Meeting Community Needs: Safety and Fire Engineering Technology Program

Edward R. Sheinberg, Alberto Gomez-Rivas, and George Pincus
Assistant Professor/Professor and Chair/Professor and Dean
Department of Engineering Technology, College of Sciences and Technology, University of Houston-Downtown

Abstract

The Safety and Fire Engineering Technology program at the University of Houston-Downtown developed in response to community needs and request for technical training in safety and fire science by area fire departments. The four years Bachelor of Engineering Technology is designed to prepare professionals to asses and reduce the loss potential in industrial settings with respect to fire, floods, tornadoes, explosion, and hazardous material accidents. The program provides the graduate skills and knowledge of current trends in industrial safety, fire science, equipment operation in practice, and computer simulations.

The curriculum provides a solid foundation in basic and technical sciences and includes applied courses in facilities and catastrophe management. Courses offered by natural Sciences, Mathematics, Management, and Criminal Justice departments are also included in the curriculum. Courses in other areas support the program, such as Human Factors in Psychology. Other technology courses also complement the program. Computer usage is an essential component in the Safety and Fire program, thus, simulation program are used to train students in fire propagation studies and also in management methodologies for safety. Fire codes evolving from prescription of specifications to specifications of performance are included.

Implementation of a program that fits the schedule of firefighters requires creative scheduling in delivery of course materials. Firemen work in alternating shifts that do not allow for participation in standard college courses. Most students joining the program will have preliminary college courses from two-year community colleges leading to associate degrees. Articulation agreements with these institutions have been established.

The paper describes development of the Safety and Fire Engineering Technology program, institutional response to community needs, curriculum, facilities including laboratories and simulation programs, student background, and depicts program growth. Finally, conclusions describe reasons for success of the program and future plans for continued development.

Introduction

This paper describes the Safety and Fire Protection Engineering Technology program at the University of Houston-Downtown (UHD). The historical development of the program is described to emphasize how UHD meets the needs of the community. The objectives of the program were initially developed to satisfy community needs and the mission of the Engineering Technology Department of the University of Houston-Downtown. One

important consideration was the fact that the fields of safety and fire protection are migrating from a code or prescriptive orientation to one of performance supported by computer simulations. References to safety and fire include all areas concerned with elimination or reduction of loss potential in industrial settings. These potential losses include fire, floods, tornadoes, explosion, and hazardous material accidents.

The methodology selected for instruction was based on the performance approach supported by computer simulation programs developed by the National Institute of Standards – NIST - that are becoming standard practice in safety and fire engineering. The study of fires, floods, tornados, explosions, and handling of hazardous materials is ideal for the application of computer simulation because of their complexity and difficulty to accurately reproduce conditions in instructional laboratories.

The faculty of the department reviewed the curriculum of similar and related programs at several institutions in the U.S. and abroad once the goals of the program were established. This paper discusses the content of the courses that constitute the technical core of the safety and fire protection academic program. Simulation principles used in specific courses and its application are described to illustrate the value of computer simulations in student understanding of critical variables during fires.

Integration of the program into the existing department curriculum was also an important consideration. The department offers three other engineering technology programs in fields that are related to safety and fire protection. Courses from these programs were incorporated into the curriculum and enhanced with additional safety and fire protection considerations. Figure 1 shows students doing research on the effect of ambient temperature on the vital functions of an individual.

