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Running Head: CREATING ENVIRONMENT GEARED FOR BIOMEDICAL CAREERS

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ABSTRACT

Business, industry, and government provide fertile avenues for applications of mathematical sciences, and employment opportunities for highly trained mathematical scientists. Heretofore, collaborations between science academia and industry have focused on cooperation between research faculty and industry scientists. This paper seeks to extend this industry-academia interface by outlining an educational program which incorporates applications to industry and interactions with professionals in industry. After describing the philosophy and structure of the program, we describe various current and proposed collaborations between the faculty at a community college, a four year college, and the biomedical industry. These collaborations will fortify the proposed creation of a Biomedical Health Science (BHS) Career Program that is designed to provide students a working experience in the biomedical career world. The model designed for biomedicine can naturally be extended to any industry-related field of mathematics.

1. INTRODUCTION

Industrial mathematics is a rapidly germinating field within the mathematical sciences and aims to find the most efficient (i.e., cost-effective) way to solve problems which are

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relevant to industry (SIAM, n.d.). The problems originate from different sectors of industry such as research and development, finance, and communications. The prevalent characteristic of this field is the goal of obtaining a better comprehension and appreciation of industrial models and techniques through mathematical and scientific ideas and computations (Pyke, n.d.). One specific field of industrial mathematics is related to the health sciences. Over the past fifty years, health care in the U.S. has improved mainly due to advances made in health research. Applications derived from biomedical and behavioral research have contributed to the sharp decline in the death rate from AIDS, great improvements in survival rates from heart disease, and more effective treatments for cancer. Besides the obvious benefits of better health care, progress in many areas of biomedical research has led to promising and new career opportunities (Kelley, 1994). These opportunities must be pursued by professionals who have the adequate education to understand complex mathematical and scientific principles, and the appropriate training to apply these principles to the real life problems that industry presents.

This paper proposes a program which integrates mathematical science education with biomedical career goals and thereby prepares students to become the professionals that are needed to meet the new challenges of the biomedical industry. The unique feature of this program is its systematic approach that is designed to find students with potential, impress upon them the power of commitment and diligence, and allow them to realize their potential by affording them opportunities to interface with the health science

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industry. We firmly believe that a strong interdisciplinary career-based program that provides students with industry experience is the key ingredient for providing motivation for talented college students to realize their natural talents and abilities. The overarching priority and responsibility of STEM (Science, Technology, Engineering and Mathematics) education is to provide a potent and enhanced support system to ensure student success and career advancement in the world of applied mathematics and science.

2. THE PHILOSOPHY OF THE PROGRAM

Many mathematics and science curricula emphasize theoretical models and ideal situations. These approaches educate students in computational and analytical skills, but leave a gap between this educational training and the work environment. We propose the creation of an industry-focused curriculum within the mathematical sciences. The courses introduce various techniques and models from applied mathematics, science, and engineering as they are used in real world problems (Friedman & Littman, 1994). Such applications serve to motivate students and give them convincing reasons to pursue careers in applied mathematics and science. Our program is designed to enable students to understand technical issues, formulate precise and accurate mathematical models, implement solutions using the latest computer techniques, and convey these ideas to potential co-workers, managers, engineers, etc. With the increasing complexity and sophistication of modern industry, such personnel are becoming a necessary part of many organizations and companies. Examples of areas in industry which need such

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professionals are: signal processing, computer graphics, risk management, system reliability, software testing and verification, database systems, production line optimization, and marketing research (Ziegler, 1983).

In addition to the educational content of our program being focused on industry, the program is also designed to expose students to professionals from the real world in order to better prepare them to choose a career path. Studies show that most people change careers several times during their lives (Hansen, n.d.). A prevalent cause is that college students do not have proper guidance providing them with precise and clear-cut descriptions of the various career options. Rather, they are often misled by inaccurate descriptions of various careers which cannot be adequately portrayed in a written account. They only receive exposure to a career upon entering the work force when they realize that their chosen career is not what they had expected. In order to help prevent this unfortunate occurrence, a necessary ingredient for a robust industrial-educational environment is to provide students with appropriate exposure to industry while they are still in school. This issue is addressed in our program with the concept of a Health Science Career Day where professionals from industry are invited to describe the positive and negative components of their work experiences. These talks will introduce students to the realities of the world of industry and thereby complement the students' industry-focused education. The entirety of the philosophy of the program revolves around the integration of industrial career training into the educational program itself, as opposed to being an afterthought.

