ТЕОРИЯ И МЕТОДИКА ОБУЧЕНИЯ

УДК 37

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COMPREHENSIVE BIOTECHNOLOGY EDUCATION AND RURAL ECONOMIC DEVELOPMENT

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Introduction

North Carolina is a state of 8.2 million, the 11th most populous in the United States. The «Tar Heel State» ranks 12th in total gross state product and scores 30th in per capita income (1). Important in agriculture, North Carolina relies upon poultry products, hogs, milk and crops such as tobacco and soybeans. In the manufacturing sector tobacco products, textile goods, chemical products, electric equipment, machinery and furniture are important. Tourism is also a strong North Carolina industry sector.

The economy of the state of North Carolina is changing. Traditional manufacturing industries that once served as the foundation of the state's business and job bank; textiles, and furniture manufacturing are rapidly disappearing. Likewise the state's agricultural base is also in transition. North Carolina does possess an expanding economy that places it in a unique position: biotechnology. North Carolina biotechnology is an industry producing a wide range of services and manufacturing a daunting array of products. The state's biotechnology initiative is supported by the North Carolina Biotechnology Center (2). The North Carolina Biotechnology Center is a private, non-profit corporation created by the State in 1984 and supported by the General Assembly. The Center's strategy is to provide long-term economic and societal benefits to North Carolina through support of biotechnology research, business and education statewide.

North Carolina biotechnology has almost 200 companies employing almost 20.000 people, annually generating $8B revenue, representing a payroll of $1.7B. North Carolina biotechnology is predicted to continue to grow at a rate of 10–15 % per until the year 2025 when it will employ some 125.000 people with revenues approaching $24B (3). Worldwide, biotechnology is forecasted to become a market of greater than $120B annually by year 2015, $66B of that market will be in the United States (4).

A recent study of state policies on economic development showed that North Carolina ranks nationwide as the fourth most 'business-friendly' state, and first in the southeast (5). According to the North Carolina Biotechnology Center (NCBC) and a survey by the research organization Ernst & Young, North Carolina ranked third in the US behind Boston and the California Bay area on the importance of its biotechnology industry to the state economy (6). The success of the NC biotechnology industry is directly related to the availability of a trained workforce. According to a 2005 report by the Milken Institute, the state has the highest concentration of biotechnology human capital in the US (7). This means that presently North Carolina is able to train qualified people or attract qualified people from other states to work in the industry.

North Carolina's Portion in the U.S. Biotechnology Sector

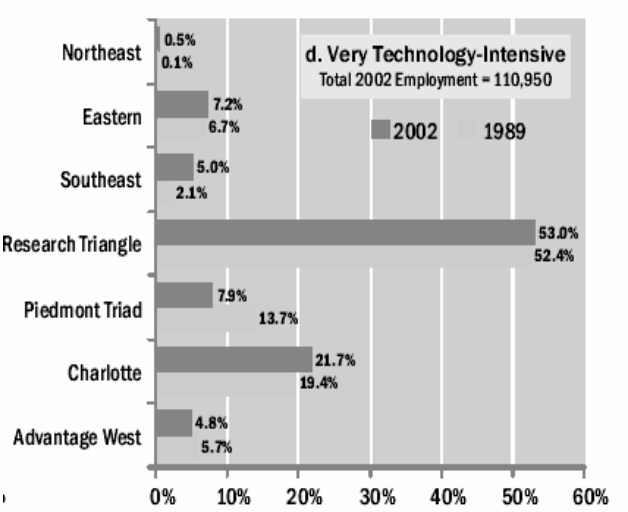
	United States	North Carolina
Biotech companies	1.466	152
Employees	194.600	18.500
Revenue	$33.6B	$3B

Adapted from: New Jobs Across North Carolina, 2004(4).

Most of the North Carolina biotechnology business is located in the technology-rich Research Triangle Park (RTP). RTP was founded in 1959 to bridge the gap between academia, industry and government. RTP has transformed into the largest research and development park in the world, housing 137 companies of which one-third are focused on «life science». The Park provides livelihoods for almost 40.000 employees.

