University of Massachusetts Lowell NIOSH TPG Final Report
for the period 7/1/2010 – 6/30/2015

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II. List of Abbreviations

ABET	Accreditation Board for Engineering and Technology
BMEBT	Biomedical Engineering and Biotechnology Program
BSPH	Bachelor's of Public Health
CPH-NEW	Center for the Protection of Health in the New England Workplace
CWEND	Center for Work, Environment, Nutrition & Human Development
DWE	Department of Work Environment
GESH	Global Environmental Sustainablility and Health
KSC	Keene State College
LCSP	Lowell Center for Sustainable Production
MSD	Musculoskeletal Disorder
NIOSH	National Institute for Occupational Safety and Health
OEH-IH	Occupational and Environmental Hygiene – Industrial Hygiene
OS-E	Occupational Safety & Ergonomics
ScD	Doctor of Science
CHS	College of Health Sciences
TURI	Toxics Use Reduction Institute
TWH	Total Worker Health
UConn	University of Connecticut
UMass	University of Massachusetts
UML	University of Massachusetts Lowell
WE	Work Environment
WESA	Work Environment Student Association

III. Abstract

The Department of Work Environment (DWE) was established in the fall of 1987; the name Work Environment was chosen to reflect a commitment to addressing all aspects of the workplace that contribute to workers' well-being and to environmental protection. DWE offers master's and doctoral degrees organized into four training programs leading to Master of Science, Master of Public Health, and Doctor of Science degrees. The Department typically has between 50 and 60 enrolled students and graduates an average of 15 students per year.

Since the founding of the department, our academic objectives have been represented by three broad educational outcomes that guide our training of professionals and promote the development of healthy and sustainable workplaces:

(1) recognition and evaluation of occupational health and safety hazards, including improving and developing scientific methods to measure health effects and exposures at work and in the environment;

(2) control and prevention of occupational and environmental health & safety hazards and promotion of healthy alternatives, such as contributing to design of production systems that are non-polluting, healthy and safe, economically and energy efficient, and non-wasteful of natural resources; and

(3) development and implementation of workplace interventions including health and safety programs as well as other social and economic policies.

Our integrated approach to health and safety strives to answer the basic question, "What is the optimal design of a healthy workplace?", and how can it be achieved?" It is our premise that specific problems, such as chemical exposures, biomechanical demands, and psychosocial stress are best addressed as a system rather than individually. We seek to close the gap between occupational and environmental health sciences and politics by understanding the inter-relationships between environment, work, and other influences, both nationally and internationally After more than 25 years of teaching, research and service, the feedback we receive from alumni, employers, unions and other partners has consistently validated the strengths of this integrated approach to all aspects of health and environment at work.

The Department is located in the College of Health Sciences (CHS) which includes the School of Nursing and Departments of Public Health Studies, Clinical Laboratory and Nutritional Sciences, and Physical Therapy. Through these degree programs, the College prepares future professionals to practice with knowledge, competence and respect for the interdependence of human and global well being. Our location in the CHS allows our students to have access to clinical data on work-related disease and opportunities to see occupational health from a health care delivery perspective.

The DWE is a major national and international occupational health and safety research center. Along with its five affiliated centers and institutes (see below), the Department faculty and staff maintain highly productive programs of research in a wide range of relevant fields. In FY 2013 the Department and affiliated centers received approximately 40 grants and contracts totaling about

$4.0 million. This active research program provides a rich environment for hands-on training of master's and doctoral students.

IV. Highlights and Significant Results

Work Environment NIOSH trainees benefit from a variety of different learning experiences within the Department of Work Environment and its affiliated centers and institutes, as well as in collaborating departments and research groups. The Department is fortunate to be mainly housed in a single building, Kitson Hall, with laboratories and two of its research centers in nearby buildings. This compactness means that there are many formal and informal opportunities for trainees to work together and to participate in Department activities.

Interdisciplinary learning among the four training programs is reinforced by the fact that trainees frequently take elective courses in the other programs, providing numerous opportunities for interdisciplinary discussions both in and outside the classroom. For example, many students in safety/ergonomics take courses offered by OEH-IH faculty in exposure assessment and exposure data analysis, which has led to increased interaction between industrial hygiene and ergonomics faculty members about course material pertinent to both fields. Cross-fertilization also occurs with other departments within UML. For example, graduate students in both Mechanical Engineering (ME) and Physical Therapy (PT) may select Work Environment options in their degree programs, leading them to take three to four safety/ergonomics courses. In turn, Ergonomics students may take courses in the PT Department. Doctoral students in any DWE program take advanced anatomy and physiology courses in order to broaden their knowledge in those areas. Nursing doctoral students often take several DWE epidemiology and biostatistics courses.

DWE students have significant interactions with the Departments of Psychology, Political Science and Economics, taking courses in the socioeconomic and psychological aspects of work, family, and community, while students in those departments also take courses of ours such as Work Environment Policy and Practice and Intervention Research. Several DWE faculty members actively participate in the intercampus Biomedical Engineering and Biotechnology (BMEBT) program. Departments from three colleges are actively involved: Engineering, Science, and Health Sciences. Dr. Buchholz was the founding program director and served in that role for the program's first ten years. He and other DWE faculty are lead advisors on BMEBT doctoral research projects. BMEBT doctoral dissertations are interdisciplinary by design, with all research committees having members from multiple departments.

The Department holds a research seminar on Mondays at noon approximately five times per semester. NIOSH trainees are expected to attend these seminars. Topics cover the full range of work environment fields, and speakers are frequently visiting experts from academia and government. Attendance by faculty, staff and students is generally very good at these events.

At the end of each academic year, graduating master's students present their capstone projects orally to a jury of the faculty in an event that takes most of one day. All NIOSH trainees who are not presenting their capstone projects (master's students completing their first year, and doctoral students) are

expected to attend this event which is an excellent opportunity to learn about the full range of work environment professional practice and research topics in the Department.

A semi-annual research symposium has been organized since 1998 by the UML and the University of Connecticut faculty and research staff. The occupational medicine program at UConn Health Science Center (Farmington) is a particularly valuable partner for Work Environment trainees. Students, staff and faculty from both universities who are working on occupational health and safety topics attend this day-long event held in Sturbridge, MA, halfway between the two campuses to present and discuss work in progress. Occupational psychology faculty and graduate students from the main UConn campus at Storrs also participate, broadening the scope of discussion even further. All NIOSH trainees are expected to attend at least one of these semi-annual Sturbridge research symposia.

Five vibrant research centers affiliated with the Department of Work Environment provide many opportunities for applied training experiences highly relevant to the NIOSH training program. NIOSH trainees are introduced to these centers in the orientation session, and the centers' work is frequently described in courses and seminars.

The Department of Work Environment has between 50 and 60 students enrolled each year. The NIOSH trainees benefit greatly from the diversity of our student body. Roughly half of our students are going to school part-time while working full time in business and government in the region. The other half are enrolled full time and "in residence". Many of these are from other countries, studying in the U.S. on student visas. In 2013, the Department was home to students from 21 countries. Another valuable dimension of the student body's diversity is provided by students sent from the military services, most frequently the U.S. Coast Guard. There is often a student on academic training leave from NIOSH as well. Alumni frequently report that this intellectual and cultural diversity was a major benefit of their time in the Department of Work Environment. The percent of our graduates who are Under Represented Minorities (URM) has risen steadily over the last 25 years and in the most recent 5 year period was 19%.

The Work Environment Student Association (WESA) is an association with annually-elected leadership. The University provides a small budget that is used for organizing social events as well as seminars on topics like how to find a job in your field. This organization provides a supportive community for students from all the work environment fields. WESA also serves as an informal support system for the students and offers networking for applicants to the Department, such as tours, housing advice and opportunities to ask current students about their experiences in the programs.

Program faculty members collaborate on research with occupational health researchers including occupational medicine physicians not only at the University of Connecticut Health Center but also Harvard Medical School, the Harvard and Boston University Schools of Public Health, Tufts School of Medicine, UMass. Medical Center in Worcester, and Yale Medical School.

These collaborations have also involved graduate students in various ways, ranging from single-semester course projects to doctoral research.

Highlights: Occupational/Environmental Hygiene

The training our students receive prepares them well for today's job market, where OEH professionals typically take on additional duties such as safety, ergonomics and environmental compliance. Unique among occupational and environmental hygiene programs is the highly integrated nature of our curriculum that introduces students to all of the core areas. The term "Work Environment" was chosen to reflect the philosophy underlying the Department's operation, namely, to address all aspects of the workplace as they contribute to workers' well-being. We take an integrated approach to worker health and safety as we strive to answer the basic question, "What is the optimum design of the healthy workplace?" It is our belief that specific problems, such as chemical exposures, biomechanical demands, and psychosocial stress are best addressed comprehensively rather than individually. This approach applies to occupational and environmental hygiene, as well as other programs within the department. For OEH-IH students the existence of the Toxic Use Reduction Institute (TURI) and the Global Environmental Sustainability and Health (GESH) program within the Department provide the opportunity for unique training in the area of hazard control focused at the source rather than through retrofitting.

The OEH-IH program underwent an ABET recertification beginning in 2010 and our ABET accreditation is now current through 2018.

Since 1990, the OEH-IH program has had 33 master's graduates and 3 doctoral graduates that were NIOSH trainees. According to our recent alumni survey 96% of our OEH-IH graduates are currently working in the occupational and environmental health field. The Occupational and Environmental Hygiene program has increased its efforts at recruiting undergraduates from Keene State University and the UMass Lowell environmental health program by offering a BS/MS option.

