-based economy, as the age of information began unfolding before our eyes. How well Virginia fares in this evolving “age” depends, in part, upon its ability to develop and handle information and knowledge networks. As a result of a number of studies, Virginia policy-makers are keenly aware that without serious attention to education and training, the knowledge and skills of our work force will not be able to keep pace with the demands of the information age.

Recent reports issued to the Governor and General Assembly on the integral role of education and training in Virginia’s economic prosperity were authored by such groups as the:

- State Council of Higher Education for Virginia;
- State Board for Community Colleges;
- Board of Education;
- Office of the Secretary of Commerce and Trade;
- Office of the Secretary of Technology;
- Virginia Department of Housing and Community Development;
- Commission on the University of the 21st Century;
- Joint Subcommittee to Study Noncredit Education for Workforce Training in Virginia;
- Joint Commission on Technology and Science;
- Center for Innovative Technology;
- Virginia Business Higher Education Council;
- Virginia Chamber of Commerce; and
- Regional Technology Council; as well as
- Groups of Virginia business leaders, and
- Virginia’s universities and colleges.

Virginia’s key policy-makers readily recognize that, in a society in which efficient production and competent management are of paramount importance, being **economically** competitive is synonymous with being **educationally** competitive. In order to retain the Commonwealth’s current reputation as the home of several world-class institutions of higher education and to become even more educationally competitive, investments in the infrastructure of the Commonwealth’s colleges and universities are important. More specifically, strategic investments are imperative, as the standard infusion of resources into undergraduate education will not likely suffice. Graduate education is essential to realizing Virginia’s goal of attaining a first-tier position in the burgeoning technological and global marketplace of the 21st century.

“Graduate education, and its associated research activities, are the major forces behind innovation. As more and more technology becomes both globalized and commoditized, it is the power to generate new ideas that will allow Virginia to stay competitive in the New Economy.”

**The Honorable
Donald W. Upson**
Secretary of Technology
Commonwealth
of Virginia

The Information Age

“The continued success of economic development in Virginia is a result of, and directly tied to, the ability of our higher education system to promote and fund the graduate education programs needed for tomorrow—the 21st Century.”

**The Honorable
John Watkins,**
Senator
Commonwealth of
Virginia

SOCIETY, AS MOST OF US HAVE KNOWN IT, IS EXPERIENCING A TRANSFORMATION. TEMPORAL, physical, and cultural boundaries are dissolving, as technology spans time, distance, and nations. This worldwide transformation is the result of the convergence of two powerful currents of change—computerization and globalization.

Knowledge has become a primary economic resource, transcending traditional organizational and geographical boundaries. In the global marketplace of the 21st century, capital, resources, products, and information are traveling around the world electronically, with little regard for national borders. International *collaboration* is replacing international *competition*, and in this new age, a global economy is beginning to emerge. A corporation in London can hire an engineer in Boston; the engineer in Boston can transmit specifications for a new product via satellite to a high-resolution computer belonging to a manufacturing engineer in Hong Kong; the manufacturing engineer in Hong Kong can turn the specifications into a prototype, which can then be reproduced in Munich.

New rules for competition in the business sector are surfacing, along with radical shifts in other sectors of society. Behind this revolutionary transformation of society are the driving forces of *information and knowledge*.

In every arena, information is propelling society forward:

- Information is driving economic prosperity;
- Information is driving social development; and
- Information is driving cultural creativity.

In our information-driven society, technological advances are occurring with astounding rapidity. As quickly as new knowledge appears, it is often replaced by even more novel ideas.

Information also drives solutions to social problems. Just as ways to increase industrial production are flourishing amidst the currents of computerization and globalization, ways to improve society are being developed through the collective work of scholars. For instance, international “virtual” conferences are becoming gateways to profound breakthroughs in areas that touch all countries and cultures, such as poverty, crime, and ethnic cleansing. Lives are being enriched through exposure to artistic innovations, which are emerging throughout the world in this era of technology.

Virginia in the Information Age

THE GOOD NEWS

VIRGINIA HAS A SUBSTANTIAL TECHNOLOGY BASE AND HAS PARTICIPATED AT A RELATIVELY HIGH level in the broad information-driven transformation that is characterizing economic activity around the world today. As a highly-populated state, Virginia ranks ninth in the nation in high-tech employment with significant expansion by prominent technology firms expected to propel it to sixth by 2002.

VIRGINIA'S RANKINGS

POPULATION	<ul style="list-style-type: none">• 12th largest state in the United States• Population of nearly seven million
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HIGH-TECH EMPLOYMENT	<ul style="list-style-type: none">• 9th in the nation, currently• 6th in the nation by 2002, based on significant expansion projected by prominent technology firms
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Virginia has the second largest number of employees in the U.S.—after California—in the computer software sector, which is a core technology component of the current economic transformation. Furthermore, another core component of the burgeoning knowledge-based economy—the Internet—is no stranger to Virginia's economy. The Internet was actually conceived in Northern Virginia, at the Defense Advanced Research Projects Agency in Arlington County. Today, Virginia is home to one of the largest concentrations of Internet companies in the world, including many of the largest Internet service providers, such as AOL, UUNet and PSINet, and it handles more than 50 percent of the world's Internet traffic.

Virginia's current leadership position in Internet service provision bodes well for the Commonwealth's future economic prosperity. While the Internet has been described as the largest communications breakthrough since the printing press, it is still in its infancy. In 1997, the Internet had about 30 million users. By 2002, that figure is expected to grow to more than 1 billion users.

The Global Internet Project estimated that 1.1 million Internet-related jobs were created nationwide in 1996 alone. Much of this Internet-related job growth was in Northern Virginia, which is rapidly becoming a major hub for Internet traffic. The explosive job growth related to technology and technological service providers has prompted business leaders to scramble to find qualified employees. The expected growth of the information technology and telecommunications industry makes it possible to imagine a future where Virginia is a leader in the global knowledge market.

Significant investment in information capital will help ensure the Commonwealth's economic future. Virginia is poised to become a global leader in aerospace, biotechnology, and high-performance manufacturing, among other industries. Graduate education is a fundamental component of the resources needed to attain this status.

THE NOT-SO-BAD NEWS

Virginia will not likely realize its full economic potential of becoming and maintaining a position as a first-tier technology state without serious resources being devoted to building a highly-educated workforce, nurturing its world-class colleges and universities, and expanding research capacities. Exemplifying the need for strategic investments in the Commonwealth's information capital, the word "crisis" has been applied to the current and anticipated shortage of competent workers in Virginia's high-tech sector. Projections of the occupational distribution of the United States labor force for the new millenium show that the proportion of knowledge-intensive occupational categories is expanding rapidly, while the number of less knowledge-intensive categories is declining.