The 12-county region known as the Piedmont Triad, to the west of RTP, is comprised of Winston-Salem, Greensboro and High Point. It is establishing its reputation as a major biotechnology «player». Presently, the Triad is home to about 45 biotechnology and life science companies and to more than fifteen educational institutions. Biotechnology continues to grow in the Triad area The state's other major economic area is Charlotte, with a population of 541.000 (twice that of the next largest NC city), one of the Southeast's banking centers (8).

As rich as North Carolina biotechnology is, the statewide distribution of technology is far from uniform.



Very Technology Intensive Sectors
a. Pharmaceutical mfg
b. Computers & IT
c. Instrumentation
d. Biotechnology
From (8)

North Carolina technology is positioned mainly along the main interstate highways indicated in the figure above. The employment data below shows that RTP, the Triad and Charlotte hold greater than 80 % of North Carolina technology. The remaining four economic regions of the state (Northeast, Eastern, Southeast and the West) account for less than 20 % of the state's technology employment. «Very» technology-intensive operations include such sectors as: pharmaceutical manufacturing, computers and IT-related businesses, instrumentation and biotechnology.

The Challenge

However, North Carolina is not alone in its action to develop its biotechnology sector. At least 40 other states are developing comprehensive plans to capture biotechnology business. Biotech has become a global enterprise as countries such as China, India and Singapore invest billions of dollars to boost both the private and public sectors of biotechnology. These are concerns to the political and business leaders of the state.

Another future challenge the North Carolina biotechnology industry will find is manufacturing capacity. More pharmaceuticals and biologics will be coming online as they pass through the final phases of Food and Drug Administration (FDA) approval. Sales of biotechnology products are projected to grow 13–15 % annually (10). North Carolina will need to invest billions of dollars for facilities, education and training.

Shortfalls in manufacturing capacity are driven by six main factors; one of the most critical is shortage of talent and trained workers (9). A recent survey studying the constraints on biopharma competitiveness indicates that technical and production staffing shortages is the biggest factor limiting capacity (10):

Capacity Constraints

1–Lack of trained technicians and production staff (52 %)

2–Lack of talented scientific staff (30 %)

3–Inadequate current technology (27 %)

4–Physical capacity of equipment (26 %)

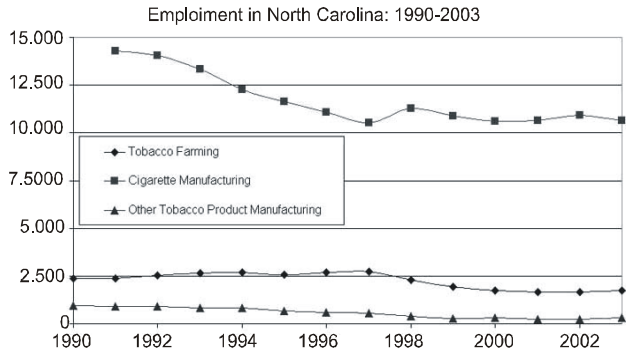
5–Inability to meet regulatory requirements (20 %)

To address pipeline needs, workforce training will need to be in three general areas: 1) GMP regulations, 2) Equipment operation and maintenance and 3) Production and manufacturing processes (11).

The Chicken Or The Egg?