Highlights: Safety/Ergonomics

This program provides the only comprehensive academic training in occupational safety/ergonomics in the New England region. It is one of the broadest such programs in the nation, with a highly integrated curriculum that introduces students to all of the core OHS areas and trains them as real-world problem-solvers on behalf of worker health and safety. Topics included within the core and OS/E program include introductions to safety engineering, ergonomics and human factors, biomechanics, laboratory and field methods for job analysis, psychosocial stress and work organization, and epidemiologic aspects of acute injury and musculoskeletal disorders. This provides our students with a unique health protection approach to safety/ergonomics and an ability to keep up with future advances in relevant areas.

Further, the option to complete requirements for both the safety/ergonomics and the occupational and environmental hygiene (OEH-IH) master's degrees is a unique educational opportunity that has been increasingly

popular as many private employers have consolidated multiple job functions, requiring broad cross-training.

Many universities locate the study of safety and ergonomics in colleges of engineering, typically in departments of industrial or operations engineering, and consequently often treat OS/E as a sub-specialty of workplace design for greater efficiency in production. In contrast, DWE incorporates safety and ergonomics into an integrated treatment of worker health and safety protection, located within a public health program. As a consequence, our students acquire a solid foundation in the public health principles and methods that are necessary for comprehensive risk reduction, as well as a full appreciation of the breadth of their future professional responsibilities.

An additional way in which our definition of occupational ergonomics is more comprehensive than most is that it is not limited to biomechanical risk factors for MSDs. While this is obviously an important area, the basic concept of "fitting the task to the person" implies a much broader perspective. In particular, very few other university training programs in OS/E have incorporated the study of psychosocial strain and work organization issues to the same extent, especially with expertise as well developed and recognized as at UML.

DWE is home to one of four national NIOSH Total Worker Health™ (TWH) Centers of Excellence, the Center for the Promotion of Health in the New England Workplace (CPH-NEW, Grant No. 5U19OH008857). The TWH program calls for examination of the opportunities, limitations, health benefits and cost-effectiveness of integrating health protection (OHS) and workplace health promotion programs. The CPH-NEW paradigm is rooted in an evidence-based orientation toward work organization characteristics as underlying or upstream determinants of both OHS hazards and personal or "lifestyle" behaviors (smoking, inactivity, etc.). Further, the CPH-NEW approach to implementing TWH programs has been heavily informed by the participatory ergonomics literature. Thus, the systems approach which underlies the DWE safety and ergonomics curriculum has also been put into practice within this research initiative.

A new addition to the OS/E program is a joint program with Keene State College (KSC), in southern New Hampshire, which offers a bachelors degree in safety management (BS in Safety and Occupational Health Applied Science: http://www.keene.edu/catalog/programs/detail/369/bs/). This program emphasizes program administration (including legal and ethical considerations) more than engineering content but does include introductory material on ergonomics/human factors, industrial hygiene, and environmental health. The SOHAS program graduates 90-95 students each year, some of whom have enrolled in previous years and successfully completed our M.S. degree program. KSC faculty members indicate that more of their graduates would be interested in pursuing a subsequent master's degree with a more technical orientation, but there has not been a systematic recruitment process in place until now.

In our 2014 survey of DWE graduates, we asked respondents to evaluate how well the program had preparted them for their careers. The 33 OS/E graduates who responded gave largely favorable evaluations. Alumni were

strongly positive regarding their technical competence, with 78% saying that they were “very well” prepared; analytic skills to solve complex problems (79%), and able to analyze and solve OSH problems (82%).

Highlights: Occupational Epidemiology

Occupational epidemiology taught at UML is tightly linked to the other work environment fields, encouraging a thoroughly integrated perspective from the very first courses. The essential components of epidemiologic method and perspective taught in any master’s level program in epidemiology are found in the Department of Work Environment (DWE) curriculum, but trainees benefit from learning this material organized around themes of work, environment and health.

Master’s training in epidemiology at UML prepares graduates to:

- Conduct research into the causes of occupational injury and illness;
- Design, analyze, and operate surveillance systems and other databases gathering data on injury and illness experience, as well as on exposures and hazards in the work environment; and
- Participate as team members in the design and conduct of injury and illness prevention programs, and in health and safety training programs.

Doctoral training in epidemiology at UML prepares graduates to:

- Teach epidemiology at the undergraduate or graduate level;
- Conduct independent research in epidemiology; and
- Contribute to health and science policy development in occupational health and related fields.

While all epidemiologic studies share many common features, the effective application of epidemiologic methods in the occupational setting creates certain opportunities and problems that may need particular attention when training the work environment specialist. For example, occupational epidemiologic studies place heavy emphasis on the quantification of exposure. Exposure control strategies – from the setting of health standards to the choice of personal protection equipment, to the design and evaluation of engineering controls - all require quantitative exposure-response information for the development of exposure-response curves and insight into possible thresholds. Whether the exposure of interest is chemical, biomechanical, physical or psychosocial, a summary measure must be developed that is relevant to the particular health outcome of interest. The epidemiologic methods for the estimation of such information, and the limitations that arise in application of these methods, are key components of the epidemiologic approach taught at UML. Students become comfortable from the first course in the master’s program with considering biomechanical and chemical exposures in closely parallel ways. Exposure assessment -- an integral part of occupational epidemiology -- has here become an active area of research in and of itself for occupational epidemiology students as well as those in hygiene and safety/ergonomics.

Our emphasis on an integrated work environment perspective has another impact on the teaching of epidemiology. Students become aware in their

introductory courses about the role of psychosocial stressors as modifiers of physical and chemical hazards at work. This generates an awareness of the importance of the assessment of effect modification in standard epidemiologic methods, and allows a more sophisticated presentation of the approaches to the study of interaction than are typical in basic epidemiology courses.

Another example of the emphasis of occupational epidemiology at UML is the collection and analysis of surveillance data. Public health surveillance is related to etiologic epidemiology, but too often epidemiologists presented with routinely collected surveillance data attempt to analyze them as if they come from a formally designed study of a specific risk factor. Through case studies, capstone projects and doctoral dissertations, students at both the master's and doctoral level learn to appreciate how surveillance programs can be used to inform occupational health prevention.

Field epidemiology experience for master's degree students is provided through capstone projects and internships. Important providers of these experiences include: NIOSH-funded research projects in the DWE like the Center for the Promotion of Health in the New England Workforce (CPH-NEW) and the Safe Homecare Project; the state departments of public health in Massachusetts and New Hampshire; and the Massachusetts Toxics Use Reduction Institute (TURI) which is housed in our department. Exposure to clinical case experience is available through colleagues at Harvard University, the University of Connecticut, and Liberty Mutual Research Institute for Safety.

Professional epidemiologists who will focus on occupational problems need not only an understanding of their science, but also how to manage studies in the high-stakes environment of labor/management relations and how to address the needs of epidemiologic risk assessment for the setting of occupational standards to protect worker health. Moreover, there is a growing emphasis on the formal evaluation of the effectiveness of control technologies and other workplace interventions, and occupational epidemiologists need to know how to design studies to evaluate these. Occupational epidemiology in the program is taught as a fundamentally interdisciplinary science, and students come to see the importance to epidemiology of the full range of other offerings in the work environment sciences and related disciplines, including physiology, toxicology, biostatistics, industrial hygiene, biomechanics, psychology, sociology, and public policy.

The Occupational Epidemiology program has recently been drawing increasing numbers of students directly from undergraduate programs including mathematics, community health, and since 2014, a new bachelor's degree in public health. While this is a welcome development, it has been important to increase internship opportunities for these relatively young students who often have little experience in any public health field.

In the 2014 alumni survey, we found that 78% of NIOSH trainee graduates in Occupational Epidemiology were employed in a Work Environment field. We consider these data to be strong evidence of the long term positive impacts of the training programs on occupational safety and health and related fields. In the same survey, the Occupational Epidemiology graduates were very positive about

the preparation they received in their master's or doctoral training. For example, 90% of the respondents reported that the DWE prepared them "very well" to develop technical competence in the fundamentals of recognition, evaluation, control and prevention of occupational and environmental hazards. Only a single respondent of the 31 who trained in Occupational Epidemiology said he/she was "not well" prepared in these areas.

Highlights: Work Environment Policy

WE Policy aims to create social and technological conditions that support worker and community safety, health and well-being within specific workplaces and/or broader systems of work and the ambient environment. WE Policy is applied at local, regional, national, and global levels and frequently aims to understand the links among them in relation to identifying health and safety problems and their solutions. The scope of WE Policy includes:

- Analysis of the technological, social, economic, and work organizational sources of occupational and environmental illness and injury;
- Analysis of the incentives and barriers to safe, healthy and sustainable work environments;
- Analysis of technologies and development of social and economic policies to promote occupational and environmental health and safety, healthy work organization, and the health of working people in all aspects of their lives (Total Worker Health™);
- Evaluation of policy and technical interventions to improve working conditions, work organization, health and safety;
- Analysis of the contribution of technical and social structures of work (organization, processes, materials, practices, products and their use and disposal) to global occupational and environmental health and safety;
- Anticipation and evaluation of health, safety, and environmental hazards of emerging technologies and preventive interventions.
- Design/Re-design of work organization, processes, practices, and technologies to prevent occupational and environmental health hazards at the source (Prevention through Design).

WE Policy methods are guided by a commitment to:

- provide equal access to occupational safety and health (OSH) information to all impacted stakeholders (e.g. industry, labor, government, upstream suppliers, downstream consumers, healthcare professionals)
- identify and promote potential OSH solutions, in addition to OSH problem assessment
- engage stakeholders in participatory decision-making to define OSH problems and design and implement their solutions (Research to Practice -- r2p).

The WE Policy program trains new professionals and researchers to enter the field of OSH for the first time and it also trains professionals from a variety of sectors who are already engaged in some aspect of OSH but have never acquired formal, academic training in OSH. Many professionals who engage in occupational and environmental safety and health policy do not have adequate training: economists and lawyers know little of the scientific and technological

issues; health scientists have not been trained in social analytic methods and policy development. Many work environment experts have little understanding of the necessity and means of "risk communication" with the broad public; and few have an understanding of the social dimensions of the problems that they are seeking to address. The DWE program in WE Policy is designed to bridge the quantitative and social disciplines that evaluate the workplace. This blending of social science with technical knowledge is embodied in our own WE Policy program faculty members, whose collective higher education includes economics, sociology, management science, political science, architecture, and regional planning, as well as biology, physiology, ergonomics, safety, occupational and environmental hygiene, cleaner production, and chemical, mechanical, and process engineering.