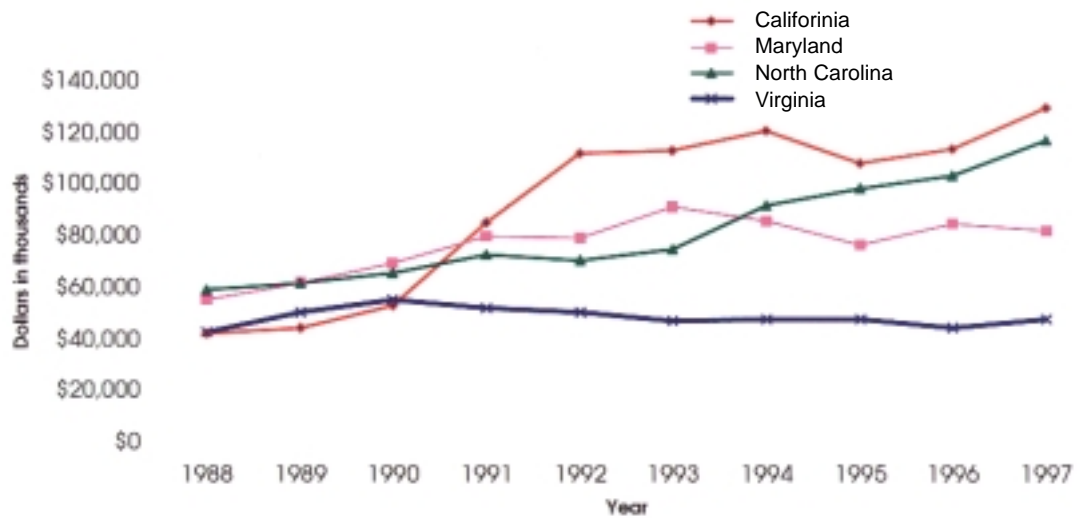


At an estimated average annual salary of \$47,190, current levels of vacancies in high-tech jobs are projected to result in nearly \$1 billion in wages not being pumped into Virginia's economy each year. That billion-dollar figure does not begin to account for lost business revenues in Virginia and lost opportunities for Virginia to dominate in the knowledge market, as a result of vacant high-tech positions.

The competition has become fierce among possible destinations for leading industries in the 21st century. Increasingly, new and expanding businesses are choosing emerging technology-incubators such as Austin, Baltimore, and North Carolina's Research Triangle Park. Currently, Virginia's investment in research and development at doctoral-granting institutions is falling behind the investments of states with leadership roles in technology development and production, such as California, North Carolina, and Maryland. According to the American Electronics Association, 8 out of the top 10 high-tech economy states also rank in the top 10 states for high-tech graduates. With the right partnerships and resources in place, Virginia can join these leading technology centers in the information revolution, and Virginia can capitalize on the global knowledge-based economic growth trend.

Over the past decade, Virginia's investment in research and development at doctoral-granting institutions has lagged behind investments of states with leadership roles in technology development and production, such as California, North Carolina, and Maryland.

STATE INVESTMENT IN R&D AT DOCTORAL-GRANTING INSTITUTIONS



Graduate Education in the Information Age

HIGHER EDUCATION

PIVOTAL TO THE DAWNING AGE OF INFORMATION IS THE LONG-STANDING AND CONSTANTLY evolving institution of higher education. Colleges and universities support technology growth by attracting the grant funding necessary to spawn the type of associations and research centers that bring cutting-edge technology to commercial products. In addition to supporting research and development—a primary benefit of graduate education—producing graduates with the skills necessary to forward society has expanded but not changed.

“Basic research is increasingly being performed at universities and colleges: In 1953, universities and colleges performed less than 30 percent of basic research; by 1992, they performed over 40 percent of it.”

A Satellite Account for Research and Development,
November 1994, U.S. Department of Commerce

“Universities and colleges spent an estimated \$24.3 billion on research and development during fiscal year 1997.”

Academic Research and Development Expenditures: Fiscal Year 1997
March 1999, National Science Foundation

GRADUATE EDUCATION

Central to the influential role of universities in the economic and social prosperity of the 21st century is graduate education. Graduate education is the enterprise within higher education that helps convert the production of knowledge into economic and social prosperity.

Consider the combustion cycle of a standard engine, where a spark converts a fuel/air mixture into a force powerful enough to move a truckload of cargo. Similarly, graduate education can ignite a mixture of publicly and privately funded research to create a powerful force of knowledge. Graduate education, then, is the spark—the catalyst that begins the process of converting society’s economic potential into prosperity. In addition to economic prosperity, graduate education sparks creative solutions and problem solving to help meet the challenges of our complex social system.

Graduate education and the economic engine can be summarized:

1. Graduate education sparks research;
2. Research fuels the creation of knowledge;
3. The creation of knowledge propels advances in technology and problem solving; and
4. The application of technological advances drives the economic engine.

The following are some of the contributions of graduate education and examples of some students' and graduates' activities throughout the Commonwealth.

Obtaining research and development funding. Graduate education is pivotal to obtaining funding for research and development (R&D) from public and private sources. In turn, funded R&D drives the technological advances that support economic prosperity.

Putting her Ph.D. in public policy from George Mason University's Institute of Public Policy to good use for the benefit of all Virginians, Maxine Lunn has applied her graduate-level skills to help develop a better understanding of the fundamental role technology infrastructure and business play in the current and future economy of Virginia. Lunn heads up the policy and research office of the Virginia Center for Innovative Technology, where the work of Lunn and her colleagues has provided a compelling case for supporting the growth of the Commonwealth's technology sector.



PHOTO: FOCUSED IMAGES PHOTOGRAPHY

Maxine Lunn

Supporting faculty research. Graduate students support faculty in their research activities by helping to develop research proposals, conduct lab and field experiments, analyze data, and write reports.

At the heart of Peter Galatin's M.D./Ph.D. studies at Virginia Commonwealth University is the type of rewarding scientific project that can come from collaboration among researchers in different fields. Having developed a lasting interest in biomedical research as an undergraduate at Harvard University, Galatin is continuing his studies of the molecular details of proteins with the hope of using such information in the design of new and better drugs, such as those that could be used in cancer therapy to suppress tumor growth. Much of Galatin's interest in structure-based rational drug design stems from how it brings together molecular biologists, chemists, computer scientists, biochemists, biophysicists, pharmacologists, and clinicians who share common goals. Working at the Institute for Structural Biology and Drug Discovery at the Virginia Biotechnology Research Park—an affiliate of Virginia Commonwealth University—Galatin is excited about how all of these specialists are “literally down the hall from one another.”