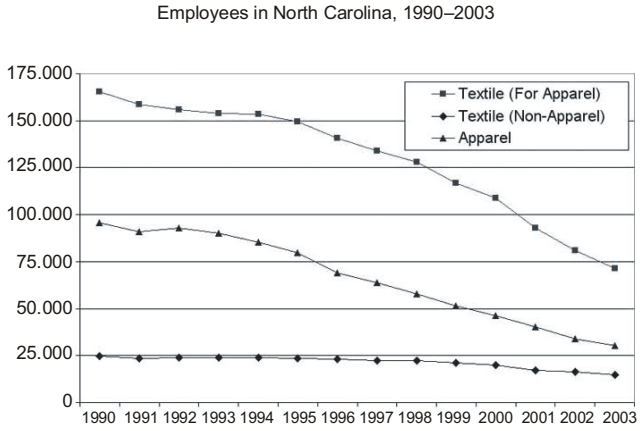
To attract new companies in a highly skilled and knowledge-based field such as biotechnology, it is imperative that there be in-place a skilled workforce. Rural regions of North Carolina may also have something to offer to the successful expansion of North Carolina biotechnology. The decision to begin designing and implementing biotechnology training programs in rural regions is somewhat controversial. There are two camps of thought. The situation can be likened to the old adage of the «chicken or the egg?» That is, why should we train people who must (presently) move out of the region if they are to work in biotechnology after graduation from college? Also, education resources could be used in a way that will directly contribute to the region's present needs. Conversely, it is argued that without the access to a stable, trained workforce, the prospects of recruitment of biotechnology and life science companies into the rural region is limited. The university, the state of North Carolina and the federal government see the option of training as the more attractive of two philosophies. It is much better to prepare a work force for technology jobs with the goal of attracting those industries in the foreseeable future than it is to simply do nothing.

Globalization has had profound effects on the rural economy. U.S. products and farm commodities no longer dominate world markets. Technologies have moved or been adopted by global markets to place highest volume and lowest cost in other countries. According to data collected by the Center for the Study of Rural America, the United States has recently been surpassed as the world's greatest producer of soybeans by South America countries (12). U.S. wheat production has slipped from 40 % of the world's supply to 25 % in the last three decades. Throughout the rural regions of North Carolina, traditional occupations and livelihoods are in decline. Between 1998 and 2003 tobacco farming declined 24 %; and all tobacco manufacturing dipped by 17 % (13).



Sourse: The Employment Security Comissin of North Carolina, Employment and Wage Data by Industry
http://eslmi12.esc.state.nc.us/ew/EWYear.asp?Report=1
NAJCS Codes: Tobacco Farming (11191), Cigarette Manufacturing (312221), Product Manufacturing (312229).
North Carolina in the Global Economy
http://www.soc.duke.edu/NC_clobalEconomy
Duke University, Duhrham NC-Fall 2004

The North Carolina textiles and furniture industry are also seeing hard times. North Carolina is the largest textile state (33 %) and fourth largest clothing manufacturing state (8 %) in terms of employment in the United States. Some of the largest textile and apparel companies in the world have plants in North Carolina. In the decade between 1993 and 2003, textiles saw a 30 % decline in the number of plants from 2 250 to 1 578, and a 57 % decrease in employment from 267 700 to 116 300 workers (13). Likewise, employment in the furniture industry declined sharply over the past decade with a 21 % decline in furniture employment since 1998 (14).



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NAJCS Codes: 313 (Textle Mills–Apparel), 314 (Textle Mills–Non-Apparel), 315 (Apparel Manufacturing).
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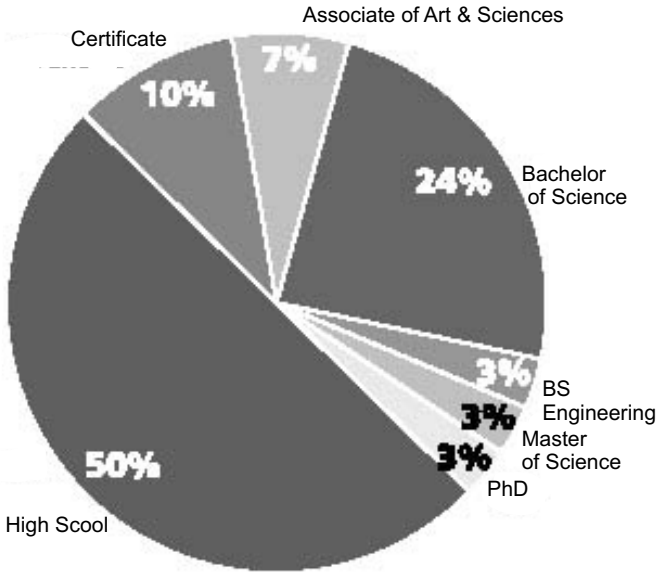
The Solution: Biotechnology Education and Training