Another important aspect of the WE policy program is that it provides an opportunity for technically trained students to expand the arena in which they can operate. Industrial hygienists, ergonomists and safety professionals who have been practicing in their field sometimes want to have an impact beyond their particular employer or clients but they have limited knowledge of, for example, organizational management strategies or economics. Training in WE policy enables them to extend their OSH reach. Equally important, technically-trained OSH practitioners are often thwarted in their attempts to introduce seemingly reasonable hazard control strategies into workplaces because they do not know how to operate successfully in the social and work organizational context surrounding their technical solution.

The WE policy program exposes students to a wider perspective through which to analyze incentives and obstacles to prevention at different levels of work organization and society. Understanding of these incentives and obstacles allows these practitioners to target interventions that fit the larger regulatory/policy climate within which their company operates, as well as to mobilize broader support for policy change. Our doctoral and masters students are often employed in positions related to WE policy while they study, providing application of their knowledge through course projects in a real-world setting and iterative feedback loops between teaching and practice.

The WE Policy program includes courses that address international, federal and state legislation and administration along with the basic economic and risk assessment tools needed to develop and analyze public policies. In addition to health and safety protection, new directions for the WE Policy program include teaching methods to promote worker well being and environmental sustainability. Students are trained to understand and critically evaluate social policies, such as U.S. Occupational Safety and Health Administration’s (OSHA) regulations and other policies, International Labour Organization’s (ILO) labor standards related to OSH and fundamental principles and rights at work , World Health Organization’s (WHO) healthy workplace model, international chemical policies for occupational and environmental health and safety, worksite injury and illness prevention programs (I2P2) – both international OSH management system frameworks and U.S.-based I2P2s, and to develop new policies to address emerging OSH issues. WE Policy courses

aim to teach students to analyze the social, political and economic context and determinants of OSH problems and solutions. Students learn to develop their own policy argument, for example, developing a proposal for a new OSH regulation and marshaling the evidence for and against it. The WE Policy program also teaches social history, case studies, and cross-national studies as methods for analyzing problems and developing new approaches to preventing workplace injury and disease.

Over the entire NIOSH Training Program (1990 – 2014) the WE Policy Program has graduated a total of 30 NIOSH Trainees 14 of whom were doctoral graduates. Among the four Department of Work Environment NIOSH Training Programs, this is the highest number of doctoral graduates, tied only with the Occupational Epidemiology Program.

In the 2014 alumni survey, we found that 87% of WE Policy graduates were employed in a Work Environment field. In the same survey, the WE Policy graduates were very positive about the preparation they received in their master's or doctoral training. Ninety one percent of the respondents reported that the DWE prepared them "very well" to develop technical competence in the fundamentals of recognition, evaluation, control and prevention of occupational and environmental hazards. There were only two respondents of the 46 who trained in WE Policy who said they were "not well" prepared on any of the survey items.

For the most recent five year period, we were able to determine the employment status of all 21 WE Policy graduates. All are working in a relevant field, as researchers or practitioners in some branch of environmental and occupational health and safety. Seven WE Policy graduate work in universities, five in manufacturing, four in government, three in health care, and one each in transportation and OS&H consulting.

V. Outcomes-Relevance-Impact

Ninety-four percent of NIOSH trainees enrolled since 1990 successfully completed a graduate degree. This percent is quite similar across the four training programs (Table 1).

Table 1. Summary of NIOSH trainee graduates since 1990.

Training Program	Master's degree	Doctoral Degree	Total
Occ.Env Hygiene	33	3	36
Safety/Ergonomics	20	4	24
Occ Epidemiology	22	14	36
Work Env Policy	16	14	30
All Programs	91	35	126

We attempted to contact all graduates to learn about their employer and job title. We successfully identified this information for 81% of our graduates. Using these data, we determined that overall, 86% of NIOSH trainee graduates are employed in a Work Environment field (Figure 1). This fraction was somewhat higher for graduates of the OEH/IH training program (96%) and lower in Safety/Ergonomics

and Occupational Epidemiology (79% and 78% respectively). The figure was 87% for WEP. We consider these data to be strong evidence of the long term positive impacts of the training programs on occupational safety and health and related fields.

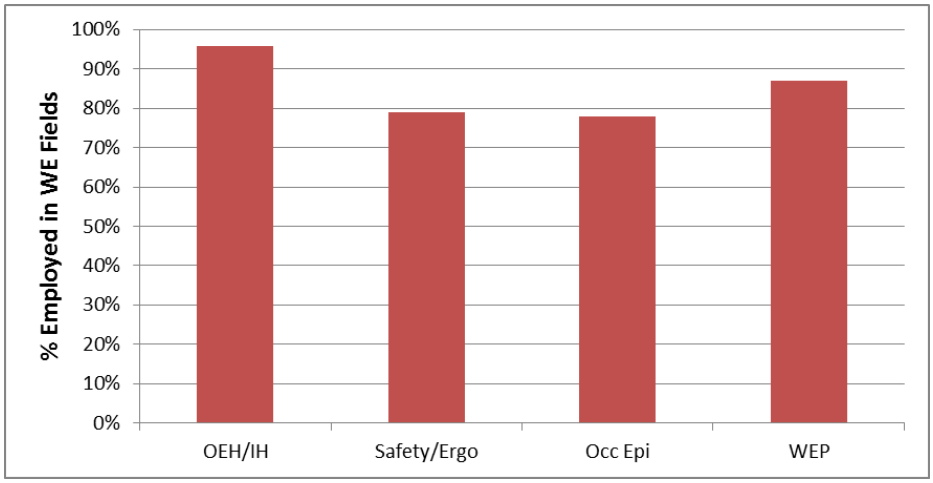


Figure 1. Percent of NIOSH trainee graduates employed in a Work Environment field.

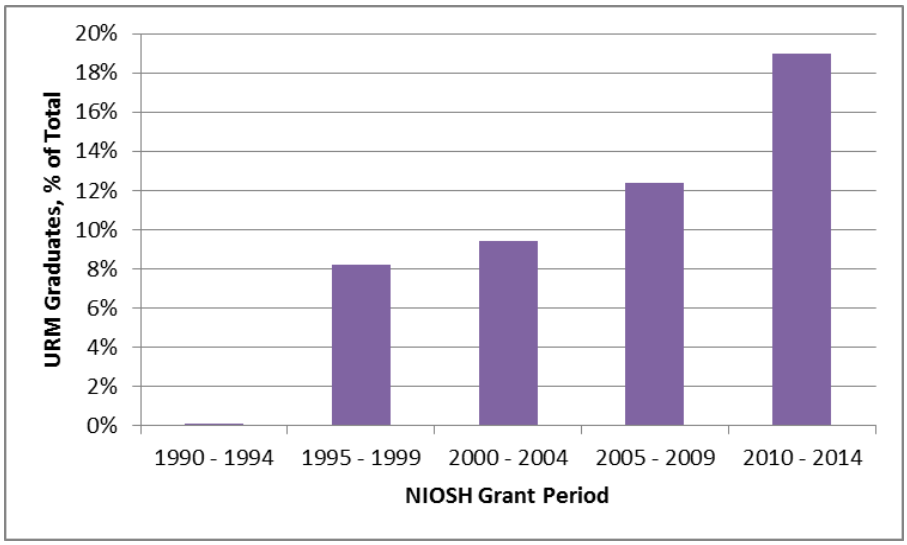
Minority Recruitment & Retention. Nearly two-thirds of the under-represented minority and/or disabled applicants entered the program (Table 2), a number quite close to that for all other applicants.

Table 2. URM/Disabled trainees applied, admitted, entered, 2010-2014

	URM/Disabled Trainees Applied	URM/Disabled Trainees Offered Admission	URM/Disabled Trainees Entered Program
Number	29	26	19
%	100	89.7%	65.5%

Using data on applicants since 1990, we were able to look at long-term trends in enrollment (Figure 2). There is a trend of increasing URM graduates over the entire period of NIOSH training grants to Work Environment. In the most recent NIOSH TPG grant period, 2009 – 2014, there were 43 NIOSH trainees who graduated. Eleven of these (26%) were under-represented minorities. This is higher than the percent of all Work Environment graduates who were URM (19% in Figure 2). We believe that one in four successful NIOSH trainees being a URM is a significant achievement that demonstrates the success of the Department of Work Environment using NIOSH traineeships to attract and retain under-represented minorities.

Figure 2. Under-represented minorities as % of total graduates.



Trainees from the most recent grant period 2009-2014 have published at least 30 papers in the peer-reviewed literature during or subsequent to their training.

The NIOSH training budget devotes most — about 80% — of the requested funds directly to trainee stipends, tuition and fees and travel. This is possible because the cost of supporting a graduate student at UML is relatively low compared to private universities; tuition and fees range from $13,000 to $23,000 (full-time student), depending on residency status (in-state/out of state) and number of credits. In addition we offer a stipend of about $13,000 for the academic year. All full time tenure track faculty receive nine month 100% "hard money" salaries from the Commonwealth of Massachusetts. Thus our ability to devote most of our training grant money to student support, together with the relatively modest cost of a graduate education at UMass Lowell, has allowed us to attract many excellent students to each of our four training programs.