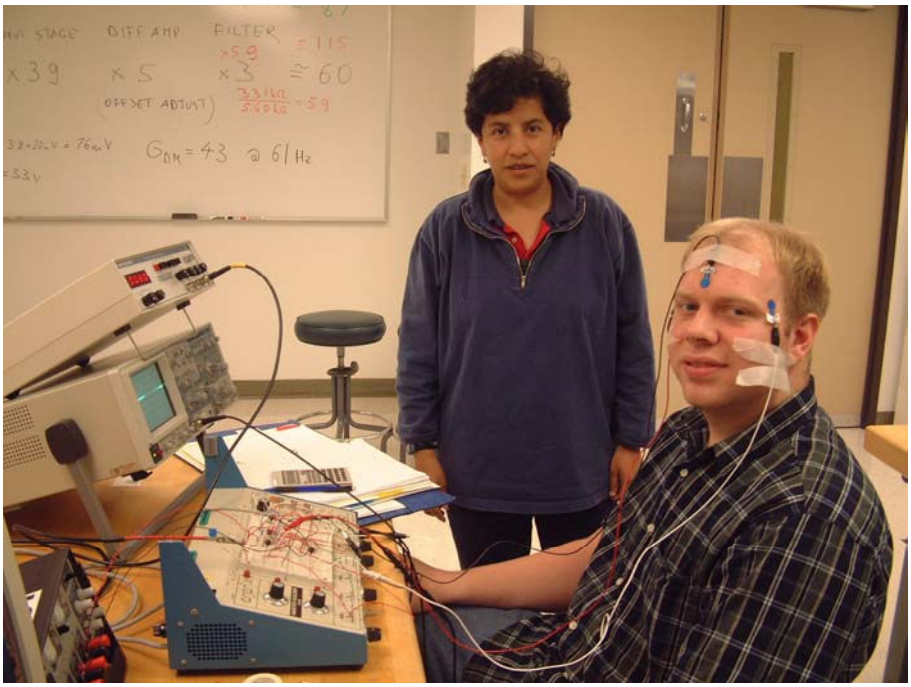

Figure 1. Students performing research on physiological effects of ambient temperature

Implementation of the program required additional considerations. The variable schedule of firefighters, integration of the program into the existing curriculum of the university; faculty recruitment and development, laboratory improvement, and articulation agreements with other institutions, among others, were important components of the implementation plan.

A review of program growth is included below. Finally, terrorism attacks of September 11 and continuing threats have created a strong demand for additional programs in safety and fire protection.

History of the program

A number of institutions and individuals within Houston, for example, the Society of Fire Protection Engineers, Houston Chapter, and the Houston Fire Department were faced with scarcity of fire protection professionals and specifically, to complete pending contracts for the Houston Fire Department. This concern was communicated in 1997 to members of the University of Houston System Board of Trustees who, together with UHD's administration, requested the Engineering Technology department to assess the need for a safety and fire academic program in the Houston area. The Texas Higher Education Coordinating Board approved the program in 2000 and the first students registered in the fall of that year.

The faculty of the Engineering Technology Department began preparation for the establishment of the program when the request of the Board of Trustees was received by the university. The first step was a feasibility study that requires study of the similar programs at other institutions. The programs selected for study were those with emphasis on fire protection engineering. The faculty of the department did not have backgrounds in fire protection engineering which was necessary for the feasibility study and implementation of the program. However, the department chair was invited to visit Worcester Polytechnic Institute's (WPI) Fire Protection Engineering program (Professor David Lucht, P.E., is Professor and Director, Center for Firesafety Studies). WPI's Fire Protection Engineering program has since helped our program and their generous support and advice is gratefully acknowledged.

Based upon the advice of Professor Lucht and the faculty's experience in computer simulations, the Safety and Fire Protection Engineering Technology program was developed using a performance approach. The approach is based on computer simulations and a curriculum with content similar to the program at WPI. However, the program at WPI leads to a master of engineering. Study of the contents and instructional materials of the WPI program gave the faculty of the engineering technology the necessary background to develop a program at the undergraduate level. Furthermore, the program coordinator and the department chair studied in detail each one of the WPI courses and audited distance-learning courses in order to develop the UHD undergraduate curriculum.

The Program Coordinator is a Mechanical Engineer with extensive experience in safety acquired during many years as a consultant to NASA and private industry. He has developed strong links with the community through the Industry Advisory Board and the Houston Fire Academy. The Industry Advisory Board includes representatives of the Houston Fire Department, Rolf Jensen & Associates, Conoco, Celanese, Halliburton, KBR, Texas Instruments, South East Fire, HSB Control Professional Loss, Insurance Alliance, Fire Risk & Safety Technology, and Chero-Key Piping Co, Inc. Thus, the board includes most representatives of the community involved in safety and fire protection activities. In

particular, the program coordinator developed a strong link with the Houston Fire Academy and participated in the design of upgrades for the burn house that is used by our students to observe fires and conduct experimental procedures. Figure 2 shows the burn house.

.
Figure 2. Houston Fire Academy burn house

Objectives of the Program

The goals of the program were established based on the request of the community to prepare graduates with a strong background in safety and fire protection engineering and the mission of the Engineering Technology Department that requires programs to prepare students to be ready to work after graduation applying the latest engineering principles and technologies. These requirements oriented the program towards the performance approach to safety and fire protection. It is of interest to compare the prescriptive and performance approaches in safety and fire protection.

