Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability

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Approval Page

Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability

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Abstract

This study's author replicated a Spanish study conducted by Cortés, Pellicer, and Catalá, who explored engineering undergraduate students being educated in occupational risk prevention as part of their total college education. The problem is that U.S. naval engineers in Washington, D.C. are not being educated in occupational risk prevention. This lack of training is hampering naval engineer's capabilities and technical acumen to prevent accidents in their designs. The purpose of this qualitative Delphi method study with thematic analysis was to explore with a panel of experts what additional education U.S. naval engineers' need in occupational risk prevention. This study's researcher explored how to integrate occupational risk prevention into current curriculum, to improve engineers' skills to prevent occupational accidents. The Delphi method allowed a procedure to follow that the experts could reach a consensus. Professors and practicing naval engineers participated in the panel to explore what kind of mandatory courses in occupational safety, health, and environmental sustainment should be a part of the required engineering curriculum for naval engineers. Utilized for this study, the questionnaire delivery system, *Survey Monkey®,* solicited inputs from engineering professors and naval engineers. The data garnered and the results indicated that naval engineers need training in occupational safety, health, and environmental sustainment. Stakeholders could use the results from this study to improve the education of naval engineers in the area of occupational risk prevention. This study should inspire further research and action to improve the education of both naval engineers and other engineers to the benefit of society. Major themes included all forms of safety issues, health, environment, curriculum, and different forms of training, costs, and timing. Subthemes included risk, hazards, blended learning, variety of mandatory subjects, and financial aspects. The conclusions and recommendations from this study indicate that naval engineers need to be educated in specific occupational risk prevention matters at all educational levels and for practicing naval engineers to use blended learning techniques. The practical implications from this study are that naval engineers need specific training in occupational safety, health, and environmental sustainment subjects to safeguard human life and protect the environment for future generations.

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Chapter 1: Introduction

Engineers are confronted with moral dilemmas in their design work because they are presented with often conflicting requirements, such as, accommodating both safety and efficiency, security and privacy, and accountability and confidentiality (Van den Hoven, Lokhorst, & Van de Poel, 2012; Van de Poel, 2009). These requirements do not have to be conflicting because the occupational death and injury rate are among the main consternations and expenses for businesses in Western societies and specifically for engineers in designing systems (Cortés, Pellicer, & Catalá, 2012). For instance, in the USA, 4,628 workers died on the job in 2012 but this number has fallen to 4,405 in 2013 (U.S. Bureau of Labor Statistics Census, 2014). For occupational injuries and illnesses in the USA, the number was 3.8 million cases in 2011 for all workers (Bureau of Labor Statistics Database, 2013). Further, the number of injured has grown to four million yearly (Probst & Graso, 2013). With all of these injuries and deaths, there is a need to understand the causation of workplace accidents and how engineers can create safer systems for workers (Boone, Ours, Wuellrich, & Zweimüller, 2011).

Current U.S. engineering and technology educational institutions administrators do not typically include safety-related training into their university's academic curricula (de Vries, Hacker, & Burghardt, 2010). Clearly though, everyone employed should be trained in safety to reduce workplace accidents and lower the costs associated with these mishaps as models show that most injuries are preventable (Gyekye, 2010). Hence, managers/engineers need to improve on safety to help reduce accidents (Yingbin, 2013).

Chapter 1 provides the background to the topic of educating naval engineers in occupational safety, health, and environmental sustainment in Washington, D.C. The problem statement outlines why the topic is important. The purpose statement lists the study method and overarching goal of this research. The research questions represent the two questions for this study of a practical applied problem. The nature and significance of the study are also important to the understanding of the problem. The definitions of key terms end the formal portion of this introductory and then followed by a summary.

Background

Education and training in occupational risk prevention had a direct impact on improving working conditions, safety culture, and making safer the systems and equipment that engineers build (Cortés et al., 2012). In fact, this research was of particular interest because of an increased concern to educate U.S. naval engineers to better design systems and equipment for the protection and safety of people, increase the health and welfare of individuals, and safeguard the environment, as these are the ethical thing to do (Finelli et al., 2012). Additionally, a Spanish study conducted by Cortés et al. (2012) found that safety educators and engineers employed in the safety industry agreed that there should be a mandatory course in occupational risk prevention given to engineers before their graduation. Conversely, the U.S. educational institutions currently do not have this same requirement of a mandatory instruction in occupational risk prevention in their engineering curriculum involving different kinds of safety matters (Kodur, Garlock, & Iwankiw, 2012). Traditionally, safety, health, and environmental sustainment education was sprinkled in some engineering, health education, psychology, and management programs but overall were not mandatory or universally applied at U.S. institutions (Love, 2013).

Exasperating the problem, naval engineers were discriminated on by not receiving the same promotion opportunities and receiving lower pay than their peers received in the U.S. Navy when the naval engineering corps was first established in 1842 (Glaser & Rahman, 2011). The naval engineering industry has slowly been trying to catch up in becoming a recognized group in the U.S. Navy; to gain the modern systems to perform their engineering jobs in a better manner (Martínez-Conesa & Briones Peñalver, 2013).