VI. Technical Report

Background

A. NIOSH-TPG Funding History.

For the period 2010 to 2015, the NIOSH-TPG Training grant has provided continued program support for four training programs: a) Occupational and Environmental Hygiene-Industrial Hygiene (OEH-IH), b) Occupational Safety/Ergonomics (OS/E), c) Occupational Epidemiology, and d) Work Environment Policy. The four programs are taught through the Department of Work Environment (DWE) at the University of Massachusetts Lowell. These programs have been funded by NIOSH since 1990, with support at the master's and doctoral level for each program.

B. Department of Work Environment Administration.

The DWE is organized under an elected Chair presiding over the faculty, with a general faculty meeting once or twice per month led by the department chair and having input from all department members. The current chair is Professor Bryan Buchholz. Research faculty members are also invited to attend. Key departmental activities are carried out by three independent committees that also meet at least once per month: a) Recruitment and Outreach (Dr. Quinn, Coordinator); b) Administration and Finance (Dr. Buchholz, Coordinator); and Academic Affairs (Dr. Woskie, Coordinator). Decisions within the committees and the full faculty meeting are reached by consensus.

The department is organized academically into program areas, each one directed by a faculty member. The four academic training programs are supported with NIOSH training funds. There are also five research centers and institutes affiliated with the department. Consistent with the department's consensual management approach, most department administrative issues are addressed and resolved by the faculty of the Department meeting as a committee of the whole. Issues that are narrowly defined and appropriately reserved to one program alone are managed by a committee of the faculty members identified with that program and chaired by the program director. As a result, the Department Chair receives continuing advice from the faculty through the regular monthly department meetings and the separate training program meetings.

Input is also sought from the graduate student leaders, in particular the Work Environment Student Association (WESA). Through this group and the student chapters of the professional societies, the students have formal and informal mechanisms to provide input on the academic program and bring student issues to the attention of the program directors and department chair. The students organize an election for an annual teaching award, and organize seminars, outings and informal activities which greatly improve the academic experience for students. The Department provides a modest budget to WESA to support these activities. The External Advisory Board, consisting of alumni, employers and regional leaders in occupational health fields has also been a very valuable source of guidance for major policy decisions including for example curriculum planning and the roles of internships and capstone projects.

C. Training Program Administration

Leadership of the training programs is the responsibility of the "core faculty" who are mostly full time tenured faculty. Key roles in teaching and mentoring are also provided by several other types of faculty. Research faculty provide valuable service as research mentors, serve on doctoral dissertation committees and also teach some courses. Emeritus faculty serve on doctoral committees, give regular lectures in department courses, contribute to research projects and provide valuable contacts with employers and funders. Adjunct faculty teach some courses, support student research projects including master's capstones and doctoral dissertations, and provide links to industry for internships and employment. Because of the interdisciplinary nature of the training programs and in particular the foundational courses, faculty members from all four training

programs participate in training all students. All full time faculty members participate equally in the master's and doctoral degree programs. The DWE faculty is notable for its high level of research activity, with frequent contributions to professional journals as well as national and international scientific conferences. There is also a high degree of activity on journal reviewing and editorial boards, as well as national and international research advisory committees. All the faculty have ongoing professional relationships with colleagues in the NIOSH ERC at the Harvard School of Public Health, the NIOSH Agricultural Safety and Health Center, the NIOSH Total Worker Health Centers, and many other national and international research groups in occupational health and safety. Trainees in the UML program benefit from these connections in many ways.

Specific Objectives

All four of the proposed training programs provide training and research on the identification, characterization and control of chemical, physical, psychosocial, and biological risks associated with work environments as well as in understanding and developing respect for the complex social, political and economic context in which environmental and occupational health problems must be studied and addressed. Our model of education and research integrates rigorous scientific methodology and practical collaboration with the region's industry, labor, communities and governments to design safer and cleaner systems of production. The goal of the graduate program is to prepare professionals with the ability to scientifically evaluate hazards of production and to design and implement efficient alternatives to hazardous exposures.

The master's programs prepare graduates to be prevention practitioners with strong fundamental skills for recognition, evaluation, and control of hazards in the work environment. Training includes working in teams and learning to make professional oral and written presentations. Many master's courses have either a field or a laboratory component that provides hands-on experience. Graduates find employment as leaders and professional practitioners of occupational and environmental health and safety within companies, government agencies, consulting firms or insurance carriers, and labor or community organizations.

The doctoral programs are designed to prepare research scientists with a strong orientation towards prevention and applied research. Graduates become research scientists and policy specialists with the background and skills needed to produce new knowledge in their chosen field of specialization, in academia, governmental or private research organizations and industry. The student selects a problem from a range of options and then participates in the design and data collection and is responsible for statistical analysis of data relevant to the problem. The completion of a dissertation demonstrates that the student has integrated the necessary academic skills and has the ability to identify problems in work environments and to work together with co-investigators in multi-disciplinary teams to carry out a successful study. The doctoral degree provides

the background and the skills needed for work in academic faculty positions, as well as careers in governmental or private research organizations.

All Work Environment NIOSH trainees, regardless which training program they are pursuing, participate in a comprehensive learning environment focused on responsible professional practice and research to improve the health and safety of working populations. The key components of this learning experience include are described below.

Results and Discussion

A. The Master's Degree

NIOSH trainees pursuing a master's degree are enrolled in either the MS degree in Work Environment, or the MPH degree. The MS in Work Environment requires 36 credits, while the MPH requires 42 credits. Both degree programs are designed to be completed in two years (four semesters) of full-time study. The common set of foundational courses (Table 3) provides an introduction to the field of Work Environment and to the essential disciplines upon which it is based. The courses emphasize the interactions among the various disciplines. Trainees take the first three of the foundational courses during their first two semesters after matriculation. There is a two-semester required Work Environment Capstone Practicum for all trainees in the second and final year during which they address a work environment problem directly relevant to their training program and their future career directions.

Table 3. Work Environment Trainee Foundational Courses (all programs)

Title	Course No.	Year
Work Environment Policy & Practice	19.551	1st
Toxicology & Health	19.503	1st
Introduction to Epidemiology with Biostatistics	19.575	1st
Work Environment Capstone Practicum I	19.600	2nd
Work Environment Capstone Practicum II	19.601	2nd
At least one "professional practice" course *	-	-
* see Program Plans for the 4 training programs for details. Trainees in OEH and Safety/Ergonomics will take at least 4 of these courses, trainees in Work Environment Policy and Occupational Epidemiology will take at least one.		

Foundational Courses

Work Environment Policy and Practice (19.551) provides an introduction to and overview of occupational safety and health (OSH) Policy and practice. It addresses OSH at two broad levels: Part 1 focuses on OSH at the macro-socio-economic level in the United States, federal- and state-level OSH policies and

their enforcement, as well as the role of labor unions and labor-management relations in OSH; Part 2 examines how policies and regulatory structures at the international and federal levels are operationalized at the level of an individual workplace, focusing on international and U.S.-based OSH management system frameworks, worksite injury and illness prevention programs, worker training in OSH, and the United States' relationship to international structures that impact OSH, such as ILO's international labor standards as well as multi- and bi-lateral international trade agreements. The course begins with legal and administrative vehicles, especially the US Occupational Safety and Health Administration (OSHA) and the US Occupational Safety and Health Act (OSHAct) of 1970, and provides an analytical framework for examining social, economic, and political factors in the recognition and control of occupational hazards and a management program for identifying and preventing hazards at the worksite. This course brings science and Policy together in an exploration of the origin of and solutions for work environment problems. Course objectives aim to enable students to: 1) be familiar with the social and economic burden of OSH injury and illness and the importance of and possibilities for prevention; a) identify the major stakeholders in OSH nationally and internationally; 2) identify international and national regulatory structures and trade agreements for the administration of OSH; 3) provide a framework for the critical analysis of government risk management policies in a public/private market economy; 4) be familiar with how to develop and manage a health and safety program at a worksite; 5) develop a persuasive OSH Policy argument and a critical analysis of its strengths and limitations; 6) construct alternative Policy approaches for the future of OSH. The textbook for this course is Occupational and Environmental Health, Levy BS, Wegman DH (Founding Chair of the DWE and Emeritus Professor), Baron SL, Sokas RK editors, sixth edition, Lippincott, Williams & Wilkins, Philadelphia, January 2011, supplemented with numerous readings on the above topics. The course is taught by Department of Work Environment faculty, Professors Margaret Quinn and Pia Markkanen.

Toxicology and Health (19.503) provides an introductory understanding of the health impacts of the principal types of hazards encountered in the work environment. The course is organized into three complementary components. The first covers the anatomy, physiology and important occupational diseases of each human body system. The second portion reviews the pathophysiologic mechanisms of workplace exposures with an emphasis on toxicologic mechanisms such as carcinogenesis and allergy, and also including the effects of physical agents. In the final portion of the course, the important classes of work environment toxins and their health effects are discussed. The course is designed to provide a comprehensive pathophysiologic and toxicologic foundation for advanced courses. Students are required to complete a final project for this class. Some students choose a project based on a clinical case of occupational disease seen at an occupational medicine clinic while most investigate a topic of their choosing in the current scientific literature. This course

is taught by Dhimiter Bello and draws on a number of guest lecturers to provide in-depth knowledge on many of the course topics.

Introduction to Epidemiology with Biostatistics (19.575) provides an introduction to the principal quantitative methods for health assessments of the work environment. Basic epidemiology study designs are introduced along with consideration of causal inference in epidemiology, bias, and confounding. There is a strong emphasis on surveillance and use of administrative data and healthcare records. The fundamentals of biostatistics are also taught in the context of epidemiology with attention to probability theory, the normal distribution, Gaussian statistics, and an introduction to linear regression. This course is taught by David Kriebel, head of the Occupational Epidemiology training program.