PHOTO: VCUMPS ALLEN JONES

Peter Galatin

Conducting student-based research. In addition to supporting millions of dollars worth of faculty-led research, graduate students also contribute to the Commonwealth's university-based R&D by conducting their own independent research activities. Studies conducted by graduate students address problems of both social and economic importance.

Since beginning her graduate studies in educational administration and supervision at Virginia State University (VSU) in 1995, Sherita Holoman has made a difference in her own classroom and in classrooms throughout the Commonwealth through her research on disciplinary methods for elementary school students. Holoman, winner of 1993-94 “Teacher of the Year” award at Ivor Elementary School, has drawn on her practical experience at Ivor, as well as on the scholarly expertise she has gleaned from her graduate studies at VSU, to help develop more successful school policies to address the growing issue of behavior problems among Virginia's youngest students.



Sherita Holoman

Recruiting first-tier faculty. Extensive graduate student involvement in the research process helps implement the type of cutting-edge research that attracts world-class, dedicated scholars to the faculty. It supports these top researchers in obtaining research grant awards and creates an innovative climate that attracts renowned scholars and researchers, as well as industry, to the Commonwealth.

Producing the next professorate and the next generation of researchers. Graduate education plays the essential role of producing the next cohort of educators and scholars—our future leaders in knowledge transmission and discovery.

As a doctoral student in chemical engineering at Virginia Polytechnic Institute and State University (Virginia Tech), National Science Fellow Monique Jackson has supplemented her research on the medical uses of polymer membranes with a full plate of extracurricular activities. In addition to working with Virginia Tech's Minority Engineering Programs and founding the Virginia Tech chapters of the Council for Advancement of Minority Engineering Organizations and of the Society of Hispanic Engineers, Jackson also initiated and organized CareerFest, a technical career fair that has raised enough money to provide several scholarships for minority engineering students. As chair of the Student Engineers' Council Engineering Exposition Committee, she organized the most successful Expo ever held at Virginia Tech, raising \$40,000 in profits, which was donated to the College of Engineering to equip the Student Assistance Center and to help support a new freshman design projects laboratory. After leaving a legacy of academic and extracurricular excellence at Virginia Tech, Jackson intends to teach at the university level.



PHOTO: SUSAN TRULORE

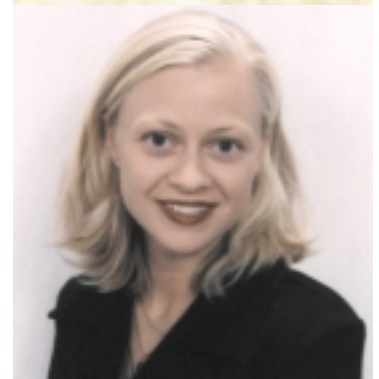
Monique Jackson

Training knowledge workers. In addition to producing academicians, graduate education is instrumental in preparing the workforce for the changing environment. “Knowledge worker” is a job description that now applies to more than one third of the total workforce of developed countries. The preparation that knowledge workers require often involves on-the-job training, but it increasingly entails a level of sophistication in handling information that only a graduate education can provide.

Knowledge workers not only include high-tech workers such as software designers and web site producers; they also are beginning to include newspaper reporters, bank tellers, and a host of other workers, as technology becomes more pervasive in the workplace.

Enhancing the quality of life, locally, statewide, nationally, and globally. Graduate education is a “public good,” the benefits of which enrich both the individual participant and society at large. The interaction between scholars and graduate students sparks thoughts, ideas, possibilities, and sometimes solutions to many of our social problems. Graduate students provide valuable input through internships and research in areas of the environment, literacy, poverty, and welfare reform, to name just a few.

Michal McElwain, a graduate student in George Mason University's Master of Arts in Interdisciplinary Studies program in Regional Economic Development and Technology, has played a pivotal role in cultivating the economic development program of the City of Manassas Park. She has created a web page, produced several video clips on the marketability of the city, secured several development grants, represented the city at national and international marketing and development conferences, and served as the city's representative to the Northern Virginia Economic Development Coalition.



Michal McElwain



Mary Lou Merkt

Promoting life-long learning. Economic competitiveness has indeed become equated with educational competitiveness in the knowledge-based economy of the 21st century. Graduate education provides an additional opportunity to enhance existing skills and to develop new skills for self-fulfillment and professional purposes.

Exemplifying the role graduate education plays in supporting life-long learning is the case of Radford University graduate, Mary Lou Merkt (M.B.A., 1991). Merkt's advanced education, as well as her selected profession, attests to her belief in life-long learning. As the Vice President for Finance and Administration at Sweet Briar College, Merkt has ample opportunities to apply the knowledge and skills she acquired from her graduate studies at Radford in a setting that fosters the desire to learn.

Benefits to participants. Having examined the role of graduate education in the wider society, it is important to understand what the endeavor of graduate education generally offers from the perspective of its participants.

Benefits to participants of graduate education:

1. Increased knowledge, broadened horizons, and expanded achievements;
2. Key credentials and personal affirmation;
3. Career advancement opportunities;
4. Career change opportunities;
5. Personalized plans of study;
6. Interdisciplinary programs;
7. Specialized research and teaching;
8. Practical experience;
9. Flexible class schedules; and
10. Financial feasibility.

Graduate programs afford learners of all ages and backgrounds the opportunity to increase their knowledge, broaden their horizons, and expand their individual achievements. Opportunities for study exist in areas as diverse as aerospace engineering, veterinary science, health science, dance, criminal justice, pharmacy, architecture, industrial/organizational psychology, education, romance languages, nursing, and molecular cell biology, among many others.



Kevin John Kelly

As a war-fighting analyst with the Joint Chiefs of Staff at the Pentagon, Kevin John Kelly (pictured outside the Department of Defense) draws upon the opportunity he had to study the relationship between military strategy and battlefield terrain, while completing his Master of Arts in Liberal Studies (M.A.L.S.) degree at Mary Washington College (MWC). Having developed sophisticated research skills during his master's studies, Kelley spends much of his time as a Pentagon analyst investigating primary statistics and records. Kelley discovered MWC's M.A.L.S. program when he enrolled in the College's Navy War seminars. As a retired naval commander who served in Vietnam, Granada, Beirut, and Desert Storm, Kelley appreciates the way his graduate education enriches his military experience. Says Kelley, "My military career has been rewarding, but it is very specialized. With the M.A.L.S. program, I took courses that I'd never have looked at, and really enjoyed them. I wanted to broaden my point of view."

