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Illinois has taken steps to improve the quality of mathematics and science teachers. New Associates of Arts in Teaching (AAT) in science and mathematics have been approved for Illinois community colleges for the purpose of increasing the numbers and quality of mathematics and science teachers. Various scholarships and tuition waiver programs are available for those pursuing an education major.[196]

Ongoing professional development for the existing cohort of teachers adds another challenge. The *Illinois Survey of Critical Technologies* identified the barriers current teachers face in trying to complete professional development in cutting-edge mathematics and science topics. Illinois needs to find ways to overcome the barriers of lack of time, financial resources, and professional development opportunities.

Support for Innovative Research and Development and STEM Education

Keeping Illinois competitive requires innovative research and development and a highly-skilled STEM workforce. A couple of examples will suffice as a reminder of the competition in this environment. "Of 120 *new* chemical plants being build around the world with price tags of $1 billion or more, one is in the U.S. Fifty are in China."[197] Also "in 2003 only three American companies ranked among the top ten recipients of patents granted by the U.S. Patent Office."[198]

Developing innovations that will succeed in the global economy requires significant resources for the recruitment and retention of the best STEM workforce and for innovative research. The following section assesses Illinois' capacity for innovation in terms of

- Scholarly articles and patents
- Financial support for STEM students and STEM education
- Investment in research and development

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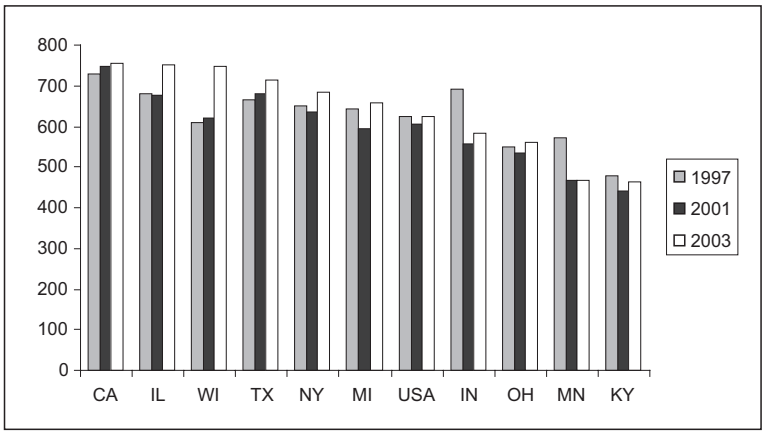
Scholarly Articles and Patents

Historically, institutions of higher education have provided a cadre of STEM researchers. The number of articles written is a traditional academic measure of research. As shown below, Illinois is one of the higher volume publishing states in terms of the number of academic articles per science and engineering doctorate.

Figure 37 Academic Article Output per 1,000 Science and Engineering Doctorate Holders in Academia 1997-2003[199]



In addition, academic institutions play major roles in the innovative endeavors to create new products, processes, services, and programs. The number of academic patents relative to 1,000 science and engineering doctorate holders provides a measure of the degree to which results with economic value are generated by the doctoral academic workforce. From 1997 to 2003, the number of academic patents per 1,000 academic doctorate holders

- increased from 10.5 to 13.0 in the United States
- Increased from 7.7 to 10.5 in Illinois

Compared to other states, Illinois fell into the second quartile. The highest patent rates was 27.5 for California. Other states with rates greater than 15 include Alabama, Florida, Iowa, Maryland, Massachusetts, New York, and North Carolina.[200]

When the patent rate is defined as the number of patents awarded per 1,000 individuals in science and engineering occupations, Illinois is slightly below average (18.8, compared to U.S. rate of 19.9).

RESOURCES FOR STEM EDUCATION

Financial Support for STEM Students and STEM Education

Financial aid is often a deciding factor for whether a student will enroll in postsecondary education. The costs of higher education can be prohibitive, especially for low-income and middle-income students. In addition, students may shy away from "high cost" degrees, such as those in engineering and science which have large laboratory costs.