Margolin (2013) believed that an extraordinary effort to improve the occupational safety, health, and the environmental sustainability in naval engineering could accomplish during wartime to generate the required motivation and energy necessary to solve engineering challenges. Correspondingly, managers needed to improve upon safety culture within their organizations to help reduce accidents and help the engineers design safer systems (Yingbin, 2013). Often and unquestionably, it was the financial impact of these accidents that determined corporate actions, regardless of the moral or ethical considerations that applied (Nuñez, 2009).

The original research plan was to use the Delphi method on 100 naval engineers to include professors who teach the subject, to form a panel all belonging to the American Society of Naval Engineers (ASNE) organization located in a suburb of Washington, D.C. The actual number ended up being 17 naval engineers agreeing to participate in the first round of questions and only 12 participating in the second round. The makeup of the panel members were professors who teach naval engineering at accredited universities and senior level naval engineers who have been practicing naval engineering for at least 10 years. Two rounds of questionnaires reached a consensus on an initial set of 10 questions as listed in Appendix A and F. These questions contained the data presented from the original Spanish study and the results compared with one another to verify the previous results and to establish themes and subthemes in this study.

The participants invited to enter into a Survey Monkey® software system that kept their identities confidential from everyone including myself. The analysis software, NVivo®, helped to organize the results but the analysis conducted manually. The ASNE Executive Director granted permission (see Appendix B) to use the ASNE organization's membership database for this U.S. study. It was the desire of ASNE's Executive Director to ask the ASNE members if they would be willing to participate in the study to avoid any privacy issues amongst the members. I sent out the Informed Consent Form to the members who volunteered for their initial acceptance and then provided them a link to the Survey Monkey® website that contained the Informed Consent information, demographic survey, the first and then second round questionnaire.

Statement of the Problem

The problem for this qualitative study was that the education among U.S. naval engineers in Washington, D.C., on occupational safety, health, and environmental sustainability, also referred to as occupational risk prevention, was not sufficient to improve their capabilities and technical acumen to prevent accidents in engineering designs that the naval engineers produced. Engineers-in-training needed to be educated in occupational risk prevention (Hurlebaus, Stocks, & Ozbulut, 2012). Engineers identified previously as needing mandatory training in occupational risk prevention subjects (Cortés et al., 2012; Popov et al., 2013). Therefore, the problem to be addressed was what kind of additional education and training do U.S. naval engineers need to improve their abilities to increase occupational risk prevention safety issues for all workers and how will it be taught to the naval engineers. This is the task for this research study to uncover along with cost/timing with an expert panel using the Delphi method.

The U.S. engineering education establishment has critics, stating that professors do not adequately train the workforce, and there is a call to update universities' curricula to educate engineers better (Chung, 2011). Further, the U.S. engineering educational system failed to provide U.S. engineers with a well-rounded education (Schexnayder & Anderson, 2011). The National Academy and the American Society of Civil Engineers leaders have called to adopt a new educational model that included a required Master's degree that improves upon U.S. engineers' training and education, but so far these initiatives have not been approved (Walker, 2012). Accordingly, the focused problem to address was a need to know what additional education and training U.S. naval engineers in Washington, D.C., needed to improve their abilities to increase occupational risk prevention. To address this there needs to be an understanding of the study's purpose.

Purpose of the Study

The purpose of this qualitative study was to explore with a panel of experts:

(1) What additional education U.S. naval engineers in Washington, D.C. needed in occupational risk prevention, also called occupational safety, health, and environmental sustainment;

(2) Improve the naval engineers capabilities and technical acumen to prevent accidents, injuries, deaths, health impacts, and environmental pollution in their engineering designs that they produced; and

(3) How best for this plan to benefit naval engineers and to provide better engineering safety to society and to the naval engineering community.

Moreover, it was important to study engineers' education, as it was currently not a priority for U.S. universities to provide this additional type of training in schools' engineering education curriculum that has changed little over the past 20 years (Chung, 2011; Whiteman, 2011). Apart from this, there was a lack of new education and periodic training in safety-related subjects deemed necessary for this study of naval engineers. A panel of naval engineering experts can provide the keen perspective of needed missing education.

Cortés et al. (2012) in Spain previously conducted the study of the occupational risk prevention issue for engineers. The goals of this Spanish study were to define a framework for including occupational risk prevention education into a new engineering syllabus (Cortés et al., 2012). A Delphi panel, made up of 59 experts participated in the Spanish study, determined that a mandatory course in all engineering programs should be required before graduation (Cortés et al., 2012).

Expanding upon the Spanish study's problem in the USA, specifically in Washington, D.C., identified how the results in the USA differed from the results achieved in Spain. To try to equal the same number of participants, ASNE staff initially invited over 800 naval engineers and professors who belong to ASNE to participate in the study, but ultimately only 17 volunteered. This USA study was an attempt to replicate the Spanish study in order to achieve a comparison between these two studies.

This study with U.S. naval engineers and professors of naval engineering determined what additional courses were required, how to incorporate them into curricula, and if there were any trends associated with the results. If this study was not completed, then the Spanish study will not undergo validation or independent verification, and no understanding of U.S. naval engineer's issue with the lack of training in occupational risk prevention. Additionally, workers will not get any safer if engineers are not properly educated and training does not focus on improving engineering designs to prevent accidents, harm human health, or damage the natural environment.