North Carolina has launched several comprehensive education and training initiatives to strengthen the state's biotechnology capacity by: (1) attracting new biotechnology companies (2) retaining presently sited biotechnology companies (3) increasing the number of startups and catalyzing biotechnology product and service diversification (4) building entrepreneurship (5) promoting technology transfer and (6) development of biotechnology in rural parts of the state. There is one common denominator to these development challenges…a trained workforce must be available. Educational programs are being designed which target biomanufacturing, agricultural biotechnology, pharmaceutical and chemical manufacture and processing to prepare the workforce required by biotechnology.

Education required in the biotechnology business ranges from high school to Ph.D. level. Most of the research and development employees have BS to post-graduate degrees. The need for high school and two-year associate degree technicians will continue to increase.

The Biomanufacturing Workforce



Current Educational Profile

Source: New Jobs Across North Carolina,NCBC, 2004, (4).

Community College Efforts

The North Carolina Community College System (NCCCS) provides business incentives by developing a state-funded customized training program called New and Expanding Industry Training (NEIT), for qualified companies. NEIT's impact in the biopharmaceutical industry has been profound (3). NEIT has been valuable to the biotechnology sector and has contributed to North Carolina's particular niche in bioprocess and pharma-

ceutical training that industry representatives say is «unparalleled».

The North Carolina investment for statewide biotechnology growth is estimated at $600M million dollars through 2009. This investment will provide favorable return. For example, Merck, lured with $39.4M in state incentives, has begun building a 250.000 square foot vaccine plant in Durham. This facility will employ some 200 employees by 2009 (15). GlaxoSmithKline, with the help of a $1.29M state money, is expanding its manufacturing facility in Zebulon, North Carolina, creating 20 new jobs. Novo Nordisk is expanding its Clayton facility creating 187 new jobs with $100M of state investment money (16).

The community college system has produced the statewide NCCCS BioNetwork, an initiative connecting community colleges across the state. By providing training, programs and equipment, BioNetwork has helped to develop a world-class workforce for the state's pharmaceutical and life sciences industries (17).

The community colleges offer three levels of biotechnology training. (1) BioWork (2) Biotechnology Curriculum Programs (3) Capstone Center courses. BioWork, a national model, is a 128-hour introductory course aimed at training entry-level technicians in biotechnology, pharmaceutical, and chemical manufacturing. The course puts special emphasis on safety, quality, problem solving and teamwork. Over 400 students per year complete BioWork training. BioWork is fostered by the participation of large multi-national companies such as GlaxoSmithKline, Wyeth-Lederle and Bayer.

With the help of $60M from the Golden LEAF Foundation (18) and state and industry support, the community college system has created six Centers of Excellence to promote biotechnology education statewide. The diversity of the Centers reflects the diversity of the industry, people, geography and the resources across North Carolina: (1) BioBusiness, (2) BioAg, (3) BioEducation, (4) BioPharmaceutical, (5) CapStone and (6) BioProcessing Centers. Unemployed textile workers and displaced furniture personnel are now finding jobs in the biotech sector (19).

North Carolina Public University Effort

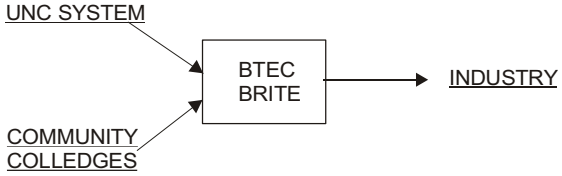
The University of North Carolina is comprised of sixteen universities. In the words of past University of North Carolina President, Molly Broad «UNC is a biotechnology catalyst» (20). With over $15B being spent annually, biotechnology is the world's most research-intensive industry. Many companies depend on UNC discovery that have commercial applications that begin in the university laboratory.