The prescriptive approach or method applies codes without further engineering analysis of the problem. The method does not provide alternatives and is very inefficient in the use of resources and materials. Prescriptive codes are typically applied when there are no tools of analysis for a problem. On the other hand, the performance approach analyzes a case and based on modern engineering principles develops a design that satisfies the safety and fire performance requirements of the specific case. Many different alternatives may be considered in this approach, which is used in most other branches of engineering. The analysis of different alternatives provides more economical and rational solutions to a problem.
Fire protection problems involve many variables that represent combustibles, structural materials, and the geometry of the building including windows and doors. Furthermore, time is a critical variable because the goal is to provide time for escape. The development of an engineering model representing realistic cases makes the use of computer simulations imperative. Furthermore, computational procedures require extensive validation because of the possible consequences for human life. Thus, the program focuses on preparing graduates able to apply performance-oriented methods of safety and fire protection based on computer simulation.

Methodology

Figures 3, 4 and 5 show three stages in the development of a typical room fire. The goal of engineering analysis is to determine a temperature vs. time graph as shown in Figure 6. The data is analyzed to determine time to escape from the room by the occupants. Occupants need to escape before the temperature reaches 100 C, which in this case is about 5 minutes. The maximum temperature reached in the fire and duration of temperatures above 1000 C is interesting to determine the fire resistance of the structure.

Figure 3. Fire ignition of a chair

.