Admission to graduate study is competitive and tends to be based upon a careful review of applicants' academic, as well as professional, qualifications. Thus, completion of an advanced education program offers students a vote of confidence and the opportunity to excel both professionally and personally. Graduate schools have been responsive to the growing population of professionals who want, or are forced by the market, to make career changes and expand their competencies into new areas. Graduate schools are responding to the call for excellence in interdisciplinary research and teaching by rethinking parts of the traditional structure of the academy.

For James Madison University alumna Vivian Begali (Ed.S. 1985, Psy.D. 1996), graduate education provided the credentials and knowledge base she needed to advance her expertise and her career. Already recognized for her outstanding abilities in the area of school psychology, Begali wanted to extend her accomplishments and further focus her interests. After receiving the School Psychologist of the Year Award from the Virginia Association of School Psychologists, Begali entered the doctoral program in clinical, school, and counseling psychology at James Madison University. Once concluding her advanced studies, Begali decided to stay in Virginia and work as a staff neuropsychologist at Sheltering Arms Rehabilitation Hospital in Richmond, as well as do specialized private practice work.

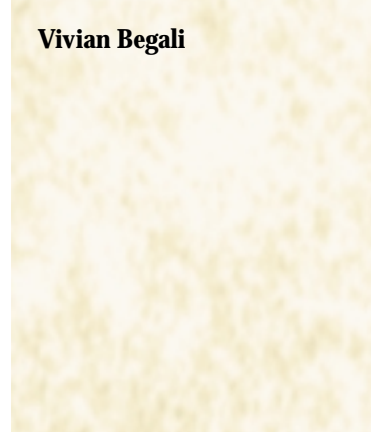
The convenience of off-campus programs, the flexibility of scheduling, and the possibility of tailoring a unique interdisciplinary graduate program has offered graduate education to the working population, and a growing number of full-time workers are taking advantage of this opportunity. The increasing popularity of this concept of individualized plans of study is reflected in the growing trend for schools to offer interdisciplinary master's and doctoral degree programs, where students can combine such areas of interest as history and women's studies, nuclear engineering and business administration, psychology and computer science, economics and education, or law and social work.

As life-long learning becomes more of an essential prerequisite to professional success, a majority of graduate enrollment has become comprised of part-time students who support themselves through school by working fulltime. Part-time study allows students to remain in the workforce, while advancing their credentials.

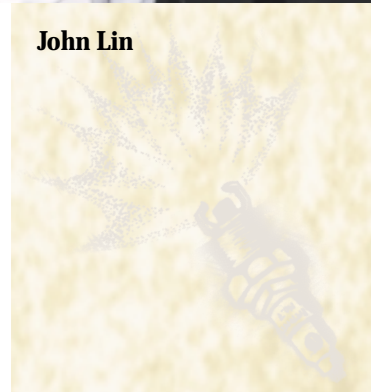
John Lin exemplifies how graduate education affords students an opportunity to pursue their individual interests. When he was an Old Dominion University doctoral student, Lin was able to pursue his unique research interests in controlling flow separation, a phenomenon that slows down moving aircraft and watercraft. Now, as a NASA scientist, Lin's fluid mechanics technology is speeding up travel in Virginia. His internationally-recognized research is being applied locally to Navy projects at Newport News Shipbuilding, as well as to aircraft throughout the country.



Vivian Begali



John Lin



In addition to traditional degree-oriented programs, graduate certificate programs are being offered that allow students to hone particular skills in a more cost- and time-efficient manner. Graduate programs also have become more action-oriented and experiential, placing greater emphasis on research and practical experience than ever before. A core component of graduate study is usually some type of hands-on learning—often a practicum, laboratory experience, studio time, or work-study opportunity—thereby enabling students to develop as practicing professionals while completing their programs of study.



Bob Belcher

Christopher Newport University master's student Bob Belcher is an important member of the research team studying and monitoring the restoration efforts on Atlantic White Cedar (AWC) Wetlands. Funded by an Environmental Protection Agency (EPA) grant, this research will develop a carbon model for AWC Wetlands, as well as underwrite surveys on floral, fauna, and breeding bird densities. The project, to which Belcher is making a vital contribution, will assist the EPA in developing procedures for monitoring future restoration projects. Belcher is establishing an important network of contacts with agencies, businesses, and volunteers, as he coordinates, provides technical support for, and oversees the quality of the research project.

Narrowing the view from the top of the new century, let us now turn our focus on graduate education to the specific case of Virginia.

Benefits of Graduate Education to Virginia's Prosperity

TRADITIONALLY, THE FOCUS IN VIRGINIA HIGHER EDUCATION HAS BEEN ON UNDERGRADUATE education. However, graduate education has long been—and is rapidly becoming even more of—an integral part of the overall mission of almost all of Virginia's colleges and universities.

In its 1990 report, "The Case for Change" (Senate Document No. 18), the Commission on the University of the 21st Century predicted that "our graduate schools will play an important role in meeting the state's growing needs for advanced education, research, and technology." In less than a decade, the Commission's prediction has become a reality.

The Commonwealth's programs of graduate education are central to realizing Virginia's vision of becoming a first-tier state in the U.S. technology arena, as well as central to Virginia's goal of securing a worldwide place of leadership in the information age.

"The trend toward viewing universities as part of the economic engine of the state will grow with increasing partnerships between campuses and industry that go beyond workforce development issues to increased public and private funding of basic and applied research. Graduate programs in selected areas will become increasingly important as the Commonwealth continues its shift toward knowledge-based industries."

1999 Virginia Plan, State Council of Higher Education for Virginia

Consider the following 10 roles graduate education plays in Virginia's economic and social prosperity.

Graduate education affords Virginia the benefits of:

1. Research breakthroughs that spawn new industries;
2. Production of faculty;
3. Workforce training;
4. Infusions of money into the market;
5. Larger tax revenues;
6. New and existing business development;
7. Strategic growth of Virginia's population;
8. Alleviation of "brain drain;"
9. Solutions to social problems; and
10. A rich cultural life.

RESEARCH AND DEVELOPMENT

Across the nation, research and development that is sparked by graduate education fuel the current knowledge-driven market. Just as with the nation as a whole, graduate education plays a pivotal role in R&D in the Commonwealth of Virginia.

In 1995, R&D expenditures by Virginia colleges and universities totaled \$445 million, up from \$331 million in 1990, for an average annual rate of growth of about six percent.

Graduate students are instrumental to the hundreds of millions of dollars in R&D that Virginia's institutions of higher education generate each year.

In its 1990 study on the role of graduate students in research, Virginia Polytechnic Institute and State University reported that stipends for graduate students accounted for 44 percent, or \$2 million, of its \$50 million in sponsored research funding. As of June 30, 1999, funds for graduate student stipends from 4,000 projects supported by sponsored programs at Virginia Tech had risen to approximately \$11.3 million.