A questionnaire sent out to 17 initial participants, to obtain their consensus on the topic of educating naval engineers in occupational safety, health, and environmental sustainment subjects to increase their capabilities and improve naval engineers' technical acumen. Three individuals ended up not participating and one had to drop out when he realized that the study focused on USA education and this individual obtained his education in Europe. The positive outcome from this research was the realization that the statuses of naval engineers' education improvements needs concerning occupational risk prevention education could achieve evaluation by a panel of peers. The results of this study motivated professors that teach naval engineering subjects to incorporate occupational risk prevention topics and that naval engineers used what they learn in their academic curriculum to design safer systems. The practical implication was that this study contributed to the literature on research for this subject matter and motivates others to continue the research and take positive action in the education of engineers.

Health issues improvement by engineers still has a long way to be understood (Robson et al., 2012). Likewise, the naval industry operates in the coastal and ocean regions of the world that makes up a majority of the earth's surface where most people live and work. Environmental considerations on how the naval service's impacts on the oceans and ports of the world are also very important to the sustainment and vitality of operating via the world's waterways (Robson et al., 2012). Naval engineers need to be trained better in these areas of occupational safety, health, and environmental sustainment because the workers and operators of naval engineering equipment and systems in the future can be adversely impacted by these naval systems if safety and environmental sustainment considerations are not safely built-in the designs (Robson et al., 2012). To design a safer workplace, engineers need to understand the environment, people, and behavior of people better (Geller, Bolduc, Foy, & Dean, 2012). Engineers need to be educated in more than just engineering principles but how to make systems and equipment safer and not adversely impact the health of people at work or the environment (Geller et al., 2012). Engineering students in their education also need an understanding of how to sustain the environment without polluting it (Thomas, 2012).

Research Questions

The two research questions listed below, taken from the original Spanish study and slightly modified to improve upon the previous European wording that, first tried to determine if there was a need for engineers trained in occupational risk prevention. The minor alterations do not change the meaning, validity, or reliability of the questions and have improved upon them by eliminating any implied bias; a field test verified them as satisfactory questions. These questions aligned to the problem and purpose to continue the understanding of the education and training of U.S. naval engineers in occupational safety, health, and environmental sustainment so as to improve their capabilities and technical acumen to prevent future accidents.

The Spanish study's first question: "Do engineers need specific undergraduate education in occupational risk prevention as a consequence of their professional activity?" (Cortés et al., 2012, p. 33). The Spanish study's authors answered the question as positive, so the new question for this study was what specific kind of training did these naval engineers need. With the Delphi method, the research questions did not change after subsequent rounds but would have if I found that this would have improved upon them and if further clarification needed from a previous round to reach a consensus. This was not the case for this research.

Q1. What additional education do U.S. naval engineers in Washington, D.C., need in occupational safety, health, and environmental sustainability (also known as occupational risk prevention) to improve their capabilities and technical acumen to prevent accidents?

Q2. How can occupational risk prevention, integrated into undergraduate engineering degree programs, professional development, continuing education, or offered by other means to naval engineers, provide the best educational experience at the most affordable cost in Washington, D.C.?

Nature of the Study

Qualitative research used exclusively in this study, specifically the Delphi method with thematic analysis technique, to gather expert opinions to draw specific conclusions on the incorporation of occupational safety, health, and environmental sustainment educational training for naval engineering students and continuing education for naval engineering practitioners. The results of Delphi method allowed the ability to question experts individually in a systematic, participative, and interactive way with no outside influence (Linstone & Turoff, 2011). Questionnaires used twice to collect the data from a pool of first 17 and then 12 naval engineers and professors. I used Survey Monkey® to collect the data and used an analysis tool called NVivo® to help analyze the data gathered. Successive rounds of questionnaires obtained relevant data until a consensus reached like in the replicated study (Cortés et al., 2012). Stake (2010) stated that qualitative research was subjective but that no other methods allows for this erudite type of a holistic study.

The proposed method and design allowed me to accomplish the study goals by replicating the previous Spanish study in the USA. The design was the optimal choice for the proposed research because it has the same framework that the previous Spanish study used and allowed a comparison of the results together to establish any trends and differences. The Delphi method aligned with the purpose and research questions by expanding on the previous study to gain a new perspective from U.S. naval engineers and professors in Washington, D.C. The proposed study design incorporated two rounds of questionnaires. Data collection and analysis procedures followed the previous Spanish study's design (detailed descriptions are provided in Chapter 3) by every extent possible. Appropriate foundational method support for the proposed study design came from the 50 years that the Delphi method used in research (Hallowell & Gambatese, 2010).

Significance of the Study

Work-related accidents were common in all parts of the world and have direct negative consequences for workers, organizations, and the economy (Cagno, Micheli, Jacinto, & Masi, 2014). Hence, this study was important because engineers needed better training in occupational safety, health, and environmental sustainment to make improvements in systems that can save lives, reduce accidents, and prevent injuries (Cagno et al., 2014). Saleh and Pendley (2012) found that system safety competences provided to engineering students were important because they have the ability to contribute to accident prevention. These authors presented one model for the structure and content of an introductory course on accident causation and system safety (Saleh & Pendley, 2012). Accordingly, what to be avoided were accidents like the one at British Petroleum (BP) Texas City that killed 15 workers and injured 170 others in 2005 (Rodríguez, Payne, Bergman, & Beus, 2011).