Figure 4. Growth of fire to ceiling

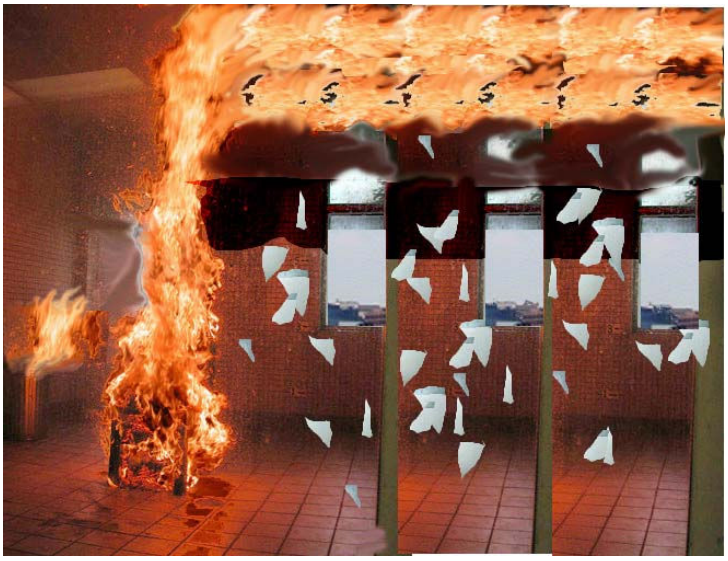

Figure 5. Glass breaking during room fire

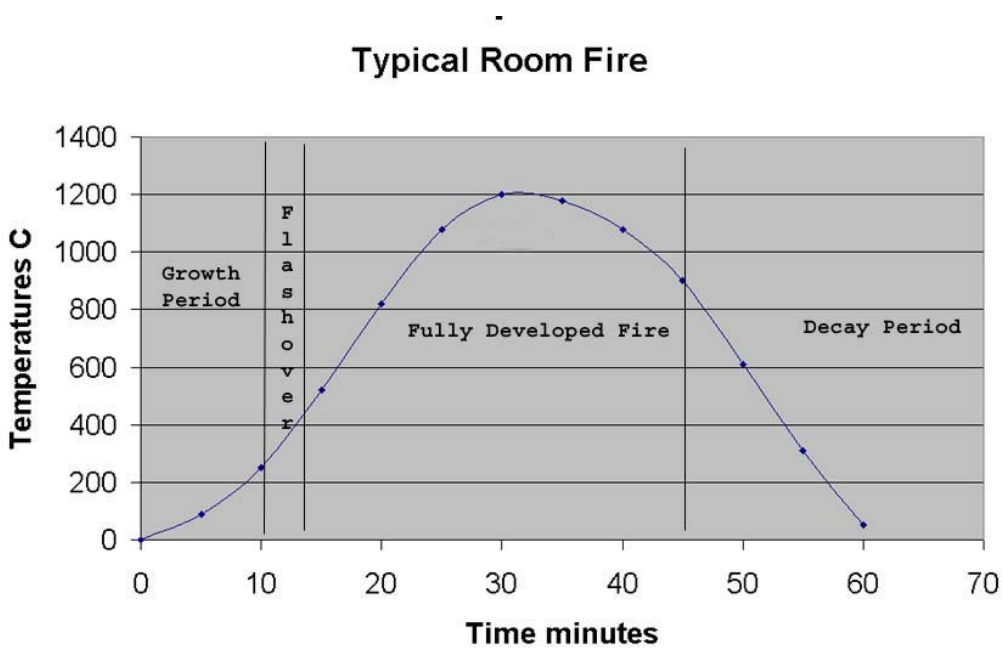

Figure 6. Room fire temperature vs. time

The manual method requires establishment of equations based on thermodynamics, chemistry and fluid dynamics taking into consideration the nature of fuels and its quantity, the 3D configuration of the room including location of the doors and windows, and the thermal characteristics of all materials in the room. The location of a sleeping occupant in the room is also relevant

.

The problem allows for some simplifications such as the dual zone model that assumes a layer of fire and smoke at the top and breathing air at the bottom as shown in Figure 4. It is not difficult to imagine the mathematical complexity of the problem and the enormous amount of information from different sources required for the solution of the problem. The complexity of the problem does not yield a practical manual solution and therefore, the only alternative is the prescriptive approach validated by observation of similar room fires in the past. It is also important to note that due to the complexity of the analysis, fire science is taught at the graduate level only in several academic institutions.

The modern computer simulation method operates as follows: The National Institute of Standards – NIST- , the National Fire Protection Association –NFPA-, and other research institutions including testing laboratories, insurance companies and universities, have developed computer simulation models that are in the public domain. The models are based on advanced principles of fire dynamics and have been validated with standard fires and with analysis of historical cases such as the fire at the MGM Hotel in Reno, Nevada in 1980, where 85 lives were lost[1].

The models serve two main purposes: Engineering analysis and education in fire science. The engineering analysis application is well documented in the literature. The part that is relevant for the purposes of this paper is the educational aspect of computer simulation. This paper emphasizes the use of fire models because they are the most common. The simulation models used in instruction are also applicable to explosions, floods and handling of hazardous materials.

It is difficult to describe the educational difference of the two possible approaches to fire dynamics. In the manual method, the student is presented with complex differential equations with an unknown closed solution[2]. The student is expected to understand fire behavior using these equations. However, the complexity of the mathematics does not allow for clear visualization of fire behavior.

The fire models on the other hand provide the students the opportunity to understand the dynamics of the equations because the models are essentially numerical solution of the differential equations. Furthermore, the output is presented in a dynamic graphical environment that allows testing and validation of different hypothesis. The student can obtain a solid background in the dynamics of fire in this interactive environment.

Students in the fire protection program can use the computer to develop fires starting with very simple cases, study the effect of different fuels, and compare the color and temperatures of the flames with the theoretical values presented in their textbooks. They can also study the effects of changing dimensions of a window on the temperatures in the room. Sitting in front of the simulation screen, students and faculty can develop a practical knowledge of fire science that is almost impossible to acquire in a lifetime. It is also possible to try different configurations of sprinkler systems and obtain their optimal location for fire extinction. Figure 7 shows the program coordinator illustrating a fire model during a fire dynamics class.