The amount of financial support from state grants which goes directly to undergraduate students varies widely by state. Some states subsidize tuition at the state level for all students; other states provide student aid directly to students. From 1995 to 2002, Illinois increased the state expenditure per full time undergraduate student from $1,040 to $1,447, a direct student funding level surpassed only by Georgia.[201] The most recent 2007 budget for higher education increased MAP (financial aid) funding $34.4 million or about 10%. Illinois public universities were cut in 2003 and again in 2004 and remained flat through 2006. During this period, universities increased tuition and fees to meet increasing enrollments and expenses. The 2007 budget has a 2% increase for public universities.

The Illinois Student Assistance Commission offers three programs for prospective teachers:

- Illinois Future Teacher Corps (IFTC) for those committing to teach in hard-to-staff schools or in critical shortage disciplines
- Minority Teachers of Illinois (MTI) for minority students wishing to teach in schools with 30% or more minority populations
- Illinois Special Education Teacher Tuition Waiver (SISTTW) for students in 4-year Illinois public universities studying to be a special education teacher

Other financial assistance programs available to education majors include the Golden Apple Scholars of Illinois, Federal Perkins Loan Cancellation for Teachers, Stafford Loan Cancellation for Teachers, and the Illinois Teacher Loan Repayment Program (see www.collegezone.com for more information).

Another measure of the priority placed on education is the percentage of the state's wealth expended on education. Based on data from the U.S. Department of Education, the *Science and Engineering Indicators 2006* computed the state expenditures as a share of the gross domestic product. From 1994 to 2003, the national average for spending on elementary and secondary education increased from 3.37% to 3.55%. In Illinois, the percentage increased from 2.93% in 1994 to 3.46% in 2003.[202]

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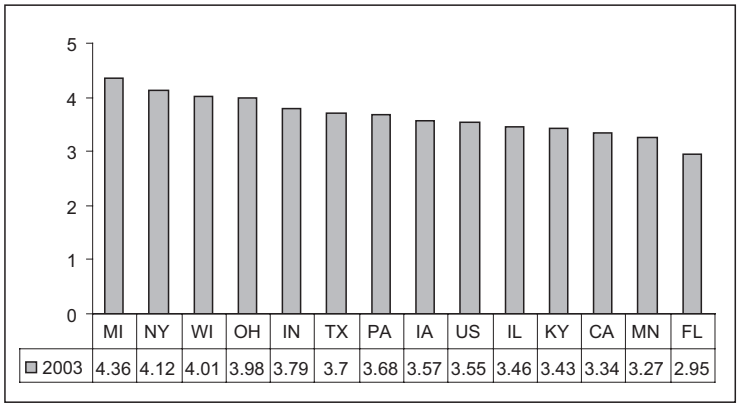
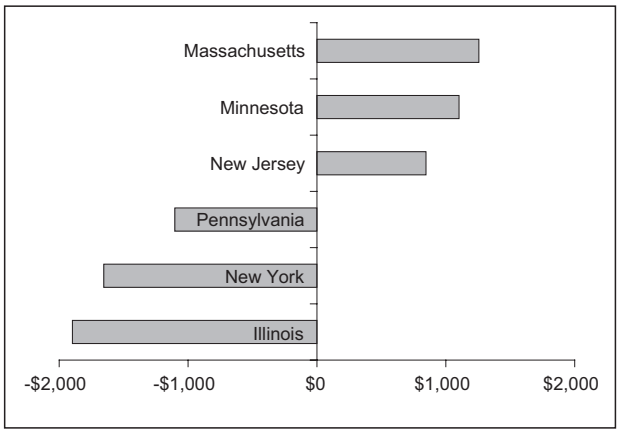
Figure 38 Elementary and Secondary Public School Expenditures as Share of Gross State Product: 2003



Another measure of educational expenditures is the gap in expenditure per student between the highest and lowest poverty districts. The average revenues per student were compared for the 25% of schools with the highest low-income students and the 25% of schools with the lowest percentages of low-income students. Illinois has a nearly $2,000 gap, one of the largest in the U.S. Other states expend more resources on high-poverty districts. The Illinois expenditure gap mirrors the achievement gap of low-income students and the fact that wealthier districts use local property taxes as a source of increased revenue.