The problem was that naval engineers are not being properly educated in occupational risk prevention, which resulted in over 4,000 workers deaths in the USA every year (Schneider & Check, 2010). However, if the engineers were educated in these disciplines, then lives saved, expensive accidents reduced, and the environment protected for sustaining life for generations to come. Other positive implications for this study were the amount of money saved and that people could live longer and have healthier lives. This study was starting out with a small subset of the broader engineering community of naval engineers who make up a much smaller subgroup of the total number of engineers. This study was the first of its kind to use the Delphi method to ask existing U.S. naval engineers and professors in Washington, D.C. on what their expert opinions were on the issue of training naval engineers in the area of occupational risk prevention.

This study was important because human lives are at stake. Deaths by mudslides, lost aircraft in the oceans, and sinking ships are currently in the news and accidents continue to occur. Engineers need to find a way to mitigate these disasters and prevent the loss of human lives in their engineering designs. Better safety designs may help further victims survive if given an opportunity to keep alive when an accident does occur. Designs need to keep people healthy and help to protect the environment by not causing pollution. Knowing the terms will help engineers understand the problems better in that it will give a bracketed idea what the concepts mean and how best to design the engineering to make people and the environment safe. This was not a priority for naval engineers before, but it is now. However, it is unpractical and impossible to obtain, a zero accident vision was encouraged by case study research (Zwetsloot et al., 2013). Indeed, safe designs start with the engineers, and for this study, naval engineers in particular, who designed the systems and equipment built as safe as possible to protect workers from harm and safeguarded the environment from pollution.

Definition of Key Terms

Accidents. Accidents are the unintended, unplanned, unforeseen consequences and events that could negatively damage, hurt, or kill people, materials, and systems that could have unknown affects upon the natural environment (Matthewman, 2012).

Acumen. Acumen is the keen insight or judgment that usually discernment in a specific area that could then use to improve worker's skills (Fortune, 2012).

Consensus. A consensus is a group agreed upon opinion, general agreement, or group solidarity in sentiment and belief on a particular subject among expert panel members reaching majority agreement on a particular subject (von der Gracht, 2012).

Culture. Culture is the emergence of a group's values, attitudes, and assumptions in forming underpinning action taken by the collective individuals of an organization and can involve specific areas, such as occupational risk prevention subjects (Mylett, 2010).

Disasters. Disasters are large accidents or natural occurrences that influence human, animals, and the environment by being of such a large-scale, expensive, public, unexpected, and traumatic event that is not easy to recover from (Matthewman, 2012).

Engineers-in-training. A student of engineering who accepted the responsibility of making sound engineering decisions, consistent with the safety, health, and welfare of the public in the performance of his or her duties in the benefit of humanity described as an engineer-in-training (Stieb, 2011).

Engineering. Engineering is a profession of guiding nature where knowledge of mathematics and natural sciences with the study, experience, and practice of systems applied with judgment to use the materials, workmanship, and forces of nature to produce something needed or desired for the benefit of humankind, nature, or the entire planet (Schexnayder & Anderson, 2011).

Environmental. Environmental relates to or concerned with the ecological impact of altering the condition of the Earth to be able to sustain and maintain life in the sky, land, and water areas (Yang, 2013).

Fit-for-duty (FfD). An individual who has the mental, physical, and emotional capability to perform the essential functions of a job that will not threaten the health or safety of the individual, co-workers, or the public said to be fit-for-duty (Kohanna, 2013).

Hazard. A hazard is a source of potential harm that triggers the expectations that exposure to those sources needs to be controlled or at least eliminated so they do no harm to the public and environment now or in the future (Elke, 2013).

Health literacy. Health literacy refers to the knowledge, motivation, and competencies of accessing, understanding, appraising, and applying health-related information within the healthcare, disease prevention, and health promotion settings for the betterment of humankind (Sørensen et al., 2012).

Industrial hygiene. The science of anticipating, recognizing, evaluating, and controlling workplace conditions that causes workers' injury or illness is industrial hygiene (Rice, 2013).

Injury. To a human, injury is a wound or trauma that causes harm or hurt, usually inflicted by an external force; for the environment, the degradation of the ecosystem that reduces the ability to promote and sustain life (Khanzode, Maiti, & Ray, 2012).

Mobile learning. Any educational interaction delivered through various portable technologies and accessed at a student's convenience from any location at any time of day, night is mobile learning. Mobile learning is also known as online learning or no instructor lead instruction (Wan, 2013).

Naval engineers. Engineers and technicians involve in the designs of naval engineering equipment and systems identified as naval engineers (Lombardi, 2010).

Occupation. Occupation is the principle activity one engages in to earn a living by receiving money and benefits from an employer and it usually is for a long duration and combined with other work of similar nature (Ferguson & Ramsay, 2010).

Occupational accident. An unexpected and unintended incident, which results in one or more workers injured, losing their life, or resulting in an environmental impact that could harm nature, is an occupational accident (Barlas, 2012).