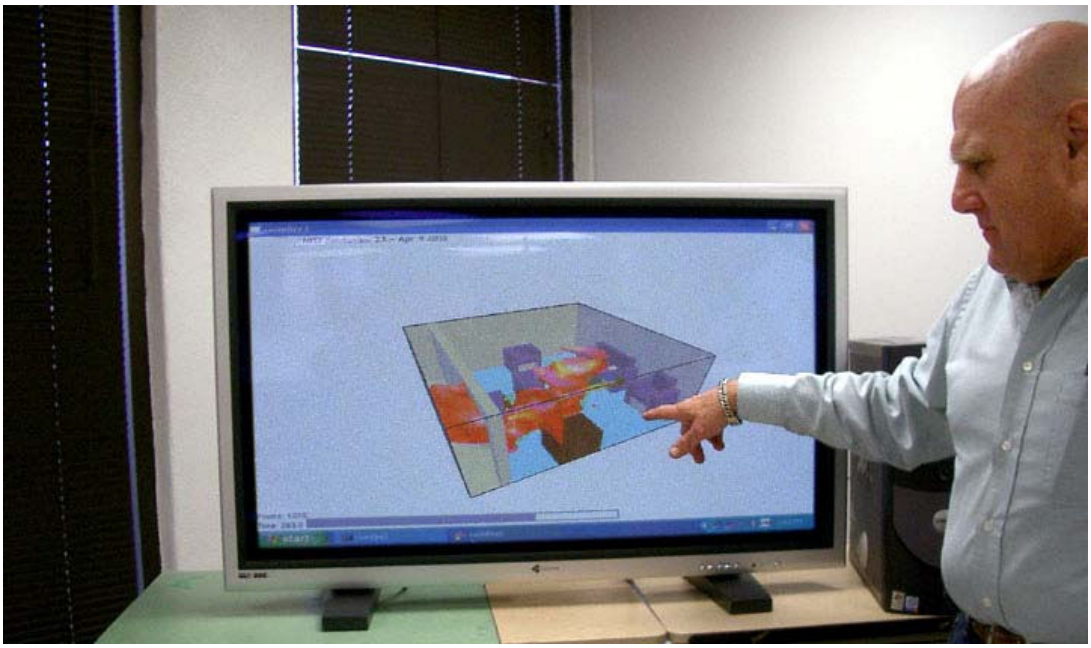

Figure 7. Program coordinator illustrating dynamic fire model

Curriculum

The curriculum of the program is divided into two main parts. The first part is the common core that satisfies general university requirements for Bachelor of Science degree. This group of courses includes English composition and literature, mathematics, natural sciences, humanities and arts, social sciences, and computer literacy.

The second part includes the technical content of the major filed of study, in this case, safety and fire protection. The technical core was developed to answer the following question: What are the basic sciences and branches of engineering required to understand and manipulate the computer simulations. Thus, a set of courses combining basic sciences, engineering applications, and management were selected and compared with similar curricula at other institutions. At present, the technical core involves courses in the general areas of safety, fire protection systems, fire dynamics, and human factors in fire protection. Table 1 shows the student degree plan.

Table 1. Safety and Fire curriculum (130 semester credit hours)

FRESHMAN												
			GRD	HRS	SEM					GRD	HRS	SEM
ENG	1302	Composition II		3	ALL		ENGR	1400	PC Applications		4	F,S
HIST	1305	US History to 1877		3	ALL		HIST	1306	US History after 1877		3	ALL
PHYS	1307	General Physics I		3	ALL		PHYS	1308	General Physics II		3	S
PHYS	1107	General Physics Lab I		1	ALL		PHYS	1108	General Physics II Lab		1	S
EET	1411	Circuits with lab		4	ALL		SPCH	1304	Intro. To Speech Comm.		3	ALL
ENGR	1402	F & S Haz. Rec. (fundamentals)		4	F,S		ENGR	1403	Fire S & D Systems		4	S
				18							**18**	
SOPHOMORE												
			GRD	HRS	SEM					GRD	HRS	SEM
ENGR	1302	Engr. Fund. (Hydraulics)		3	F		ENGR	1404	Auto Fire Supp.		4	S
CHEM	1307	General Chemistry I		3	ALL		ENGR	2409	Engr. Mechanics		4	S
CHEM	1107	General Chemistry Lab I		1	ALL		ENG	23XX	Soph. Eng. Literature		3	ALL
MATH	2401	Calculus I		4	ALL		ENGR	2407	Surveying GIS-GPS		4	SU
ENGR	2410	Analysis of Engr. Ntwks.		4	ALL							
				15							**15**	
JUNIOR												
			GRD	HRS	SEM					GRD	HRS	SEM
ENGR	4410	Indust. Hygiene Inst.		4	F		POLS	2304	US Government II		3	ALL
POLS	2303	US Government I		3	ALL		ENGR	3302	Engineering Economics		3	F,S
ET	3308	Material Science		3	ALL		ENG	3302	Business Tech. Writing		3	ALL
ENGR	4350	Indust. Loss Prevention		3	F		MGT	3301	Managment of Organization		3	ALL
		Fine Art Course		3	ALL				Social Behavioral Science		3	ALL
				16							**15**	
SENIOR												
			GRD	HRS	SEM					GRD	HRS	SEM
ENGR	4420	Fire Dynamics		4	F		ENGR	4360	Advanced S & F Problems		3	S
ENGR	4330	Systems Safety Mgt.		3	F		ENGR	4450	Industrial Safety		4	S
		ELECTIVES		9	ALL		ENGR	4370	Human Factors in F & S		3	S
							ENGR	4411	Stru Design for Fire Safety		4	S
									ELECTIVE		3	ALL
				16							**17**	
Electives (12 Hours)							(S=Spring, F=Fall, SU=Summer)					

Implementation Strategies

It is important and interesting to observe that in a country facing critical attacks similar to those of September 11 there are only a few programs in fire protection engineering while there are several hundred programs in mechanical, civil, electrical, and other branches of engineering.