Further underscoring the central contribution of graduate programs and students to Virginia's R&D base is the close affiliation of colleges and universities to Virginia's ten key technology assets. Graduate education programs, and the students enrolled in them, are instrumental to the faculty-based research that distinguishes the Commonwealth's leading technology assets by providing high quality, cutting edge, and cost efficient research support.

TEN KEY TECHNOLOGY ASSETS IN VIRGINIA

Asset	University Affiliation
Applied Research Center (ARC)	<ul style="list-style-type: none"> • Christopher Newport University • College of William and Mary • Norfolk State University • Old Dominion University
Institute for Biosciences, Bioinformatics, and Biotechnology (IB3)	<ul style="list-style-type: none"> • George Mason University
Free Electron Laser (FEL)	<ul style="list-style-type: none"> • University applied researchers, working with corporate product developers from firms such as IBM, DuPont, 3M, Lucent Technologies, Northrop Grumman, and Virginia Power
Langley Full-Scale Wind Tunnel (LFST)	<ul style="list-style-type: none"> • Old Dominion University
Smart Roads Project	<ul style="list-style-type: none"> • Virginia Polytechnic Institute and State University
University of Virginia's Institute for Microelectronics (UVIM)	<ul style="list-style-type: none"> • University of Virginia
Virginia Biotechnology Research Park	<ul style="list-style-type: none"> • Virginia Commonwealth University
Virginia Modeling, Analysis and Simulation Center (VMASC)	<ul style="list-style-type: none"> • Old Dominion University
Virtual Reality Competence Center	<ul style="list-style-type: none"> • Virginia Polytechnic Institute and State University
Virginia Space Flight Center	<ul style="list-style-type: none"> • Old Dominion University

Report on the Status of the Commonwealth's Technology Assets,
January 1999, Joint Commission on Technology and Science

Virginia's graduate programs are helping to generate the necessary R&D funding, as well as the focus needed, to make the Commonwealth a leading force in the global marketplace.

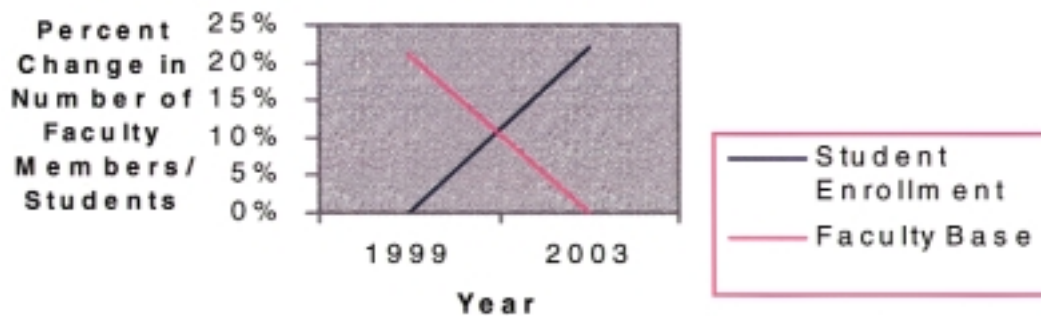
As investigators in cutting-edge arenas, graduate students and faculty members have helped keep Virginia focused on areas of emerging importance to economic development, such as:

- Information technology and Internet applications;
- Advanced manufacturing;
- Biomedical and health sciences;
- Environmental science and technology;
- Materials science, engineering and processing;
- Transportation and high-efficiency vehicles;
- Computational science, simulation and modeling;
- Educational research;
- Biotechnology and bioinformatics; and
- Intelligent systems and systems integration.

CURRENT AND FUTURE PROFESSORATE

Given the data on projected faculty retirements and student enrollment trends, supporting the growth of Virginia's professorate is essential. At a time when graduate-educated workers are being heavily recruited into business and government, higher education's need for graduate-educated professors has become a serious concern. Over the next several decades, four-year institutions will be competing with top-notch research firms for doctoral graduates, and two-year institutions will be competing with a host of industries for master's graduates.

TRENDS IN FACULTY BASE AND STUDENT ENROLLMENT: 1999–2003



In Virginia, approximately 21 percent of faculty members are expected to retire by 2003, while student enrollments are predicted to increase by 22 percent.

Responding to Virginia's pressing demand for instructors, many graduate programs entrust their graduate students with teaching responsibilities, which may include preparing teaching materials; conducting laboratory and discussion sessions; constructing examinations, cases, and homework exercises; grading students' work; and, at times, teaching the classes themselves.



Kathryn Thornton

After completing her graduate studies at the University of Virginia (UVa), Kathryn Thornton may have traveled and walked out in space, but she came back to Charlottesville, where she can be seen traveling and walking around the grounds of UVa. Thornton served for 12 years as a NASA astronaut, where she flew four missions, logging more than 975 hours in space and more than 21 hours of extravehicular activity (space walking). While those four space missions made her a record-setting female astronaut, Thornton has a new mission—to serve as a professor at UVa's School of Engineering and Applied Science and Director of UVa's Center for Science, Mathematics, and Engineering Education. Reaching out to students from kindergarten to graduate school, Thornton's dual roles make her pivotal to Virginia's efforts to promote excellence in science, mathematics, and technology education at all levels of learning in the Commonwealth.

“If the nation in general and Virginia in particular are to meet the need for faculty, as well as the need for educated workers of all kinds . . . as the new century unfolds, graduate education is the key.”

Graduate Education, Report of the State Council of Higher Education for Virginia to the Governor and the General Assembly of Virginia, October 1993

WORKFORCE TRAINING

Graduate education is as critical to the training of the workforce of the 21st century as it is to the training of Virginia's next professorate. Given Virginia's dynamic and knowledge-based economy, the requisite knowledge skills for the workforce of the 21st century will increasingly necessitate higher levels of education, making life-long learning imperative. Graduates in the age of information have to be prepared for leadership in an environment of constant and rapid change. Graduate education is quickly becoming a necessity for an increasing number of workers.



Zane Gibbs

When Zane Gibbs travels around the world to investigate emerging technologies, he takes with him the skills he attained in his Ph.D. program in chemical physics at Virginia Commonwealth University (VCU). His doctoral-level abilities have served him well, since becoming a member of the New Technology Research and Development division of Philip Morris USA, which is headquartered in Virginia. As a former recipient of a National Science Foundation graduate fellowship, Gibbs brings a depth of research experience to his worldwide quest for technologies—a quest that has helped bring information back to the Commonwealth that is essential to the development of new products and to the improvement of manufacturing processes. His graduate background also makes him keenly aware of the importance of advanced education, which he actively promotes through his efforts to support future scientists as an affiliate faculty member in the Department of Physics at VCU.