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3. THE STRUCTURE OF THE PROGRAM

The BHS Career Program is designed to create an environment conducive to active student research and industry interaction by: (1) reaching out to incoming high school and transfer students and existing community college students and introducing them to the world of biomedical and health science careers and research; (2) inviting students who have demonstrated talent and potential to excel in STEM research into the BHS Career Program; (3) motivating and guiding students to excel in BHS Career Program by giving them a flavor of the working experience; (4) revising mathematics course curricula to include real world applications from industry, biomedicine and health science; (5) forming research internships with local biomedical research centers and laboratories that will expose students to the real world of science research and give them experiences with biomedical and health science careers; (6) developing a strong interdisciplinary mentoring program to provide students with the necessary support to embark upon a course of applied STEM research; and (7) supervising students in the program, and those that transfer to four-year colleges. The totality of the research environment is designed to introduce students into the world of biomedical career research and scientific applications at an early stage of their education. This section elaborates on specific features of the proposed BHS career program.

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3.1 Curriculum Development: In order to properly prepare community college students for an industrial career path, the program calls for the revision of several mathematical courses. These revisions will make the courses more suitable for preparing the participating BHS students for research based careers. One of the key components of the course curriculum is the theme of applied mathematics and its correlation to the physical sciences. The understanding of the associated mathematical concepts is essential for a true understanding of these sciences and for the proper application of mathematics to technology-based careers.

In light of the above analysis, we have designed a *Biostatistics* course to include applications of statistics to the study of epidemiology, genetics, and preventive medicine. The course is designed to present a comprehensive view of the above fields by showing their interrelationships and emphasizing their relevance to clinical practice, math and science research, and public health policy. Students will be shown the use of statistics in clinical medicine and gain an appreciation of the use of probability in clinical decision-making.

Applications of Linear Algebra and Vector Analysis is another new industrial mathematics course that has been proposed. It presents the theory of linear systems and vector analysis and their applications. The course focuses on the mutually reinforcing components of modeling, solution techniques, and unification. These techniques are used in real-world problems that are encountered in applied mathematics, engineering, and science. Specifically, no specialty in medicine has seen more technological advancement

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than radiology (Sochurek & Miller, 1987). The course will focus on these advances and demonstrate how applications of mathematics are used to meet technological demands and advances. New and improved ways of imaging patients, integrative approaches that use the radiological techniques of computer axial tomography (CT) and positron emission tomography (PET) (Funkhouser, Jafari & Eubank, 2002) will be discussed. These discussions provide instances of significant accessible mathematical applications to modern medical science. These courses are but two examples of many possible courses which would be suitable for an industry-based mathematics curriculum.

3.2 Research Mentoring and Projects: Besides adjusting the course curriculum to meet the needs of an industry-based education, the program calls for the development of mentoring relationships and the assignment of research projects appropriate to industry related applications. This is another method to keep students abreast of industrial currents. They are put to work within an academic environment on actual industrial applications. Faculty who have collaborated with the biomedical industry and are familiar with the range of problems specific to the field can provide projects and independent study courses to students concerning concrete industrial problems. In the computer science program, appropriate application-oriented topics include: robotics, programming applications in hospital laboratories, and mechanical engineering and scheduling applications involving graph theory. The heartfelt realistic experiences discovered through a research experience provide a tangible account of industrial applications and

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enhance the traditional classroom learning process (Ziegler, 1983). To enable these research projects, the program is built around multi-level research mentoring teams consisting of research faculty and students. The faculty members will select suitable research problems for the students, elucidate the appropriate background literature, suggest directions for the research, and supervise each project. It is important that the mentors carefully assess the students' background and skill level in choosing problems for the students to pursue. Carefully chosen problems which are suitable for students' levels can be an excellent springboard to the world of mathematical research.