There is great misunderstanding in society related to fire fighting and fire protection engineering. Fire fighting, one of the most important and demanding professions, deals with the physical activities related to fire extinction. Fire protection engineers design fire sprinkler and alarm systems, exit and smoke control systems; do risk analyses of major industrial facilities and consult with architects on buildings ranging from high rise structures to hospitals, hotels, and sports stadiums. They investigate fires and explosions, assure safety in the NASA space program and industrial plants, and do fire experimentation and research.

Personnel of the fire departments can greatly enhance their abilities to plan fire-fighting strategies but there are many other activities of society where fire protection engineers are employed, Good paying jobs abound in business, government, and industry, for example: consulting engineering firms, petrochemical industries, insurance companies, federal agencies, health care facilities, and code enforcement agencies. The number of jobs consistently outweighs the number of engineers available to fill them[3].

Faculty recruitment has been the most difficult task in implementation of the program. As stated in the WPI report the employment opportunities for graduates of fire protection programs is greater than the number of engineers available. Furthermore, there are only two graduate programs in fire protection in the country. Since teaching at the university requires at least a Master's Degree, filling faculty positions has been extremely difficult.

UHD's Engineering Technology Department opted to train faculty to teach in the safety and fire area. Several other fire protection programs have followed this approach, that is, to retrain faculty with graduate degrees in other branches of engineering such as mechanical and civil in safety and fire protection.

Technology is a key ingredient in performance oriented fire protection because it provides alternatives to old traditional methods. The department has an electrical technology faculty member, with extensive background in electronics and industrial experience in fire protection devices now teaching courses related to alarm systems and developing laboratories for instruction in fire protection electronics.

The Safety and Fire protection program currently includes three tenured faculty members with advanced degrees in engineering and academic or industrial experience in fire protection. Six adjunct professors with extensive safety and fire protection experience in the Houston area support the three tenured faculty members. An important factor in the development of the program is the participation of Houston Fire Department Chiefs as Adjunct faculty, see Figure 8.

Figure 8. Program coordinator and Fire Chief (Adjunct Faculty)

Class Schedule

The program has students both from industry and from fire departments. Students from fire services have rotating shifts that make college attendance difficult. To alleviate the situation most courses in the program are offered on alternate days, such Monday and Tuesday. This approach is theoretically simple but on the other hand, the variability of the student body creates a sense of instability for faculty and students. Additional fine-tuning of the system to become an ideal learning environment continues.

Recruitment and Articulation Agreements

The program coordinator has developed an intensive program of recruitment through the fire services. Working in collaboration with the fire chiefs in Houston, he visits the fire stations to give presentations about the program. He has also developed promotional materials that are used in presentations in area high schools. The coordinator together with the advising staff of the university has developed articulation agreements with several junior colleges and with college based fire academies.

Program Growth

The initial courses in the program were offered in the fall 2000 with only two registered students. The graph shown in Figure 9 depicts growth of the program from fall of 2000 to fall 2003. The program has grown from 2 to 30 students in three years. Three students are expecting to be the first graduates from the program in the spring 2004. The future growth of the program should be enhanced by the increasing emphasis on the development of fire protection personal as suggested in a recent report of the National Academy of Sciences[4].