In its 1993 report to the Governor and General Assembly of Virginia on Graduate Education, the State Council of Higher Education for Virginia (SCHEV) stated, “Virginia will need an increasing number of well-educated workers in the coming decades.” Seven years ago SCHEV stressed that graduate degree holders would be vital to the sophisticated workplace of the future. That future is here, and SCHEV could not have been more accurate in its assessment that the age of information would create the need for people with advanced education.

Not only are graduate degrees becoming more essential in the high-tech arena, advanced education also is being required more and more in traditionally non-technical fields, as technology moves to other facets of the economy such as banking and retail. Virtually every sector of private and public enterprise is starting to require a rising number of people who are adept at handling information, creating a high demand for graduate education.

SPENDING IN THE ECONOMY

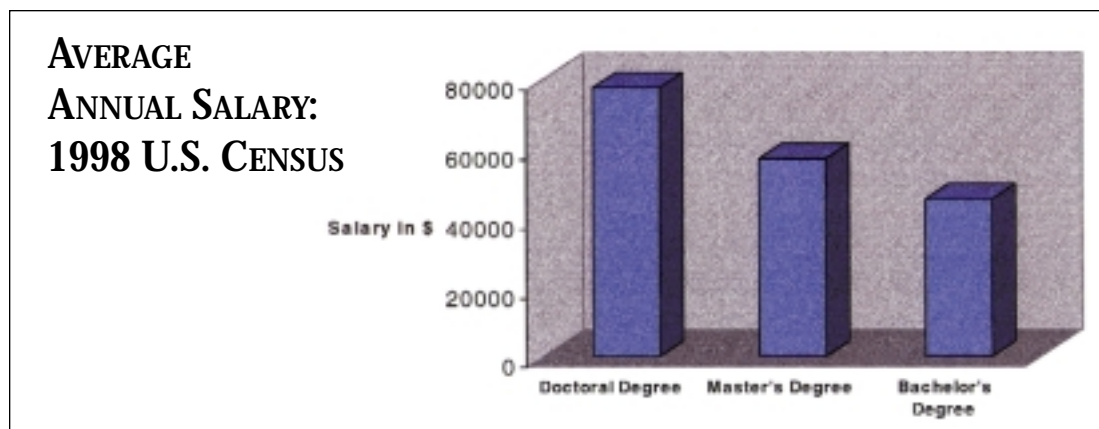
Graduate education makes sizeable financial contributions to Virginia's economy through the market behavior of graduate students. The average graduate student spends approximately \$11,000 each year in Virginia on living expenses. Multiplied by the more than 40,200 graduate students enrolled in Virginia colleges and universities as of March 1999, this amounts to a direct annual impact on the state economy of more than \$442.2 million.

Using the conservative standard multiplier of 2.5, each original dollar spent by a graduate student leads to an additional \$1.50 cycling through Virginia's economy. In other words, \$442 million in direct spending translates into an additional \$663 million of indirect economic impact.

TAX REVENUE

In addition to direct and indirect spending in the economy, graduate education also affects the Commonwealth's economy in other ways. Recent Census data indicates that individuals with doctorates earned an average annual salary of \$77,445 in 1998; individuals with master's degrees earned an average annual salary of \$51,183, while those persons holding bachelor's degrees only earned an average of \$40,478. Over a 40-year career, the average Ph.D. degree-holder will earn around \$3 million, compared with \$1.6 million for someone with a bachelor's degree.

The average annual salary figures for graduate degree recipients, multiplied by the approximately two-thirds of graduate degree holders who find employment in Virginia after completing their programs of study, reveal that the incremental contribution of graduate degree holders to the Commonwealth's base of taxable income for one year alone equals roughly \$346 million. While this large pool of taxable income is a notable contribution to Virginia's economy, it does not even factor in the multiplier effect of the increased personal income or the tax revenue generated by faculty and staff members who come to Virginia for employment in, or related to, graduate programs.



According to 1998 Census data, individuals with doctoral degrees earned an average annual salary of \$77,445, and individuals with master's degrees earned an average annual salary of \$51,183, while persons holding bachelor's degrees only earned an average of \$40,478.

BUSINESS DEVELOPMENT

Graduate programs are instrumental in helping recently established and existing businesses develop and prosper, as well as in attracting new entrepreneurial businesses to Virginia. Recent surveys of major businesses and industries support the view that today's employees are expected to perform more complex functions, such as statistical quality controls, implementation of innovations, and continuous improvements in processes at the point of production. These sophisticated tasks require more advanced levels of computational, oral, and written communication skills, as well as more advanced levels of problem-solving skills. One of the primary requirements for these firms is proximity to a university.

Strong graduate programs play a pivotal role in the type of research and development that spawns new companies. The synergism created by the collaboration of strong faculty and graduate student researchers sparks innovation. Through partnerships and contracts, research and technology are transferred from universities to the workplace. Increasingly, industry, business, research parks, and incubators want to be near these university hubs of R&D.



PHOTO: JOHN JACKSON

Warren W. Buck, III

Having earned both his master's and doctoral degrees from the College of William and Mary (W&M), Hampton University Professor of Physics Warren W. Buck, III credits his success as an educator and as a scientific advisor at the Jefferson National Accelerator Facility User's Group in Newport News to his graduate school years at W&M. Buck, who is a former researcher at the *Institut de Physique Nucleaire* in France and the current director of the Nuclear/High Energy Physics Research Center of Excellence at Hampton University, was awarded the Outstanding Service Award from the Continuous Electron Beam Accelerator Facility (now Jefferson Lab) in 1986 and an Honorary Superior Accomplishment Award from NASA/Langley Research Center for significant contributions in radiation physics. Buck's award-winning research in radiation physics has been instrumental to manned space missions. Not only has Buck proven to be one of the Commonwealth's brightest stars in technology, he hopes to inspire young people to follow in his footsteps. "Keeping the fire alive and passing it along to others is one of the most important acts of a civilized individual," Buck says. "I just hope that I may be able to touch the minds and hearts of others as I have been so touched."

Virginia's graduate programs also directly support business development by providing instruction in the traditional classroom, as well as at the workplace and other off-campus sites convenient to students' homes and places of employment. Graduate programs also offer pre-employment training, work profiling, retraining and other non-credit and continuing education services to support business development.

ATTRACTING RESIDENTS

In addition to attracting new businesses, graduate education programs attract high-caliber students from outside of Virginia. The presence of these non-resident students in the Commonwealth's graduate programs helps foster diversity, increase state enrollments, fill job openings, and create new jobs.

The significant dollar amount of direct and indirect spending on tuition, fees, and living expenses associated with graduate students in Virginia is partially attributable to new money brought into the Commonwealth's economy by the approximately 10,500 out-of-state students who are in Virginia for graduate study.