Occupational health and safety (OHS). The OHS designation is the term used to identify the scientific and professional areas dedicated to the analysis of improving the working conditions of employees' health and wellbeing by reducing hazards and risk factors that can harm them while they are at the workplace (Arezes & Swuste, 2012).

Occupational risk prevention. The amount of accepted or tolerated uncertainty outcomes that an organization's managers are willing to take to achieve corporate goals is occupational risk prevention. Occupational risk prevention is also known as occupational safety, health, and environmental sustainment (Aven, 2013).

Occupational Safety and Health Act (OSHA). OSHA is a law enacted in 1970 to assure the safety and health of workers by implementing regulations (Borstorff & Lowe, 2010).

Presenteeism. Presenteeism concerns an employee is present at work, but may be limited in some aspects of performance because of health issues (Cancelliere, Cassidy, Ammendolia, & Cote, 2011).

Prevention through design (PtD). PtD is the optimal method of reducing illness, injury, or fatalities in order to minimize hazards to humans, animals, and the environment by constructing engineering designs that prevent damage or harm (Lamba, 2013).

Risk. Risk is the possibility of loss or injury occurring, chances that an investment might be lost, degree of probability of a problem occurring, or a hazard from a specific cause or source resulting in a negative impact upon operations (Sordillo, 2013).

Safety. Safety is the condition of being protected against physical, social, spiritual, financial, political, emotional, occupational, psychological, educational, or other types of consequences of failure, damage, error, accidents, harm, or any other undesirable event; it can also be defined as the control of recognized hazards to achieve an acceptable degree of risk (Nassif, 2013). Safety means being free from danger, injury, or harm (Topf, 2013).

Safety culture. Safety culture is a set of beliefs, feelings, and values that shared by an organization's management, staff, and employees that influence life, health, and wellbeing as related to perceptions and behaviors (Fang & Wu, 2013).

Safety and health performance. Safety and health performance is an operational positive outcome, resulting from an organizational member's wellbeing of its stakeholders in the prevention of injury and keeping oneself in good condition (Hsu et al., 2012).

Seamanship. Seamanship is a blending of professional knowledge, pride, and common sense in the ways of travelling in the water and ocean environments (Knudsen, 2009).

Sustainability. The practice that focuses on collaboratively progressing health determinants, instilling aspirations through emphases upon processes, and outcomes to achieve the capacity to endure to become positively productive in protecting the environment is sustainability (Harris & Sandor, 2013).

Sustainable development. Sustainable development is the challenge to meet human demand for resources, products, energy, food, transportation, shelter, and waste management, while conserving and protecting the environment (Bhandari, Ong, & Steward, 2011).

Trust. Trust in this study is a positive expectation that individuals have about the intent and behavior of management's impact on employee's job satisfaction, productivity, and organizational commitment to programs like a safety program (Kath, Magley, & Marmet, 2010).

Summary

The key point from Chapter 1 was that this study would help elucidate the problem of inadequate naval engineers' training in occupational risk prevention. The purpose of identifying what was specifically missing and how will it be incorporated into education and training for naval engineers in the USA (specifically in Washington, D.C.). This study achieved these aims by replicating a Spanish study conducted in 2012.

Correspondingly, this study asked for expert opinions from naval engineers and professors who teach naval engineering, to explore what subjects in occupational risk prevention taught to students, and how best to incorporate the information into naval engineering curriculum. This was an explorative study to start the process to identify the extent of the problem in the U.S. naval engineering community. These naval engineers appeared not adequately or properly trained in occupational risk preventive methods. Moreover, the issue for this qualitative Delphi methods study was to understand how a lack of education among U.S. naval engineers in Washington, D.C., on occupational safety, health, and environmental sustainability affected performance. This lack of education was hampering their capabilities and technical acumen to prevent accidents, safeguard human health, and the health of the environment in their engineering designs.

The background, nature, and significance of the study were all discussed stressing the importance for engineers to be adequately educated to be able to design systems that do not contribute to the death of human life, cause harm or injury, nor pollute the environment. Making more systems automated to prevent workers from being exposed to harm was one solution to improve safety. However, if these automated systems do fail, then engineers need to design in the safeguards to help protect people.

The research questions and terms helped bracket the study to focus on safety issues. Naval engineers and the professors who teach naval engineering were the expert panel members because they represent a small segment of the overall engineering community. They have the knowledge and experience that represents the naval engineering community at large. The terms provided a good starting point for this exploratory qualitative study to understand the definitions.

The purpose of this study was to explore with a panel of experts what additional education U.S. naval engineers in Washington, D.C. needed in occupational risk prevention, to improve their capabilities and technical acumen to prevent accidents and then to compare these results from this U.S. study with that conducted in Spain (Cortés et al., 2012). The U.S. study explored how naval engineers trained to address the topics they need to study in occupational risk prevention. Again, the methodology allowed experts to use the Delphi method with thematic analysis to answer questionnaires on occupational safety, health, and environmental sustainment. After each questionnaire round, a summary synopsis generated from the results, and additional rounds of questionnaires provided to these same panel members, until a consensus reached on the answers to the questions.