Figure 39 Absolute Dollar Gaps in Expenditure Per Student for Highest and Lowest Poverty Districts



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The appropriations of state tax funds for higher education operating expenses in Illinois increased 10.1% from 1990 to 2005. During the same period, the aggregate funding for states in the Midwest increased 8.7% and national funding for higher education increased 19.2%. The decline in the manufacturing industry was particularly severe in the Midwest, taking a toll on tax revenues.

Investment in Research and Development

Research and development activities (R & D) are necessary to support a strong STEM infrastructure. Globally, the top five countries with R & D as a percentage of the gross domestic product are Israel, Sweden, Finland, Japan, and Iceland. The U.S. leads in per capita spending on information and communication technology, followed by Switzerland, Denmark, Sweden, and Norway. The top producers of innovations in genetically modified crops are the U.S., Argentina, Canada, Brazil, and China.[203]

The ratio of the amount of academic spending relative to the gross state product is a measure used in the *Science and Engineering Indicators 2006*. The U.S. average ratio of academic R & D spending to $1,000 GSP increased from 3.01 in 1993 to 3.60 in 2003, and in Illinois, the ratio increased from 2.45 to 3.23 during the same period. [204]

From 1998 to 2002, the U.S. average percent of the gross state product attributed to R & D remained stable (2.48%, 2.46% respectively). Similar conclusions can be made for Illinois, with the percentage of the gross state product attributed to R & D going from 2.14% to 2.10%. Over 3.5% of the gross state product was attributed to R & D in states such as California, Massachusetts, Michigan, New Mexico, Rhode Island, and Washington.[205]

Another measure of R & D funding is the amount of federal R & D obligations per civilian worker in a state. From 1992 to 2002, federal R & D obligations rose from $64 billion to $84 billion. The per civilian expenditure in the U.S. increased from $536 to $612. In Illinois, the per civilian rate increased $166 to $284. As pointed out in the *Science and Engineering Indicators 2006,* federal R & D obligations varied greatly. For instance, some sparsely populated states host national laboratories, and a number of R & D institutes surround the District of Columbia.[206]

The federal Small Business Innovation Research (SBIR) program supports companies with 500 or fewer employees with awards for planning and commercialization. *Science and Engineering Indicators 2006* examined the three-year total of SBIR awards relative to $1 million in the gross state product. For 2001 to 2003, the U.S. ratio of SBIR to $1 million gross state product was 141, compared to Illinois' ratio of 43. States with the highest rankings tended to have federal laboratories or well-recognized academic research institutions from which small businesses have emerged.[207]

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Private industry is another source of R & D funding. From 1998 to 2003, private industry funding increased from $164 billion to $198 billion, an increase of 21% unadjusted for inflation. The percentage of R & D conducted by industry in the private sector decreased in the United States from 2.14% to 2.06% in 1998 to 2003. In Illinois, the percentage of industry-performed R & D increased from 1.90% in 1998 to 2.00% in 2000 but decreased to 0.85% in 2003.[208]

The expansion and emergence of companies can also be funded via venture capital. In 2003, the ratio of venture capital expansion to the gross state product was 0.76 in Illinois compared to the national average of 1.73. California and Massachusetts received the majority of the total venture capital dispersed in the U.S. in 2003.

Lastly, the amount of resources expended in ongoing training of employees is essential to the currency of workers' knowledge and skills. Increasing the educational level of employees by approximately one year can result in a 12.7% increase in productivity in the non-manufacturing sector.[209]