Virginia's graduate education programs have attracted the interest and admiration from people across the world, with international students seeking entry into and foreign governments seeking to collaborate with the Commonwealth's programs. Currently, approximately 4,400 international students are enrolled in Virginia's graduate programs.

Originally from Egypt, Mona El-kadi is changing the way college and university students—in Virginia, as well as across the country—capture what they see and hear during cyber classes. As part of her doctoral research at Old Dominion University, El-kadi is developing multimedia tools for distance education systems, such as a multimedia computer notebook program that can save text, audio, and video images and later make them available for viewing through a standard Web browser.



Mona El-kadi

RETAINING RESIDENTS

Many of the out-of-state graduate students who attend school in Virginia remain after graduation and enter the workforce. By growing a skilled workforce, Virginia helps alleviate the costly phenomenon of “brain drain.” Based on the national average, 67 percent of all graduate degree holders remain in the Commonwealth after completing their courses of study. This equates to roughly 6,500 additional advanced-degree holders filtering into Virginia’s workforce each year.

The retention of graduate degree holders results in the growth of Virginia’s pool of highly-skilled workers, reduced recruitment costs to companies, and a wider tax base for the Commonwealth. Domestic students who travel abroad in the course of their studies and the retention of international students assist Virginia in developing and expanding its network and base of worldwide trade and technology.

Roger Crouch left Virginia Polytechnic Institute and State University with master’s and Ph.D. degrees in physics and the knowledge and confidence to bring nations together for the sake of advancing science in the service of humanity. Crouch is lead NASA scientist in the Office of Life and Microgravity Sciences and Applications, and was a payload specialist aboard the space shuttle Columbia for 33 microgravity scientific investigations for researchers worldwide, which could allow scientists to design more effective drugs against fatal diseases, reduce pollution, control the spread of fires, and produce better semiconductors and high-performance alloys. Having organized and co-chaired microgravity science working groups between NASA, the European Space Agency, France, Germany, Japan, and Russia, Crouch now is responsible for science and technology development programs in NASA’s Human Exploration and Development of Space enterprise, which selects and funds science projects worldwide, including many by researchers in Virginia. “Graduate school gave me the self-confidence to start doing things and use my own thoughts,” Crouch says. “It gave me the courage to challenge a bigger world.”



PHOTO: NASA

Roger Crouch

SOLUTIONS TO SOCIAL PROBLEMS

Graduate students make many contributions to the well-being of their immediate communities, the Commonwealth, the nation, and the world. Graduate education provides essential training for addressing critical social problems, by creating innovative and knowledgeable policy-makers and practitioners in the arenas of education, government, business, health, defense, international trade, and technology. By applying their skills and expertise, these well-educated citizens help ameliorate issues that threaten the infrastructure of Virginia’s economy, as well as issues that cause human suffering and lead to social injustice.

After graduating from the Massachusetts Institute of Technology (MIT) with dual bachelor’s degrees in science and humanities, Courtney McBath settled at Regent University, where he completed his Master of Divinity degree and began making a positive difference in Virginia, by founding a church in 1990 for a congregation of 21. As a new student in Regent’s Ph.D. program in organizational leadership, McBath continues to have a dramatic social impact on the Commonwealth. McBath currently supervises that same church, which now has 4,500 regular attendees as well as a credit union, restaurant, full-service elementary and middle school, job-training ministry, “freedom from welfare” ministry, “life-altering addictions” ministry, youth conferences, and women’s ministries.

Both during and after completing their graduate degree programs, these competent and motivated individuals commit their time and talents to public service work throughout the Commonwealth. In fact, many graduate programs require their students to donate significant hours of community service work through unpaid practicum experiences. Benefactors of graduate students’ energy and expertise include a broad array of agencies, social services, political campaigns, educational systems, charities, and local governments.



Courtney McBath

QUALITY OF LIFE

Above and beyond the considerable economic and social benefits of graduate programs, graduate education also contributes to the culture of Virginia. With nationally-recognized programs in the performing and visual arts, Virginians can enjoy displays of talent and creativity throughout the Commonwealth's communities. These leading graduate arts programs also have a spillover effect that helps develop the creative talents and abilities of undergraduate students, as well as students in the primary and secondary schools. Thus, above and beyond its ability to multiply state funds many times over and to stimulate regional and state economic activity, graduate education helps ensure a better quality of life for all Virginians.



Caryn Grim

Caryn Grim attended the University of California in San Diego for her undergraduate degree but, returned to the Commonwealth to pursue her graduate studies. Grim, who is from a family of Virginians, selected the College of William and Mary (W&M) for graduate work, not only because of personal connections to the state, but also because of the reputation for personalized attention in W&M's Thomas Jefferson Program in Public Policy. When she graduates, Grim plans to settle in Richmond, where she will face the challenge of realizing her long-term career goals of influencing public policy. "Regardless of what I end up doing or where I end up working, I know I will be in a position where I am helping to improve the quality of life in my city and state."

Call for Action

IN ORDER TO MEET THE DEMAND FOR R&D, FACULTY MEMBERS, AND TRAINED EXPERTS, AS WELL AS meet the social and cultural needs of Virginians, the Commonwealth's colleges and universities need to selectively increase the supply of graduate students and ensure that students who are now in graduate school successfully complete their programs.

WHAT HAS BEEN DONE

In response to this call for action, Virginia's institutions of higher education have already implemented initiatives to improve the qualitative and quantitative capacities of graduate education in the Commonwealth by:

- Decreasing program duration, with fewer credit hours, in some cases;
- Reallocating internal dollars to support graduate student stipends;
- Collaborating with public and private partners to better leverage graduate funding;
- Working collectively to promote the Commonwealth's educational programs on the Internet;
- Establishing and enhancing satellite campuses for graduate studies;
- Instituting more flexible schedules;
- Brokering graduate programs from other state institutions;
- Raising endowment dollars for grants to graduate education;
- Raising Federal dollars for research that includes funding for graduate students in grant proposals;
- More closely connecting graduate education to economic development;
- Developing distance-learning programs;
- Instituting more flexible program designs; and
- Instituting a variety of graduate programs in response to market demand.