This study resulted in additional research and acceptance in the engineering community that engineers of tomorrow needed more education and training to build upon technology of the future to keep workers safe, healthy, and maintain a sustainable suggested ways to incorporate this information into existing naval engineering curriculum and professional development for practicing naval engineers. There were suggestions generated for increased content of safety education in this study by the panel of experts.

Chapter 2: Literature Review

The purpose of this qualitative study was to explore with a panel of experts what additional education U.S. naval engineers in Washington, D.C. needed in occupational safety, health, and environmental sustainability, also referred to as occupational risk prevention, to improve their capabilities and technical acumen to prevent accidents, disasters, and environmental pollution. The problem for this study was to understand how naval engineers in Washington, D.C., lack the training in the fields of occupational safety, health, and environmental sustainability, which poses a threat to the safety, health, and wellbeing of workers and operators related to the naval industry (Cortés et al., 2012; Popov et al., 2013).

The focus of this study was on naval engineers in Washington, D.C., because they are a unique subset of marginalized group of engineers that conducted a variety of engineering designs considered hazardous jobs for the U.S. Navy (Glaser & Rahman, 2011). These naval engineers, not easily recognized as other types of engineers, are a disadvantaged class (Michael, 2012). Naval engineering does not typically have its own separate recognized degree program at most universities and it was competing with other industries that pull away many potential naval engineers to other disciplines not related to naval engineering (Madni, 2012).

The identified paragraphs listed below are documentation, safety culture, occupational safety, occupational health, environmental sustainment, safety engineering curriculum, types of educational training, costs of accidents, costs of developing course materials, timing of implementation, and naval engineers with a summary at the end of this Literature Review.

Documentation

This start to the literature search strategy used all of Northcentral University's database search engines to research the key words outlined in the key terms paragraph above and the paragraph headings listed below in this paper. Some of these key terms include accidents, safety, health, environmental sustainment, and naval engineers just to name a few. There are topic headings of safety culture, safety, health, environment, curriculum, costs, timing, and naval engineers. The primary sources for references came from the Ingent Connect, Science Direct, EBSCO host, Elsevier Science, Gale, SAGE, and ProQuest databases. Two additional association databases used to include the American Society of Naval Engineers (ASNE) and the American Society of Safety Engineers (ASSE). I would have also liked to use the U.S. Naval Institute peer reviewed articles but they are still in the process of digitizing them. It will be a number of years before they will have this task completed. I was able to use Google Scholar to retrieve and research peered review articles. As specific information obtained, then additional searches made and articles downloaded.

As references read, additional searches by using author and subjects listed in these references expanded the research area fields. This resulted in the collection of hundreds of additional references. However, many of these references after further study did not provide any significant enhancement to this specific topic of study. In fact, it was difficult to find peer-reviewed articles that addressed safety aspects in naval engineering. In spite of this, design innovation did address topics such as optimization, productivity, strength, reliability, longevity, efficiency, affordability, and utilization (Kelley, 2010). All of these attributes provided a basis of understanding the concepts of the subject.

Once the topic headings were set, expanded searches in these areas conducted frequently to pick up any new research recently published or any that missed in the initial search. Science Direct would even allow up to 100 additional references found that related to the specific topic of interest, which could grow the number of potential references exponentially. To identify how it related to other literature and researches, notes to identify any gaps or areas of disagreement noted. Prominent researchers searched to see if published works related to the subject of naval engineers training in occupational risk prevention or the related topics found. The references used by these cited peer reviewed documentation also examined for any pertinent information. My mentor also provided suggestions for topic areas that would also add value to this research study. Cortés et al. (2012) provided the real impetus for this study.

Engineers are continuing innovating and developing new systems. For example, there is an urgent need to develop a way to determine the presence of marine mammals many miles away so that no harm will come to them when conducting naval operations (Tinney, 2010). Naval engineers are working on this problem and many others that are unique to the marine environment. What really seems to be lacking in the literature is a focus on occupational risk prevention methods in naval engineering. This research rectified this situation by starting this study with an expanded literature review that identified this shortcoming in research. Duffy (2011) acknowledged this issue of needing more safety and health research. Feigh, Dorneich, and Hayes (2012) encouraged supporting adaptive systems that could be automatically track information on the environment and to keep people safe. This would take time to have humans trust machines and develop a strong safety culture.

Safety Culture

Researchers have not come to a consensus on what an organization's safety culture really was involved with, and no clear-cut definition currently existed (Bell, 2013; Blair, 2013; Edwards, Davey, & Armstrong, 2013; Frazier, Ludwig, Whitaker, & Roberts, 2013; Guldenmund, 2010; Pater & Remmo, 2012; Probst, Graso, Estrada, & Greer, 2013; Todorovic, Zivkovic, Nikolic, & Markic, 2012). This gap in the literature might not be easy to resolve since confusion existed about the concept of culture as it was related to safety subsists (Blair, 2013). Yet organizational culture studied by more researchers was better understood (Pater & Remmo, 2012). Safety culture understanding was lacking and this was a primary cause for accidents, injuries, and mishaps to occur in past investigative reports when calamities occurred (Blair, 2013; Guldenmund, 2010; Jin & Chen, 2013). To rectify this, Borstorff and Lowe (2010) called for more research to identify what were the safety cultures of specific organizations, since this was the most important resource for a company to understand, to be developed further to allow them to improve upon their occupational risk prevention efforts.