The Work Environment Capstone Practicum (19.600, 601) is a two-semester intensive experience taken in the final year of the master's degree. The capstone is designed to complete the experience of the master's level training in work environment disciplines by further developing and integrating the major themes of the fundamentals courses through application to a real-world problem. In this final project, the student addresses a specific work environment issue by defining the problem, characterizing the risk, and developing solutions in an interdisciplinary fashion. In addition to developing an integrated approach to occupational health and safety problem-solving, two explicit goals of the capstone are: 1) to develop students' skills in report writing and oral presentation; and 2) to educate them in the responsible conduct of research (the latter discussed further in section 5. below). Many students need help in improving their written and oral communications skills, and the capstone course is an important opportunity for this coaching. Draft written reports and practice final presentations are critiqued and discussed in class before each final product is submitted. Students may work in pairs, but the weekly meetings provide all students the chance to share their experience and to benefit from each other's areas of concentration. Students produce a final report and make a public presentation of the proposed approach, with formal judging by a jury of all DWE faculty members. The student is expected to address at least two of the four disciplines in Work Environment.

In addition to these courses required for all trainees regardless of their training program, all trainees must take at least one course in the "professional practice" of occupational safety and health. The Work Environment faculty believe that all trainees regardless of their ultimate career path should be exposed to the applied and practical work of identifying and controlling hazards in the work environment. Trainees in the occupational and environmental hygiene and the safety/ergonomics training programs take four or five of these courses, and trainees in Work Environment Policy and in Occupational Epidemiology are required to take at least one.

B. The Doctoral Degree

Work Environment NIOSH trainees in any of the four training programs may also be enrolled in the doctoral degree program, leading to the ScD in Work Environment. The doctoral degree requires 30 credits beyond the master's degree, including a minimum of 9 credit hours of course work (courses are typically 3 credit hours each) and 12 credit hours of dissertation research. This usually requires about three years of study beyond the master's degree. Work Environment NIOSH doctoral trainees must satisfy the same fundamental course requirements as the master's students (Table 3). If a doctoral student has already completed either the MS or MPH, then the work environment foundational courses will have been completed. Doctoral students admitted with either a bachelor's degree or a master's degree from another institution must demonstrate mastery of a set of basic competencies through previous coursework, planned coursework or documented prior learning experience with an academic component.

Each doctoral student trainee will be assigned a doctoral program advisor upon matriculation. The choice of advisor is based on review of the student's application by the faculty and agreement as to the best match for the student's interests, along with which faculty member may have research funds to support the student. The advisor works with the student to propose a set of courses and prepare him/her for the breadth and depth needed for dissertation work. The student will then file a program approval request with the DWE Department Graduate Committee, made up of faculty representatives from each of the training programs, who then approve the planned program or request revisions in the coursework.

Following approval of this course program, the student will be eligible to take a written qualifying examination. The exam is designed to test the knowledge in the major field. Upon meeting the course and written exam requirements, the student must identify a dissertation topic and select a dissertation committee. In addition to the chair, the committee must have at least two other faculty that represent other disciplines relevant to the topic. The student must then prepare a dissertation proposal in the format of a NIOSH R01 grant application and pass an oral qualifying examination based on the proposal.

Course Requirements for the Doctoral Degree: Doctoral students, in addition to demonstrating mastery of the basic competencies specific to their training program area, select course work (9 credits minimum, but typically 18 credits) to deepen their training in their major field. Nine credits of this course work must consist of two semesters of Advanced Research Methods in Work Environment Seminar (19.605) and one semester of Work in Progress Seminar (19.609).

Advanced Research Methods in Work Environment (19.605) is a doctoral seminar focused on developing research skills needed for advancing understanding of the causes of health and safety hazards in the work environment as well as their solutions. The seminar is organized as a series of three modules of roughly one month each. The topics will vary each semester

depending on the research fields of the students enrolled as well as the expertise of the participating faculty members. The goal is to provide, for several important current topics, depth in theory, background literature, state of the art measurement tools and methods at an advanced level appropriate to students undertaking independent research. All doctoral students are required to register for two semesters of this seminar for a total of six modules.

Work in Progress Seminar (19.609) provides a forum for doctoral students (and advanced master's students) to discuss their research with their peers and the faculty in a supportive interdisciplinary community. Doctoral trainees from all Work Environment fields present their work in progress to their peers. At least one Work Environment faculty member is always present, and advisors of students who are presenting in a given week are generally also in attendance. Although all doctoral trainees formally register for this seminar for credit in one semester during their training, they are expected to attend regularly while they are in the research and writing phase of their training.

The Doctoral Dissertation is based on a substantial body of original research carried out by the candidate. The selection of the research topic will be the responsibility of the student in consultation with the academic advisor. NIOSH doctoral trainees will choose a dissertation topic that advances knowledge in occupational safety and health, and following the guidelines of the NIOSH extramural research program, the dissertation must address one or more NIOSH NORA sector agendas. When the doctoral student has completed all course requirements, the student, advisor and the other members of the dissertation committee will meet at least as frequently as every six months to review the student's progress. The student and advisor generally meet much more frequently, typically once per week during the active research phase, and at least once per month during the writing phase. The dissertation committee will assess whether the student is making adequate progress toward completing the dissertation in the required years of study and will approve the dissertation. The dissertation will, in general, be in the form of three publishable manuscripts and will include an appropriate literature review and overview of the dissertation research. The successful student is required to pass an oral defense of the dissertation before the dissertation committee and other faculty members. The defense is open to the public.

C. Interdisciplinary Training Experiences

Work Environment NIOSH trainees benefit from a variety of different learning experiences within the Department of Work Environment and its affiliated centers and institutes, as well as in collaborating departments and research groups. As described further below under training facilities, the Department is fortunate to be mainly housed in a single building, Kitson Hall, with laboratories and two of its research centers in nearby buildings. This compactness means that there are many formal and informal opportunities for trainees to work together and to participate in department activities.

Trainee orientation. At the start of each academic year in September, an orientation session is held for NIOSH trainees. They learn about NIOSH, the founding federal legislation and mission of the agency, as well as the NIOSH training program. The opportunities and responsibilities of being a trainee are explained. Trainees are expected to follow an approved academic program, to conduct a capstone project (master's trainees) or dissertation (doctoral trainees) that addresses a work environment topic, as described above. Trainees receive funds for professional travel from the NIOSH training grant, and the opportunities and procedures for taking advantage of these funds are also explained during the orientation. Additional opportunities and responsibilities of NIOSH trainees are described below.

Interdisciplinary course work. Beyond the required foundational courses (Table 3), interdisciplinary learning among the four training programs is further reinforced by the fact that trainees frequently take elective courses in the other programs, providing numerous opportunities for interdisciplinary discussions both in and outside the classroom. For example, many students in safety/ergonomics take courses offered by OEH-IH faculty in exposure assessment and exposure data analysis, which has led to increased interaction between industrial hygiene and ergonomics faculty members about course material pertinent to both fields.

Cross-fertilization also occurs with other departments within UML. For example, graduate students in both Mechanical Engineering (ME) and Physical Therapy (PT) may select Work Environment options in their degree programs, leading them to take three and four safety/ergonomics courses, respectively. In turn, Ergonomics students may take courses in the PT Department. Doctoral students in any DWE program may take advanced anatomy and physiology courses in order to broaden their knowledge in those areas. Nursing doctoral students take several DWE epidemiology and biostatistics courses.

DWE students have significant interactions with the Departments of Psychology, Political Science and Economics, taking courses in the socioeconomic and psychological aspects of work, family, and community, while students in those departments also take courses of ours such as Work Environment Policy and Practice and Intervention Research.

Several DWE faculty members actively participate in the intercampus Biomedical Engineering and Biotechnology (BMEBT) program. This program is an interdisciplinary effort involving four of the UMass campuses: Lowell, Boston, Dartmouth, and the medical school at Worcester. At UML, departments from three colleges are actively involved: Engineering, Science, and Health Sciences. Dr. Buchholz was the founding program director and served in that role for the program's first ten years. He and other DWE faculty are lead advisors on BMEBT doctoral research projects (Buchholz on projects related to biomechanics and Dr. Dhimiter Bello on the toxicology of nanoparticles). BMEBT doctoral dissertations are interdisciplinary by design, with all research committees having members from multiple departments.

Interdisciplinary research seminars. The Department holds a research seminar on Mondays at noon approximately five times per semester. NIOSH trainees are expected to attend these seminars. Topics cover the full range of work environment fields, and speakers are frequently visiting experts from academia and government. Attendance by faculty, staff and students is generally very good at these events. At the end of each academic year, graduating master's students present their capstone projects orally to a jury of the faculty in an event that takes most of one day. All NIOSH trainees who are not presenting their capstone projects (master's students completing their first year, and doctoral students) are expected to attend this event which is an excellent opportunity to learn about the full range of work environment professional practice and research topics in the Department.

Semi-annual interdisciplinary research symposium. A semi-annual research symposium has been organized since 1998 by the UML and the University of Connecticut faculty and research staff. The occupational medicine program at UConn Health Science Center (Farmington) is a particularly valuable partner for Work Environment trainees. Students, staff and faculty from both universities who are working on occupational health and safety topics attend this day-long event held in Sturbridge, MA, halfway between the two campuses to present and discuss work in progress. Occupational psychology faculty and graduate students from the main UConn campus at Storrs also participate, broadening the scope of discussion even further. All NIOSH trainees are expected to attend at least one of these semi-annual Sturbridge research symposia.

Affiliated research centers. Five vibrant research centers affiliated with the Department of Work Environment provide many opportunities for applied training experiences highly relevant to the NIOSH training program. NIOSH trainees are introduced to these centers in the orientation session, and the centers' work is frequently described in courses and seminars. The centers are described under Training Facilities below.

Diverse student body. The Department of Work Environment has between 50 and 60 students enrolled each year. The NIOSH trainees benefit greatly from the diversity of our student body. Roughly half of our students are going to school part-time while working full time in business and government in the region. The other half are enrolled full time and "in residence". Many of these are from other countries, studying in the U.S. on student visas. In 2013, the Department was home to students from 21 countries. Another valuable dimension of the student body's diversity is provided by students sent from the military services, most frequently the U.S. Coast Guard. There is often a student on academic training leave from NIOSH as well. Alumni frequently report that this intellectual and cultural diversity was a major benefit of their time in the Department of Work Environment. The percent of our graduates who are Under Represented Minorities (URM) has risen steadily over the last 25 years and in the most recent 5 year period was 19%.