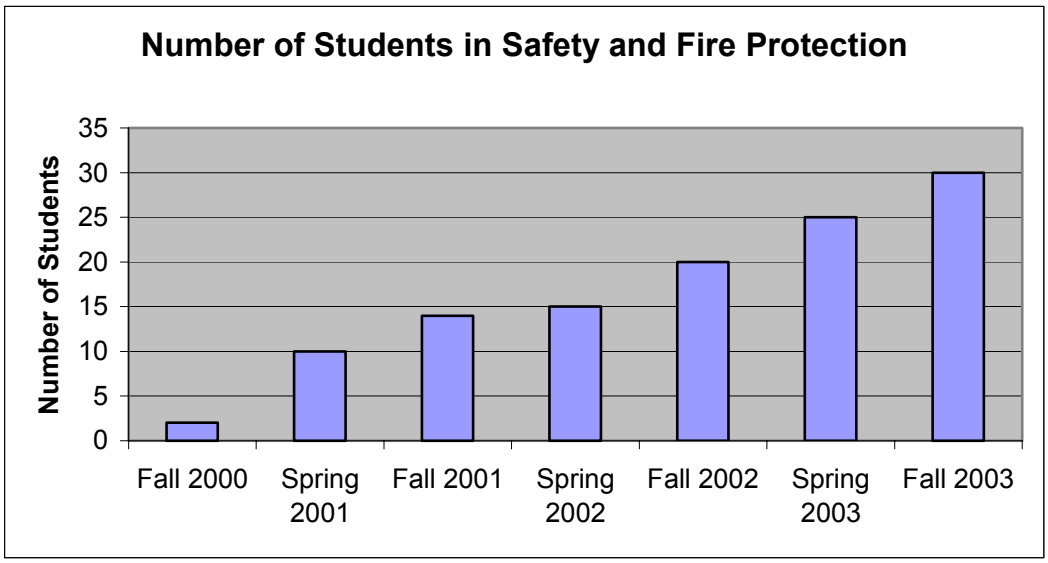

Figure 9. Program growth from 2000 to 2003

Conclusions

This paper describes the development of the program Safety and Fire Protection Engineering Technology suggested by the Chief of the Houston Fire Department following inputs from the local Society of Fire Protection Engineers. The program developed following the requirements of the community such that its implementation agrees with the mission of the Engineering Technology Department at the University of Houston-Downtown.

The request of the community implies preparation of personnel trained to perform professional tasks in fire protection engineering dealing with the application of science to the protection of lives and structures from fire. The paper reviews the accepted definition of fire protection engineering as distinct and different from traditional fire fighting.

The curriculum implemented in the program follows the content of graduate level programs in fire protection modified for the undergraduate student level. This model has been applied in other programs of the department with great success for more than ten years. The growth of the program is relatively robust especially for a program in an entirely new local discipline and in which there are only a few national programs.

University of Houston-Downtown faculty and administration provide extraordinary support to the Fire and Safety Engineering technology program. Future growth and continued development of the program is expected thus becoming another key academic program in the arsenal of community-oriented activities offered by the University of Houston-Downtown.

Bibliography

[1] Buchanan, A. W., "Structural Design for Fire Safety," John Wiley & Sons, LTD, New York, 2000.
[2] Drysdale, D., "Introduction to Fire Dynamics," John Wiley & Sons, LTD, New York, 1998.
[3] WPI Report, "Taming an Element: Two Decades of Making the World Safe from Fire," Worcester Polytechnic Institute, Worcester, Massachusetts, 2003.
[4] NAS Report, "Making the Nation Safe from Fire," National Academy of Sciences, Washington, DC, 2004.

Biographical Information

EDWARD R. SHEINBERG

Edward R. Sheinberg is Assistant Professor of Engineering Technology and Coordinator, Safety and Fire Engineering Technology program, University of Houston-Downtown. Professor Sheinberg received the Master of Mechanical Engineering degree from the University of Houston. He is a Registered Professional Engineer and has extensive industrial consulting experience with NASA and other engineering firms.

ALBERTO GOMEZ-RIVAS

Alberto Gomez-Rivas is Professor of Structural Analysis and Chair of Engineering Technology. Dr. Gomez-Rivas received Ph.D. degrees from the University of Texas, Austin, Texas, in Civil Engineering and from Rice University, Houston, Texas, in Economics. He received the Ingeniero Civil degree, with Honors, from the Universidad Javeriana in Bogotá, Colombia. He also served as Chief of Colombia's Department of Transportation Highway Bridge Division.

GEORGE PINCUS

George Pincus is Dean of the College of Sciences and Technology, and Professor at the University of Houston-Downtown (1986-date). Prior service includes Dean of the Newark College of Engineering and Professor, New Jersey Institute of Technology (1986-1994). Dean Pincus received the Ph.D. degree from Cornell University and the M.B.A degree from the University of Houston. Dr. Pincus has published over 40 journal articles, 2 books and is a Registered Professional Engineer.