3.3 Student Cohorts: A vital feature of the BHS program is the provision for formation of student cohorts where the students are subdivided into groups which are each assigned to a specific industry or biomedical research center. Under the guidance of the research faculty and collaborators in the biomedical industry, each group would visit a work site and share their personal experiences with the rest of the cohort. The students relate their observations of the ordinary and the atypical procedures that take place at the work site or laboratory. Thus, some students get a firsthand look at an industry of choice while the other students obtain information about an industry directly from their peers. Additionally, this process helps students develop communication skills and initiates students to the process of working in teams, two all-important skills necessary for success in the workforce.

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3.4 Student Internships: Another important component of the BHS Career Program is student internships. These internships are beneficial to industry and students alike. The industry gains from useful labor of the students who can contribute to the development and expansion of the biomedical industry. The students get a chance to observe the day-to-day activities of professional employees, to involve themselves in an actual industrial experience, and to see the relationship of the classroom material to a real life industrial setting. These internships will provide employment experience that will prove advantageous for future career considerations.

3.5 BHS Forums: Once each semester, the program will sponsor an educational forum that informs the faculty and participating students regarding up-to-date research advances in the world of biomedicine. The forum will be given by invited researchers who share their experiences, thoughts and advice with the students of the program. The objective of these forums is to enlighten the students and give them a strong impression of and attraction for the world of biomedical research. Appropriately chosen speakers can provide a strong motivation for students to pursue a career in biomedicine.

3.6 Career Support: The program calls for organizing an annual Health Science Career Day that introduces and acquaints students with companies and research centers. As these centers provide career employment opportunities in biomedicine and health science, they will send representatives to describe some of their personal work experience and research activities. Additionally, they will address significant questions such as types of biomedical research problems, previous research results, salary rates, percentage of entry level positions, employee benefits, working conditions, degree

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requirements, previous work experience requirements, promotions, and internship opportunities, giving the students an inside look into the reality of a biomedical career.

3.7 Alumni Relations: It is imperative that one addresses the issue of how to convey to students the multifarious benefits of an interdisciplinary mathematical education. One of the most appealing resources for this kind of information is alumni. When students graduate and start working in industry, they gain a concrete understanding of the practical applications of what they have learned in the academic setting. Fresh out of a theoretical environment, they appreciate how the formulas and the equations that they pondered in their courses are used to solve real life problems. This leads to a new-found excitement, almost a relearning of the theory, but this time via practical applications. In many instances, students have only heard of applications, but have never experienced the nitty-gritty operational aspects of the application of the theory. Industry gives the right setting and context for hashing out the ideas learned in rigorous textbooks.

It cannot be disputed that when prospective students witness successful professionals from their peer group, they are motivated to believe that the education they are pursuing has value and content. Alumni are one of the best resources that prospective or newly enrolled students can have access to, to glean important information about how to structure their college experience. There are two approaches to utilizing this huge resource. Firstly, the students seek out alumni in particular areas of industry and attempt to gain an understanding of the exact skill set that is used in the particular area of work. In discussions with alumni, prospective students glean a snapshot of the path that eventually led the alumni to their chosen work, be it by way of college courses, focused

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internships, or other vehicles of training. Understanding this path also provides tangibility to a process that otherwise appears quite overwhelming and somewhat arbitrary. Instructors can design projects for students to seek out alumni from various branches of industry and interview them. These interviews would be written up and presented to the class. Since different areas of industry are typically represented by the students of a given class, this approach has the desirable effect that students come to appreciate the multiple aspects of various jobs. Student questions will be encouraged, and if there is sufficient interest and unanswered questions, a second visit might be in order. Secondly, one can invite alumni who are successful professionals to engage in a Q&A session with the students of the program. These sessions will be preceded by an introduction to the area represented. Many alumni are only too happy to revisit their alma mater which was a stepping stone to their success. They often view it as "giving back" to the community that nurtured them.