The North Carolina Biomanufacturing and Pharmaceutical Training Consortium (BPTC) is a creation of the University of North Carolina and the North Carolina Community College System. The capital investments in this project ($60M) is funded by the North Carolina Golden LEAF (Long Term Economic Advancement Foundation). Golden LEAF (GLF) was created in 1999 from tobacco settlement agreements with cigarette manufacturers to assist the state in making the transition away from its traditional tobacco-based economy. The Golden LEAF serves 84 North Carolina counties.

North Carolina State University (NCSU) is planning the 100.000 gsf Biomanufacturing Training and Education Center (BTEC). It is predicted that biomanufacturing will grow at a rate needing 2.500 new employees per year for more than another decade. Currently, fewer than 300 workers are being trained annually. The $36M BTEC project, slated for completion in 2007, will train 3.000 students and workers annually. BTEC will provide access to large-scale, pilot plant and clean room experiences, good manufacturing practices (GMP) and good laboratory practices (GLP) instruction. Dr. Peter Kilpatrick, Director of BTEC states: «The BTEC will be a major new force for statewide economic development and job creation in the biomanufacturing, pharmaceutical and related agricultural industries in North Carolina. This training exists nowhere else in the country and should serve as a magnet for new business expansions and relocations by this critical sector for our state's economy». BTEC is designed to train almost 3,000 students, employees and prospective employees annually (21, 22).

The other major university biotechnology initiative is being launched by North Carolina Central University (NCCU). The Biomanufacturing Research Institute & Technology Enterprise (BRITE) Center (65.000gsf) is designed to provide comprehensive training and state-of-art laboratories to conduct research in several areas critical to biotechnology and biomanufacturing (23). North Carolina Central University has expertise in cell culture assay development, macromolecular separations and data management which the functionality of the BRITE Center will build upon. BRITE programs will support the large-scale training offered in the BTEC Facility at North Carolina State University. BRITE received $17.8M from GLF and the North Carolina biotechnology industry has pledged $1.3M to purchase equipment and provide industry experts to inform the academic programming. The BRITE Center will open in 2007.

The Relationship of the BTEC and BRITE Centers to Biotechnology Training



The core competencies which lie at the heart of BTEC and BRITE include: Biochemistry Genetics Analytical chemistry.

The plan for designing curriculum is outlined in a 2005 North Carolina Biotechnology Center publication, *The Model Employee, Preparation Careers in the Biophar-maceutical Industry, North Carolina Biotechnology Center, 2005* (24). This publication contains detailed information about selected biophar-maceutical workforce job descriptions:

* Process Technician Control Quality/ Assurance

* Process Development Maintenance/Instrumenta-tion Technician

High School Biotechnology Education

Biotechnology education in K-12 is related to the economic health of a region because the quality of public education is a key factor that new technology businesses and industries measure when considering to site in a new location. The quality of K-12 science programs build basic skills of students in science and technology and has a large impact upon future career choices. Biotechnology education and training at the North Carolina secondary educational level is beginning to show its presence. High School curriculum is implemented by the North Carolina Department of Public Instruction. North Carolina first established a *Standard Course of Study* in 1998 (25). The North Carolina Standard Course of Study provides every content area a set of competencies for each grade and high school course. The present Standard Course of study is comprised of thirteen curriculum areas. The Science areas for high school includes:

– Biology and Physical sciences

– Chemistry and earth/environmental science

There are plans to integrate biotechnology into high school Career and Technical Education (CTE) curriculum. The North Carolina Department of Public Instruction, contracted with the North Carolina Biotechnology Center (NCBC), is launching an ambitious project to combine rigorous classroom instruction with curriculum preparing students for future careers.

The NCBC project includes:

– Publishing a career guidance book for students, parents, teacher and counselors

– Developing biotechnology-specific career maps

– Developing and reviewing K-12 biotechnology material

– Wide focus of agriculture, allied health, biological and chemical technologies.