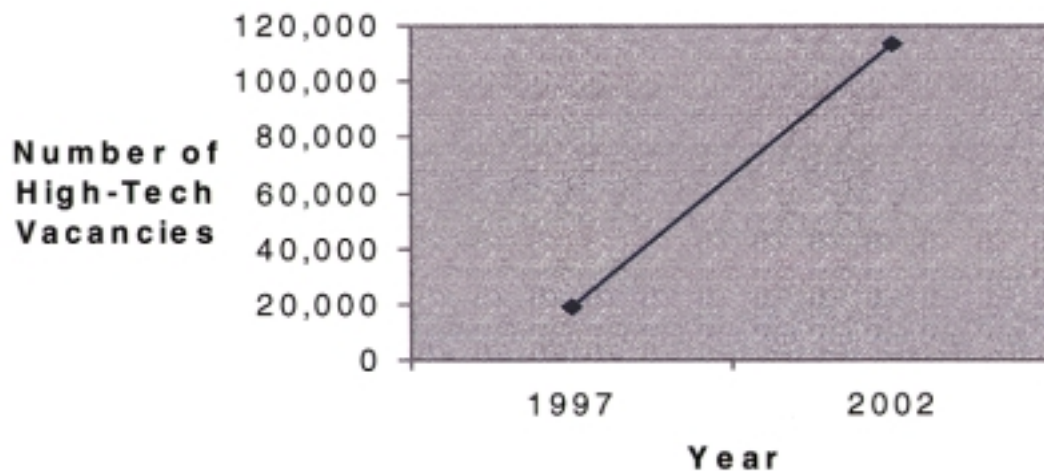
WHAT REMAINS TO BE DONE

While colleges and universities have made major efforts toward illuminating and enhancing graduate education in the Commonwealth, Virginia needs to do more. In comparison to the national growth rate of 3.5 percent for R&D expenditures by colleges and universities, Virginia's investment represents a growth rate of less than 1 percent.

The American Electronics Association ranked Virginia first among states in increased high-tech graduates, but a dearth of adequately-skilled graduates remains—a shortfall that is predicted to cause high-tech growth in the Commonwealth to stagnate. In 1997, there were 19,000 job vacancies among high-tech companies in Northern Virginia alone, with that shortage projected to swell nearly six-fold by 2002. Throughout the Commonwealth, approximately one-third of the unfilled jobs, advertised as high-tech positions, require advanced degrees, such as engineering or computer science.

In 1997, there were 19,000 job vacancies among high-tech companies in Northern Virginia alone, with that shortage projected to increase to nearly 115,000 by 2002.

VACANCIES IN HIGH-TECH JOBS IN NORTHERN VIRGINIA



Virginia's colleges and universities continue to launch strategic initiatives in order to restructure their resources in a manner consistent with the Commonwealth's economic and social needs.

- The College of William and Mary is launching a new interdisciplinary Graduate Center Program which will prepare all graduate students for a life of community service through short course offerings and opportunities to serve as interns in the community;
- James Madison University is planning for the future by adding new programs and adapting existing graduate programs, including a master's degree program in Integrated Science and Technology; an innovative doctoral program in Assessment and Measurement (PsyD) to meet the expanding accountability, quality assurance, and outcome assessment needs of the 21st century; and on-line concentrations in Information Security—offered as a part of both the Computer Science and the MBA degrees;
- Mary Washington College is planning a variety of new graduate programs through its new James Monroe Center for Graduate and Professional Studies that opened in August, 1999;
- Old Dominion University, through its TELETECHNET program, has been delivering live, televised graduate instruction in 10 degree programs to over 60 sites in Virginia, with additional graduate programs currently being modified to address high-tech needs in modeling and simulation, materials science and engineering, geographic information systems, and information technology;
- Radford University has extended outreach by providing graduate programs at five off-campus sites throughout southwest Virginia;
- Regent University is extending its master's and doctoral degree programs in business, communication, counseling, divinity, education, government, law, and organizational leadership, by offering graduate courses both online and on campus—at both the main campus in Virginia Beach and at the new Northern Virginia/D.C. Graduate Center in Alexandria;

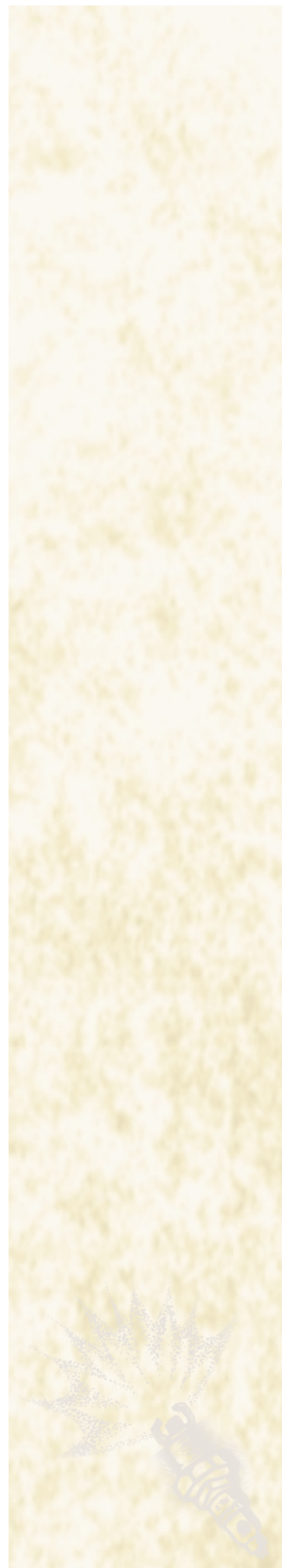
- Virginia Commonwealth University is placing greater emphasis on graduate certificate programs and interdisciplinary/multi-disciplinary master's and doctoral degree programs to fill the unique niches being created by technology and life sciences research; and
- Virginia Polytechnic Institute and State University continues to lead the nation in advanced Information Technology (IT) training; responding to the needs expressed by Virginia businesses and industry; making IT skills a requisite in virtually every field; offering IT concentrations in master's and doctoral degree programs; and being one of the first universities in the country to require electronic theses and dissertations.

These initiatives reflect the commitment of the Commonwealth's colleges and universities to meet the needs of society and maintain excellent graduate education programs. However, if Virginia is going to move into a position of preeminence in the global economy of the information age, additional resources and more collaboration with the state will be needed.

Current levels of graduate education funding will continue to produce a basic level of research and knowledge-production in the Commonwealth and, probably, maintain the economy's current level of performance. However, higher levels of state funding for graduate education can enhance Virginia's ability to obtain—and more fully leverage—its total research dollars.

If Virginia is to have preeminent regions like California's Silicon Valley, North Carolina's Research Triangle Park, and Maryland's hub of research parks in Baltimore, the Commonwealth will need to make similar state-level investments. Given concerns over the decline of certain Federal R&D funding sources (e.g., Department of Defense and NASA), greater state-level investments in the type of R&D that is driven by the Commonwealth's graduate programs could be critical simply to maintain Virginia's current level of performance.

At our fingertips is a potent resource in helping Virginia achieve even greater dominance in the knowledge-based economy—Virginia's graduate programs.



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