Crucial to this approach is for the college to have a functioning alumni relations wing that is up to date on alumni employment, contact information etc. This is best accomplished in a manner that is also available for students to access. A website containing alumni information, accessible to enrolled college students, will allow students to get their own sense of the options available after graduation. Periodic emails are also to be sent to alumni requesting them to update their information, if any changes have occurred.

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4. CONNECTIONS TO INDUSTRY AT COMMUNITY COLLEGE AND SENIOR COLLEGE LEVEL

Without concrete connections to industry, this program cannot truly be implemented. Thus, to illustrate how we plan to achieve the preceding goals, this section describes the collaboration between the faculty at a community college (Kingsborough Community College (KCC)) and a senior college (Brooklyn College) with the biomedical industry. This collaboration is the backbone and infrastructure necessary for the formation of the program. This section also illustrates our college's focus on educational programs related to health sciences.

4.1 KCC's Focus on Health Sciences: The KCC administration has demonstrated a significant interest in career programs related to health science by its recent commitment to associate degree programs for surgical technologists and physical therapist assistants (Kingsborough, 2006). The college has received positive responses from three hospitals indicating support for the program and offering to serve as clinical sites, providing clinical faculties, and serving on the Advisory Committee for the BHS program. The President of the New York Society of Radiologic Technology Educators has been brought in to consult on the development of this program.

The college is in the process of expanding its health science horizons by creating a joint A.S. in Biotechnology degree program in collaboration with Brooklyn College.

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This program will include basic computing technology, statistics, and mathematics through calculus during the four years of the program. Although there exist career opportunities for students with only an A.S. degree in biotechnology within the allied health field, the pharmaceutical industry, and research labs, the community college students will be encouraged to continue their education and earn a Baccalaureate (B.A. or B.S.) in Biology at the senior college to broaden their career opportunities.

4.2 Community College and Senior College Faculty Collaborations with Industry: We describe the various industry-academia collaborations between the community college and senior college faculty in the field of biomedicine.

A professor from KCC has been collaborating with Dr. Richard Goldfarb, Division of Nuclear Medicine of Beth Israel Medical Center, in forming student internships where students will observe patient care aspects of diagnostic imaging and radionuclide therapy. The students will actively contribute to academic research and publications of scholarly material.

We have also established close relationships with the biotechnology industry in many regions. Faculty routinely attend conferences organized by the New York City Economic Development Corporation (NYCEDC), New York Biotechnology Association (NYBA), New York State Foundation for Science, Technology and Innovation (NYSTAR), and New York Stem Cell Foundation (NYSCF) in order to keep up-to-date with the new needs developing in the biotechnology industry.

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Faculty at KCC have collaborated with the faculty at University of Pittsburgh Medical Center, Radiology Department in the design of a system to minimize the occurrence of medical errors.

The senior college offers the Academic Associates Program, a capstone, center-piece, and top quality selective program enrolling some of the very best students. These students are involved in biomedical research at Kings County Hospital Trauma Center and Downstate Medical School and Hospital, SUNY. Most students win honors at graduation. The students are encouraged to continue beyond their AS degree to BS degrees in the sciences and become members of the exclusive Academic Associates program by doing biomedical industrial research even before graduating. The Academic Associates program is the ideal enrichment partner for the BHS Career Program.

One of the program coordinators of the Academic Associates program at the senior college and a faculty member from the Biology Department at KCC, along with the collaboration of a faculty member from the CIS Department at the senior college are proposed to supervise the transfer of the community college students and provide them with academic and career advisement to help in the transition process. They will encourage the transferring students to apply to the Academic Associates program, and will assist them in adjusting to the biomedical career environment.

5. CONCLUSION

The proposed BHS Career Program is a promising new educational program

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which seeks to incorporate into the traditional undergraduate mathematical education a training program for students who wish to pursue careers in the field of biomedicine. The model which this paper presents can be extended from the field of biomedicine to any other sector of industry which is integrally connected with mathematics and science education. The growing need in our society for professionals who are educated in theoretical knowledge and who are also equipped with practical skills calls for the wide implementation of similar programs in many different disciplines.

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