The Center as well as federal agencies and private foundations fund many biotechnology «academies, camps, special courses and workshops» for North Carolina students and teachers. Greater than one-half million K-12 students have been introduced to bio-technology through Center-sponsored programs. The strategy that North Carolina is adopting toward strengthening K-12 math and science curriculum address three main needs:

– Take advantage of key opportunities

– Prepare teachers

– Provide the tools

Summary

The steady movement of traditional manufacturing and farming out of North Carolina has created a need to approach economic development and sustainability in new ways. North Carolina has undertaken a comprehensive strategy to build a stronger biotechnology industry with particular attention being paid to strengthening the economies of its rural regions. At the heart of this strategic plan are unified efforts and investment to develop a world-class workforce, thereby attracting new knowledge industries into the state while retaining the present excellent workforce. The state has recognized that it will be educational and training opportunities that will produce such a workforce. Education and training in biotechnology has been instituted at all levels in the North Carolina public institutions. The North Carolina Community College System is focusing on job training to produce technicians, scientists and business people with the requisite knowledge and biotechnology skills to supply the growing biotechnology industry. Through its *BioNetwork* Office the community colleges are organizing to grow their biotechnology training programs through cooperation and rational distribution of resources.

All public North Carolina universities are developing biotechnology courses, programs or degrees. North Carolina State University and North Carolina Central University have been funded by the North Carolina State Legislature and the Golden LEAF to construct state-of-the-art biotechnology facilities for training and research. These facilities are evidence of the deep commitment that North Carolina has to its biotechnology-based economy.

The North Carolina biotechnology industry is a stakeholder in sustaining biotechnology statewide. Approximately two hundred companies in North Carolina are engaged in biotech-related business. North Carolina biotechnology business is giving its support to education at all levels. Pharmaceuticals, biologics, agriculture, forestry, medicine, energy and environmental industries are working with North Carolina public education to sustain and increase the quality of life for all North Carolinians.

Acknowledgements

The authors would like to acknowledge Dr. Roger Brown and Ms. Sylvia Pate for their tireless efforts towards growing biotechnology in North Carolina as an engine for economic health state-wide. Much of this work was supported by a grant from the National Science Foundation, Award ID 0332650.

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УДК 53: 372.8

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О НОВОМ ПОДХОДЕ К ПРИНЦИПУ НАГЛЯДНОСТИ В ПРОБЛЕМЕ СООТНОШЕНИЯ ВИРТУАЛЬНЫХ И МАТЕРИАЛЬНЫХ НОСИТЕЛЕЙ ДИДАКТИЧЕСКИХ СРЕДСТВ В МЕТОДИКЕ ОБУЧЕНИЯ ФИЗИКЕ

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Рассмотрена концептуальная проблема наглядности и визуализации в дидактике физики для отражения в содержании обучения различной степени детализации учебного материала компьютерными средствами. Дано определение визуальной модели и сформулирована общая типология визуальных моделей. Показано, что наибольшую эффективность в обучении можно реализовать, применяя композиционное сочетание визуальных и натурных моделей, взаимосвязанных моделированием.

В связи с широким применением в педагогике современных компьютерных технологий (СКТ) появилась необходимость теоретического обоснования применения понятий наглядности и визуализации как для реального, так и виртуального представления объектов изучения. Наглядность рассматривается учеными педагогами и дидактами как средство ***активизации познавательной деятельности учащихся.*** Философы рассматривают проблему визуализации как метод научного познания и одну из актуальных гносеологических проблем. В теории и методике обучения физике эта проблема становится методологической в связи с широким применением компьютерных мультимедийных средств обучения. Кажущаяся простота возможности отражения в содержании обучения различной степени детализации учебного материала компьютерными средствами очень часто приводит к поверхностному изучению физических явлений. Следует отметить, что компьютерные визуализации часто фрагментарны, текучи, искажены личностными факторами, слабы по дизайну, который в последнее время становится элементом дидактики физики. Компьютерная визуализация сопровождается неустоявшейся терминологией; например, динамичные модели называют «живыми» и т.д. Имеется большая степень неопределенности, существующая в использовании терминов наглядности и визуализации при применении СКТ в обучении. Не являются разработанными типы визуальных моделей виртуальной реальности и теоретического знания, что необходимо при