Hale and Borys (2013) categorized safety rules and procedures as either driven from a top-down approach by senior management or a bottom-up from the employees. Schulman (2010) research supported these two models as well as many more that existed to be all included in a framework for rules and models to improve safety culture. Some researchers have even developed links between safety culture and safety performance in their studies and have found that safety culture was a leading indicator and predictor of welfare outcomes and other relationships (Akselsson, Jacobsson, Börjesson, Ek, & Enander, 2012; Heese, 2012; Zohar, 2010).

Heese (2012) reported that the gap of not having a definitive and agreed upon definition of safety culture was a problem for researchers. Safety climate and organizational culture was much better understood concepts (Heese, 2012). He, Xu, and Fu (2012) reported that for over 30 years now, researchers have been trying to understand what safety culture involved on a component elemental level, but so far, this has not been successful. Researchers recommended further research in this area of safety culture to better understand all aspects of safety issues (Fernández-Muñiz, Montes-Peón, & Vázquez-Ordás, 2012; Hall, Blair, Smith, & Gorski, 2013).

Naval engineers primarily deal with maritime organizations and ships by effective interventions to maintain and improve safety culture that were the best way to improve security (Ek, Runefors, & Borell, 2014). Naval engineering also included aircraft, which considered one of the safest forms of transportation, but improvement could always be achieved in this area as well (Valdés & Comendador, 2011). Safety had improved for reduction of seafaring deaths with injuries greatly declined in the 21th century, but still going to sea remained one of the most hazardous of occupations (Ek et al., 2014). Ek et al. (2014) found that safety culture could be better understood by displaying visual results in dendrograms (graphic plots of data), but work was still needed to be done to conduct analysis, interpretation, and further discussion of the results.

Huang, Ho, Smith, and Chen (2006) studied issues surrounding safety climate and self-reporting of injuries by employees that needed to be incorporated into management's commitment to safety, return-to-work policies, post-injury administration, and safety training to reduce injuries. These findings highlighted the importance of incorporating organizational factors, constructs, and workers' characteristics in efforts to improve upon organizational safety performance (Huang et al., 2006). Further studies to determine if differences change over time needed research (Huang et al., 2006). Likewise, Lu and Tsai (2008) found that the job safety dimension was the most important dimension in regards to effecting ship accidents. In the same way, Luria and Yagil (2010) demonstrated the boundaries of safety heterogeneity by exploring what accounts for safety-climate theories, methodologies, and practices.

Probst and Estrada (2010) found that for every one accident that was reported there are two that were not reported, because either a lack of training or fear of punishment. An organization's safety culture was determined to be the main reason for this lack of reporting (Probst & Estrada, 2010). Furthermore, Lu and Yang (2011) suggested in their study that greater safety climate would lead to better safety behavior and further reduction in accident occurrences. One limitation of this study was that the data came from self-reported information that could be bias or not have been completed (Lu & Yang, 2011).

Schröder-Hinrichs, Baldauf, and Ghirxi (2011) discovered that accident investigation reports for machinery space fires and explosions tended to focus on technical components, which could cause misleading information, misconceptions, and reactions instead of the identification of what the safety issues involved. Further, Yi, Kim, Kim, and Koo (2012) identified the construction industry as being the most accident-prone activities caused workers to risk fatal injury, hospitalization, and disability, because of accidents resulted from organizations having a poor safety culture. Safety accidents and safety culture therefore inherently connected together within one another.

Safety culture, first introduced after the Chernobyl accident, was the start of this research (Goh, Love, Stagbouer, & Annesley, 2012). Hence, Reiman and Rollenhagen (2013) stated that safety culture should be the starting point for further investigation and that research in this area of safety culture had missed the opportunity to integrate with systemic perspectives. In addition, Wu, Lin, and Shiau (2010) found that safety culture influenced by four predictive factors. These factors included safety inform by managers; safety care by employees; safety coordination; and regulation by safety professionals (Wu et al., 2010). These areas needed further study and investigation.

McGonagle and Kath (2010) found that work-safety tension was an important variable of safety climate and worker's perceptions of job demands interfering with safety outcomes. Nielsen (2014) stated that the concept of safety culture was vague and not easily changed. The way around this, Nielsen (2014) argued, was to view safety culture as a more general concept of organizational culture, which understood in research as the best way to understand safety aspects.

Williamsen (2013a) found that organization's managers could improve upon safety culture by reporting near-miss accidents that improved trust, gets employees involved, identified risk, and enhanced management credibility. Correspondingly, Idris, Dollard, Coward, and Dormann (2012) suggested that psychosocial safety climate was an indicator of risks and health issues in the workplace. Idris et al. (2012) found that psychosocial safety climate involved policies, practices, and procedures for the protection of worker's health and safety, but that it should also expanded to include environmental sustainment issues as well.