Work Environment Student Association (WESA). The student body is organized through an association with annually-elected leadership. The University provides a small budget that is used for organizing social events as well as seminars on topics like how to find a job in your field. This organization provides a supportive community for students from all the work environment fields. In 2013, the co-presidents were an occupational hygiene trainee and an epidemiology trainee. In 2014 the president was a safety/ergonomics trainee. WESA also serves as an informal support system for the students and offers networking for applicants to the Department, such as tours, housing advice and opportunities to ask current students about their experiences in the programs.

Collaborations with other Boston-area institutions. Program faculty members collaborate on research with occupational health researchers including occupational medicine physicians not only at the University of Connecticut Health Center but also Harvard Medical School, the Harvard and Boston University Schools of Public Health, Tufts School of Medicine, UMass. Medical Center in Worcester, and Yale Medical School. These collaborations have also involved graduate students in various ways, ranging from single-semester course projects to doctoral research.

D. Training Facilities

Affiliated Research Centers and Institutes:

There are five affiliated centers and institutes providing many opportunities for student research and practice experiences.

The Center for the Promotion of Health in the New England Workplace (CPH-NEW), Director: Laura Punnett. CPH-NEW evaluates multiple models for integrating health promotion with occupational health interventions, with a strong emphasis on musculoskeletal, cardiovascular, and mental health outcomes; the underlying role of work organization; and the importance of worker involvement in program design and implementation. It is one of four CDC national Centers for Excellence of the NIOSH Total Worker Health™ program. CPH-NEW is a joint interdisciplinary initiative of the University of Massachusetts Lowell and the University of Connecticut. The key academic units are the Department of Work Environment and Public Health Studies at the University of Massachusetts Lowell, the Department of Occupational and Environmental Medicine at the University of Connecticut Health Center (UCHC), and the Departments of Psychology and Allied Health Science/Health Promotion at University of Connecticut Storrs. (URL: http://www.uml.edu/Research/centers/CPH-NEW/).

The Toxics Use Reduction Institute (TURI), Director: Michael Ellenbecker. TURI provides resources and tools to help make Massachusetts a safer and more sustainable place to live and work. Established by the Massachusetts Toxics Use Reduction Act (TURA) of 1989, TURI collaborates with businesses, community organizations and government agencies to reduce the use of toxic chemicals, protect public health and the environment, and increase competitiveness of Massachusetts businesses (URL: http://www.turi.org/).

Lowell Center for Sustainable Production, Director: David Kriebel. The long-term goal of the Lowell Center for Sustainable Production (LCSP) is to integrate environmentalism and occupational health and safety while also demonstrating how these are compatible with new systems of production and consumption that are healthy for workers, environmentally sound, economically viable, and socially accountable. Through its solutions-oriented and collaborative research projects, the LCSP has become an internationally recognized resource for developing and piloting the concepts of sustainable production and consumption. Faculty, staff and students at LCSP help organizations find practical solutions to urgent environmental health and safety problems. The Center also forms partnerships with and draws upon the expertise of government officials, industry managers, private consultants, public interest groups, community groups, and faculty, staff, and students from throughout the University of Massachusetts Lowell and other universities. The LCSP has several projects with direct occupational health impacts including the Safe Home Care Project, the Sustainable Hospitals Program and and a recent report: Lessons Learned: Solutions for Workplace Safety and Health. The FY2013 budget of the Center was approximately $1.2 million (URL: http://www.sustainableproduction.org/index.php).

Center for Work, Environment, Nutrition & Human Development (CWEND), Director: Susan Woskie. The purpose of CWEND is to foster research collaborations and faculty and student exchanges between UMass Lowell and Mahidol University in Bangkok, Thailand. CWEND members have collaborated on an NIH Fogarty/NIEHS funded pilot project on Brain Disorders in the Developing World titled “Neonatal Neurobehavioral Impacts of Iodine Insufficiency and Pesticide Exposures”. Through that project two Thai faculty visited UMass Lowell and two UMass Lowell faculty spent time at the Mahidol Faculty of Public Health. In September 2012, CWEND received a 2-year planning grant to develop a proposal for a Center of Interdisciplinary Research & Training in Global Environmental and Occupational Health called a GEOHealth Hub. The project is funded by the U.S National Institutes of Health Fogarty International Center (FIC), the National Institute of Environmental Health Sciences (NIEHS), and NIOSH (URL: http://www.uml.edu/Health-Sciences/WE/Research/CWEND.aspx).

WHO Collaborating Center for Occupational Health, Director: Maria Brunette. Since 1996, the Department of Work Environment has been a Collaborating Center for Occupational Health supporting the World Health Organization’s (WHO) mandate for international partnerships promoting global occupational health. The Collaborating Center works through the WHO’s regional office in the Americas, the Pan American Health Organization (PAHO). There are only five other U.S. universities with this designation. The international scope of our WHO Collaborating Center research activities benefits graduate students exposing them to an array of research methodologies conducted by interdisciplinary teams and most importantly, broadening their understanding of different socio-cultural environments in which theory and methods need to be culturally appropriate for the study populations. All current WHO Collaborating Center activities take place

in the developing world, e.g. Mexico, Ecuador, Perú and Thailand (URL: http://www.uml.edu/Research/WHOCC).

Resources in the DWE:

The Department of Work Environment has a dedicated classroom with full computer audiovisual technology, a seminar room, a computer laboratory, and reception and lunch/informal meeting areas as well as offices and laboratories.

Classroom Space. The department has a large wired classroom with permanent LCD projector equipment and computer with internet high speed connection capabilities. It also has a department conference room with similar projection capabilities. The department has additional portable video projectors, and laptop computers that faculty can use for classes elsewhere.

Laboratories. Detailed descriptions of the industrial hygiene and ergonomics laboratories are provided in the sections describing those programs.

Office Space**.** Each faculty member has his/her own private office with appropriate computer, desk and file storage facilities and enough space to meet comfortably with students. Research assistants and doctoral students generally share office space and are provided with individual desks and computers. Separate offices are provided for both the department coordinator and the grants coordinator. Most research staff members also have private offices.

Computer and Telecommunications Resources**.** The Department has a student computer laboratory with six desktop computers. These machines have SAS and Stata software as well as several other packages used in specific classes. The Occupational Biomechanics Laboratory has a desktop capable of analog-to-digital data collection and storage and the Industrial Hygiene Laboratories also have a number of PCs for use in laboratory courses. There are additional personal computers for use by Research Assistants on research projects, including a number of laptops for fieldwork. All of the faculty members have PCs. All computers have word processing, spreadsheet, presentation, statistical analysis software, and Ethernet connections to the internet for access to E-mail and the Internet, as well as LAN connections to department laser printers.

The University has been supporting distance learning and training via video for over 10 years. Connections for video are primarily using ISDN technology. Video connectivity exists between all UMass campuses as well as other institutions in the area. Video streaming is also a supported service on the UML campus.

All courses now are supported by online resources. Some professors use the University's online course software called Blackboard, while others build course wikis. Lecture capture capability is available in all classrooms and faculty are increasingly taking advantage of this to enable students to view classes at their convenience.

Library Resources. The campus system includes three separate libraries. Together, these libraries cover more than 203,000 square feet of floor space, include more than 1200 seats, and hold approximately 357,000 volumes. UMass Lowell's "electronic library" offers access to over 300 databases providing full-text

access to scientific journals, 200 newspapers and reference works such as the Gale Business Resources. Professional library staff members have produced local content databases that are available through the library's web site as well.

Voyager, a multi-tiered, client/server, fully integrated on-line system in use in more than 300 academic libraries as well as the Library of Congress, is our Web-based catalogue that showcases the electronic library and provides a single point of access to all library materials, in all formats. Through the library web site, users are able to search local databases, other library collections, remote and local citation databases, and all internet resources. The journal collection includes 717 print subscriptions and access to more than 42,000 titles in full-text through various database subscriptions. Database subscriptions also include full-text access to many of the major newspapers. The Media Center's Video Catalogue allows title searching of the collection of over 5,000 titles (video and DVD) along with a listing of new titles and an on-line form to request new purchases. UMass Lowell is the regional depository library for all government documents of the Fifth Congressional District.

Distance learners have equal access to on-line materials through the Library's Remote Access services. Instructions are available on Library's Web page for proxy access to all information available through the library web page including subscribed databases. The Library Web page offers live help which offers on-line assistance via the main menu on the Library Web page. The services allow users to chat on-line with a reference librarian.

The DWE also has its own library, with current journals, reports, monographs and textbooks in relevant fields, which is maintained jointly with the Toxic Use Reduction Institute and staffed by a librarian and information specialist who provides assistance to students informally as well as through presentations in classes.

E. Student Recruitment

An important recruiting opportunity for the master's degree programs is the new Bachelor's of Public Health (BSPH) degree program at UMass Lowell. The Work Environment faculty took an active role in designing this program specifically because of the potential to attract undergraduates to the DWE. BSPH students will be introduced to work environment fields during their course work. In their junior year, these students take a two-semester sequence of Occupational Health & Safety I and II that introduces them to occupational hygiene, safety and ergonomics. In the senior year, these students take additional courses preparing them for graduate work in occupational safety and health including Introduction to Epidemiology, Chemicals and Health, and an Environmental Health Practicum. This new program will provide a large and effective feeder program that will create interest in work environment fields among undergraduates, and will also insure that they are adequately prepared in core sciences.

A second important new recruiting opportunity is described in detail in the OEH-IH and OS/E training program plans. We have developed a formal joint

BS-MS program with Keene State College (KSC) in Keene NH, 1.5 hours northwest of Lowell. Keene State has a large undergraduate program in Safety and Occupational Health Applied Science. Through this program, upper level undergraduates at Keene State with high grade point averages will be eligible to enter the MS in Safety/Ergonomics even before completing their BS. The KSC faculty is known to this department; one member is a Work Environment doctoral alumnus. Similarly, a number of students from this KSC undergraduate program have successfully obtained the M.S. degree at UML in the past, primarily in the OS/E program but a few also in OEH-IH and WE Policy. The two faculty groups (DWE and KSC) have had extensive discussions over the past year in order to ensure that the BS/MS program is designed so as to appeal to a small but select group of KSC students who will enter well-prepared. The KSC faculty will specifically recruit for this program among their honors students. Careful comparison of course syllabi has been undertaken so that the planned waivers and transfers will be consistent with the preparation needed to complete the master's degree in a fifth year. We are planning on receiving two students per year (on average) from KSC, out of a graduating class that typically numbers close to 50.

The University has been encouraging the development of programs in which undergraduates with high standing can apply to a master's program in their junior undergraduate year, potentially completing the BS and MS degrees in a total of five years. These are called Accelerated Master's programs. DWE has created several by developing formal linkages with undergraduate departments. These programs are another strategy for increasing awareness of undergraduates about the excellent career opportunities in occupational health and safety fields. We currently offer accelerated master's programs with the Department of Public Health Studies (leading to a master's in OEH-IH), the Department of Exercise Physiology (leading to a master's in Safety/Ergonomics) and the Department of Mathematics (leading to a master's in Epidemiology). The program with mathematics has been particularly successful and we currently recruit one or two students per year through this arrangement.

The Departmental Recruitment and Outreach Committee oversees the implementation and evaluation of the critical activities of enrolling new students and cultivating connections with alumni and other occupational safety and health stakeholders. The breadth of our programs attracts a population of diverse and often non-traditional students. This means that recruitment and outreach strategies must reach this diverse population; and since students are only enrolled for a few years, it is a continuous process. At the same time, the focus of our programs – workplaces -- are in constant flux, as the nature of when, where and how work takes place rapidly changes. Thus our courses and research activities are constantly evolving as well.

Strong web presence. The DWE website is the most important portal for attracting and communicating with potential students worldwide. Our website was recently (2012-13) refined based on the recommendations of a marketing consultant who conducted focus groups with faculty, current graduate students,

and undergraduates in programs relevant to our department (see Progress Report).

An effective website must be continually updated and new content added. We have been further improving our online presence with several types of content targeted specifically at undergraduates who are interested in careers in health or environmental fields and might be recruited to work environment fields.

These include:

- A semi-annual alumni newsletter. Many of our alumni now serve in leadership positions in occupational and environmental health and safety and they often make training recommendations for their more junior employees. We believe therefore that it is important to keep the alumni updated about the Department and new developments in our programs and staff. The recent alumni survey (see Progress Report) asked about preferred means of communications and newsletters and short email bulletins were strongly preferred over alternatives like using social media.
- Posting on the web profiles of students and alumni in exciting careers or research projects. These short biographical sketches, with photos, are posted on the department and university's web pages in locations designed to attract visitors and draw them in.
- Posting short news articles on faculty, staff and student professional accomplishments, appointments, awards and other newsworthy events.

Outreach and Networking. We used job fairs and professional meetings as opportunities for student recruitment. Probably the most successful of these was the New England section of the American Industrial Hygiene Association (NEAIHA). This is an active organization with regular meetings and professional development activities. The elected leadership almost always includes one or more alumni of the Department of Work Environment, and our faculty regularly are invited to give talks on developments in the field. Other meetings that have were useful for recruiting included the American Public Health Association meeting, the Human Factors and Ergonomics Society meeting, the American Industrial Hygiene Association Meeting and the Boston regional meeting of the Society for Risk Assessment.

F. Admission Requirements

Admission to Master's Programs**:** Prospective students must apply to the UMass Lowell Graduate School and meet the requirements of both the University and the Department before admission. To be admitted, applicants must have a BA or BS with an overall GPA of at least 3.0. Applicants must have a grade of C or better in required, prerequisite technical courses. All four training programs require one semester of undergraduate mathematics (pre-calculus, calculus, statistics or biostatistics) and one semester of undergraduate biology (physiology, anatomy, cell biology, genetics, ecology). The occupational hygiene and safety/ergonomics programs also require a semester of undergraduate physics, and occupational hygiene requires a semester of general chemistry.

GRE's are generally required, but may be waived either because the applicant has completed a previous relevant graduate degree or else has taken three required Work Environment courses prior to admission, with an overall average grade for the three courses of >=3.3 (B+) and has received at least a B in each course. Except for these special cases, applicants must have minimum GRE scores as follows: Combined Verbal & Quantitative ≥ 290 and Analytical ≥3.5. There are specific admission requirements for each of the four training programs that are described below in each Program Plan. For students who graduated from a university in a country where English is not the official language, TOEFL scores should be at least 79 (internet-based).

Excellent written communication skills are important in graduate school, as well as in professional careers. For this reason, the Department places special emphasis on documentation of writing ability. The applicant's statement required as part of the graduate application is one such document, but applicants may also submit other writing samples.

Successful applicants also have demonstrated the ability and motivation necessary for independent creative work and an interest in issues of the work environment. Preference is given to candidates with both a quantitative academic background and work experience in industry, government or health care. At the same time, the faculty of the Department of Work Environment believes that the program (and the profession) is strengthened by admitting students from a wide diversity of backgrounds, and therefore students with non-traditional educational or work backgrounds will be considered carefully.

A faculty committee evaluates each applicant's complete packet of application materials including GPA, GRE, TOEFL, experience, recommendations and essay. Meeting minimum requirements does not guarantee acceptance. In some cases, applicants who do not meet one of our entry requirements may be admitted if other parts of their application outweigh the deficiency. In addition, applicants who do not meet one of our entry requirements may be admitted if they have completed 9 credits of Work Environment Department courses, all with a B+ or better as a non-matriculated student.

Admission to ScD Program**:** In addition to the requirements above for master's admission, doctoral students require a more extensive review process. In any of the training programs, successful applicants must demonstrate the potential for independent research, good writing skills, and a substantive area of interest that is compatible with faculty expertise within that program. The faculty members of the training program where the candidate wishes to matriculate carefully evaluate the candidate in terms of his/her potential ability to conduct research, often with a personal (face-to-face or telephone) interview. If the program faculty members are in consensus and at least one appropriate advisor can be identified from these faculty, the candidate is presented to a DWE faculty meeting. Doctoral training is built on the didactic training gained in the master's degree program. Candidates who enter with a master's degree in a related area from another

university often have gaps in coursework. These gaps are made up upon admission to attain the competencies provided through our master's degree in the designated major field.

G. Minority Recruitment and Retention

As noted above, the percent of DWE students overall and NIOSH trainees specifically who are Under-represented Minorities (URM) has been rising steadily in recent years. While we cannot attribute this to any one factor, we have worked hard in several ways to be more explicitly inclusive in our public image and student recruitment materials. The increase in URM students is an encouraging sign that suggests we should continue the recruitment and retention activities that we have put in place over the past five years.

One member of the department Recruitment and Outreach Committee, Dr. Maria Brunette, serves as coordinator of Under-represented Minority Recruitment and Retention. She is engaged with the staff of the UML Office of Admissions to coordinate efforts for a systematic approach to recruiting ethnically under-represented students into our programs. In addition to the Office of Admissions, we partner with other groups on campus, including the Office of Equal Opportunity and the Office of Student Activities and Multicultural Affairs, in recruiting students. We also recognize the importance of the support and vision of the campus leadership, engagement of faculty and staff, and current students in this effort.

Dr. Brunette conducted a UML-funded research project aimed at identifying factors that hinder and/or support Hispanic women in science and engineering. The research team, which included an undergraduate Electrical Engineering major, and a Work Environment graduate student, surveyed more than 100 Hispanic female engineering faculty members throughout the U.S. to identify factors relevant to their academic success. In 2010, selected Hispanic female faculty participated in workshops as role models for Lowell and Lawrence High School and UML undergraduate Hispanic students interested in science and engineering careers. Through this research, Dr. Brunette developed contacts with undergraduate and high school mentors which she has been using to raise awareness in this population about careers in work environment professions.

Table 2 (above) summarized the numbers of applicants who were URM/Disabled and their subsequent admission and entrance into the program. There was a trend of increasing URM graduates over the entire period of NIOSH training grants to Work Environment (Figure 2, above). In the most recent NIOSH TPG grant period, 2009 – 2014, there were 43 NIOSH trainees who graduated. Eleven of these (26%) were under-represented minorities. This is higher than the percent of all Work Environment graduates who were URM (19%). We believe that one in four successful NIOSH trainees being a URM is a significant achievement that demonstrates the success of the Department of Work Environment using NIOSH traineeships to attract and retain under-represented minorities.

H. Instruction on the Responsible Conduct of Research

The responsible conduct of research and the related topic of responsible professional practice are taught in several courses, but they are a major emphasis in the required course Work Environment Policy and Practice (19.551) and in the required master's capstone/practicum courses (19.600 and 19.601). Responsible research conduct is presented in a dedicated module of the first semester first year course Work Environment Policy and Practice (19.551). The material includes readings, small group work with real-world case studies, as well as a lecture and discussion on ethical considerations in occupational health and safety research and practice. One of the case studies is based on an article by Dr. Quinn and Professor Emeritus Dr. Charles Levenstein, "Good Practice Guidelines for Occupational Health Research Funded by the Private Sector." It is supplemented by several other readings including a Chapter by Dr. Kathleen Rest, former Acting Director of NIOSH, "Ethical Considerations in Occupational Health". The course also includes presentation and small group discussion of case studies in the ethical and responsible conduct of research and professional practice. In the small group exercises, the students are asked to identify the ethical issues in each case and how they could conduct themselves ethically and responsibly in the context of these cases.

The two-semester capstone course provides an opportunity to integrate all of the course work experience of the master's program, by applying the knowledge and methods to solve a real-world problem. A final applied research project is developed, conducted, and presented in the form of a written report and a professional quality oral presentation is made to a panel of the Work Environment faculty. The final project addresses a specific work environment problem by defining the problem, characterizing the risk, and developing solutions in an interdisciplinary fashion. In addition to developing an interdisciplinary work environment approach to occupational and environmental problem-solving, explicit goals of the capstone course are to educate and train students in the responsible conduct of research, to train students to conduct independent work, and to enhance students' skills in report writing and oral presentation.

The fall semester capstone course (19.600) includes a lecture and discussions in a small group seminar format focusing on the ethical and responsible conduct of research. The website of the U.S. Health and Human Services Office of Research Integrity, Responsible Conduct of Research is reviewed in class and students are given an assignment which requires a review of topics related to informed consent, confidentiality, potential conflict of interest, and research misconduct. An overview of issues and the history of the development of responsible human subjects research policies are presented with examples from real research projects. The website for the University of Massachusetts Lowell Institutional Review Board (IRB) is reviewed in class and the National Institute of Health (NIH) Office of Extramural Research online training course "Protecting Human Research Participants" is introduced. All capstone students are required to complete this online course and to submit their certificate of completion in the fall semester. Capstone students are instructed

how to prepare an IRB application for the approval of their projects by the UML IRB, including a description of their project, methods, and tools such as questionnaires and study population recruitment materials. The capstone training also includes a second two-hour lecture and interactive discussion with a member of the UML IRB. This lecture occurs after the capstone students have drafted their IRB applications so that they have grappled with the issues as they relate to their own projects and can ask specific questions of the IRB member. All capstone students are required to have approval from the UML IRB before they begin data collection.

In addition to these formal teaching activities, doctoral students have several other opportunities for learning about responsible research. They are also required to attend University-approved human subjects research training when they reach the dissertation proposal phase of their doctoral work. Most will participate in a faculty-led research team as a part of their dissertation research, and issues of human use, privacy of health data, ethical publishing and related topics are regularly discussed.

Responsible research conduct is a frequent theme at the departmental seminars. As noted above, these work in progress seminar are well-attended by full time students. In the past five years, we calculated that 14% of the seminars (10 out of 73) were directly relevant to responsible research conduct. Examples of topics included: “Community Indicators and Social Change: Lessons Learned the Hard Way”, “Why Science Policy Matters”, and “Native American/Aboriginal/Indigenous/First Nations People and Occupational Safety and Health: Issues and Approaches.”

I. Training Program Evaluation

The key overall qualitative measure of effectiveness of a training program is the ability of graduates to function successfully in professional positions for which they have been prepared. The two broad objectives of our NIOSH training program evaluation process are to: 1) continuously improve existing program operations and strategies; and 2) determine the effectiveness of our programs to produce graduates who function successfully as leaders, professionals and scholars in occupational safety and health. Accordingly, our program evaluation plan focuses on two stages of program development: 1) measurement of successful program implementation; and 2) measurement of successful progress toward outcomes. We collect both quantitative and qualitative measurement data following a program evaluation approach developed by the CDC[1]. The application of some of these methods is described below.

[1] Centers for Disease Control and Prevention. Office of the Director, Office of Strategy and Innovation. Introduction to program evaluation for public health programs: A self-study guide. Atlanta, GA: Centers for Disease Control and Prevention, 2011.

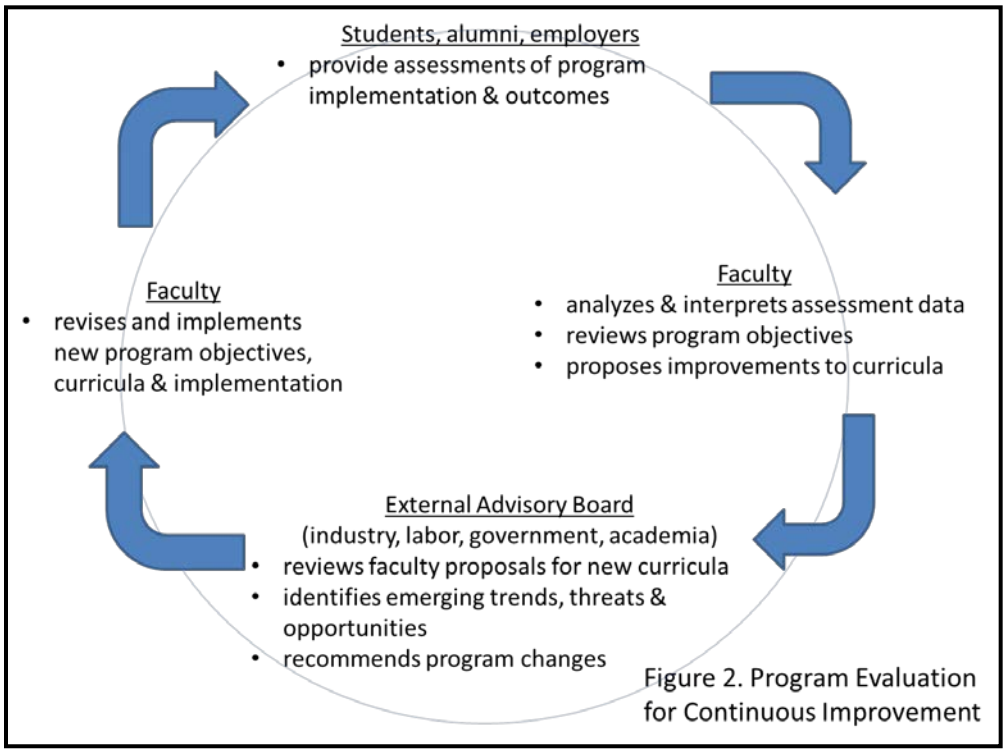


Figure 2. Program Evaluation for Continuous Improvement

The measurement data are used primarily by the DWE faculty, collaborating faculty from other departments and the External Advisory Board to make improvements in our program curricula, the content of individual courses, overall program management, and recruitment and outreach strategies. The collection of program evaluation data is ongoing, following a continuous improvement approach (see Figure).

Systematic program evaluation has also been an important course of action to adapt our training and education to the changing requirements of the practice of occupational health. To achieve our program objective, we have implemented an action plan for continuous assessment of outcomes and to address shortcomings identified by our stakeholders. The major steps in this process (Figure) are:

1. <u>Students, alumni and employers provide assessments of program implementation and outcomes.</u>

There are a number of types of data provided by stakeholders. These include:

- *Continuing assessment of student outcomes within courses.* Regular course evaluations (tests, homework assignments, reports, projects), informal mid-term course assessment by faculty, a standardized end-of-semester student course evaluation.
- *Student end-of-semester written assessments.* Students are asked to provide anonymous data on progress towards specific course objectives as well as more general information on course quality solicited in UML standardized course evaluations. The former have been found to be more helpful in making course revisions than the latter.
- *Annual exit surveys of graduating master's students.*
- *Employer feedback through the External Advisory Board, class presentations by local employers and professional societies*.

- *Alumni surveys approximately every three years*. The most recent (summer 2014) focused on how curricula can be improved, as well as questions on alumni perceptions of how the field is changing.
- *Elected representatives of the Work Environment Student Association are consulted by the faculty on important academic matters*

2. The faculty analyzes and interprets assessment data, reviews program objectives and proposes improvements to curricula.

- *Regular faculty meetings are used to review general program status*.
- *Advisor and full-faculty conduct a review of all master's and doctoral students* every semester.
- *An annual master's program review by all DWE faculty* is held to evaluate student progress, identify strengths and weaknesses, and develop plans for follow-up
- *An annual doctoral program review by all DWE faculty* is held to evaluate student progress, identify strengths and weaknesses, and develop plans for follow-up.
- *Semi-annual faculty retreats* are held to review the overall program and determine if changes are needed.

3. The External Advisory Board reviews faculty proposals for new curricula, identifies emerging trends and opportunities and recommends program changes.

The External Advisory Board meets annually and reviews the academic programs. The heads of the four training programs work with the Chair of the Advisory Board (the current Chair is Dr. Karla Armenti, New Hampshire Department of Health and Human Services) to develop an agenda for the meeting covering the most important topics that year. In the past, the Board has been helpful in reviewing course syllabi in order to evaluate outcomes/competencies and any gaps in curricula.

4. The faculty revises and implements new program objectives, curricula and implementation.

The faculty take all the feedback and develop plans for programmatic changes. This continuous improvement evaluation process underlies our successful accreditation activities (ABET: MS OEH-IH, submission of our self-study 2010 and then a site visit in 2011; our ABET accreditation is current through 2018; and AQAD (Academic Quality Assessment and Development) most recent review was 2008).

We continue to gather and evaluate additional quantitative measures including the annual proportion of students who graduate; the percentage of graduates who are employed in occupational health-related professional positions in industry, academia, and government agencies; among master's graduates the numbers who obtain relevant professional certification and who successfully complete related doctoral programs; and among doctoral graduates, the number of conference presentations and peer-reviewed journal articles that results from dissertation research.

Conclusions

In conclusion, the UML Department of Work Environment has maintained a strong educational and research environment as evidenced by our successful preparation of occupational health and safety practitioners and researchers. The DWE faculty members have a high degree of research productivity and participate in many national and international scientific review panels, journal editorial boards and professional associations. Students are actively engaged in research and supported to develop their own interests while being guided to meet high standards. DWE graduates have strongly endorsed the training that they have received and remain engaged with the department to guide the continuous improvement of all aspects of the training program.

VII. Financial Report

The Financial report has been sent separately to NIOSH.