Biggs, Banks, Davey, and Freeman (2013) found that leadership was a key factor for providing positive organizational safety culture when these leaders emphasized a commitment to safety and making it visible and transparent to the project-based workforce. Biggs et al., (2013) also found barriers to safety culture in subcontractor managers, the rapid pace of change, and reporting requirements. Apart from this, safety culture was a complex construct, difficult to define, and even more difficult to understand (Biggs et al., 2013). Equally, Zheng and Chen (2012) discovered the core concept of safety culture was that safety must come first in any real action, otherwise, workers might become complacent, and the problem of accidents could continue to result.

A common characteristic of safety culture was that they all have an element of trust associated with them (Kath et al., 2010). In addition, Ismail, Salimin, and Ismail (2012) stated that the environment influences safety culture's detailed development. Further, Williamsen (2013a) found that a simple change could have a big effect on safety culture. Instead of a sign posting the statistics of injury results for a particular project, it was better to focus on the amount of safety effort and positive activities of avoiding accidents. This simple act of changing the information on a sign could have lasting results of improving an organization's culture (Williamsen, 2013a).

As previously stated, the definition for safety culture had not come to a consensus. For the purpose of this study, the definition from Fang and Wu (2013) that stated safety culture was a set of beliefs, feelings, and values that were shared by an organization's management, staff, and employees that influences life, health, and wellbeing as related to perceptions and behaviors will be the guiding principle for this study. Instead of trying to define what safety culture was, it might be better to understand the safety chain, which was a structure in the efforts of risk management for low-probability of disasters (Jongejan, Jonkman, & Vrijling, 2012).

In the manufacturing industry, the majority of accidents came from non-compliance with regulations, not following procedures, and incorrect work practices (Stuart, 2014). Researchers have found that safety training was an important factor in promoting safety culture and reducing accidents (Stuart, 2014). As a result, Stuart (2014) found that providing students with a blended learning environment was important for them to promote safe work habits and to establish a life-long learning practice that will keep them safe and looking out for the safety of others when they enter the workforce.

Han, Saba, Lee, Mohamed, and Peña-Mora (2013) discovered that as management applied production pressures, such as schedule delays, cost overruns, or needing to work faster, then safety performance affected the workers to try to find shortcuts and workarounds. Also impacted was the quality of the workmanship. All of this could affect the safety culture of an organization if the status quo was to operate in this matter and avoid the emphasis on safety (Han et al., 2013).

Goh, Brown, and Spickett (2010) found in their study that that a poor safety culture often lead to calamities and that system thinking tools could aid in identification of the systematic problems within an organization. In fact, the construction industry, which naval engineering was a part, was considered the most hazardous because of its' high-risk nature of activities and often working outside in the elements that was dangerous (Chan, Chan, & Choi, 2010). These construction industry managers could use some improvement in the identification of effective intervention systems thinking tools to improve safety culture and prevent major incidents within their organizations (Goh et al., 2010).

Hale, Guldenmund, van Loenhout, and Oh (2010) concluded that the literature was sparse in organizations interventions methods to improve safety performance. The nature of the workplace environment had drastically improved over the years, and it played a smaller role in determining workers health, safety, and environmental impact, but that further improvements and research were still needed (Bambra et al., 2009). More research, as determined by Bambra et al., (2009) in this area of safety culture, should discuss organization intervention methods. An accident pyramid was a term that defines the ratio-relationship between the numbers of incidents at an organization with no visible injury (Reniers & Gidron, 2013). The concept of an accident pyramid used to determine when accidents would occur next would allow organization managers to take proactive measures to avoid near misses and minor accidents in the future (Reniers & Gidron, 2013).

Carrillo (2012) research found that theories to describe accidents are difficult because of the ever-changing world that cause decline in the ability to replicate over time. Journals often do not publish new findings that disprove a theory (Lehrer, 2010). This phenomenon was not widely understood even in the scientific community (Carrillo, 2012). In order for organizations to communicate and improve upon the safety culture to make it a priority over production, according to Carrillo (2012), they must continually reinforce the safety message, repeat the necessary safety communication, and perpetually assess how to improve on safety matters.

Heij and Knapp (2012) provided suggestions to meet IMO (2009) regulations for safety and environmental protection that can also improve safety culture. Likewise, Gyekye and Salminen (2009) found a relationship between education and policies could affect safety culture of an organization. Feng, Teo, Ling, and Low (2013) found that synergy effects safety culture from the amount of investment and hazard that exists. Every organization was a little different in what makes up their safety culture. By improving an organization's safety culture then it was apparent that the overall organizational safety could improve even if not completely understood by everyone. All safety cultures had similar features in trying to protect employees, people, and the environment from harm, which is the main idea behind occupational safety.

Occupational Safety

Safety literature had identified as being weak in critical understandings of how to make workplaces safer, and it did not link operational priorities (Veltri et al., 2013). This gap in the research had organization's leadership to call for a better understanding in the competitive implications of safety (ASSE, 2012; European Agency for Safety and Health at Work [EASHW], 2010; National Institute for Occupational Safety and Health [NIOSH], 2009). Veltri et al. (2013) attempted to address this shortfall in their research where managers and workers were at the same risk level, and should work together to address safety issues within organizations. Another gap existed in how organizational policies and practices related to safety outcomes (Krause, Groover, & Martin, 2010; Neumann & Dul, 2010; Tompa, Dolinschi, de Oliveira, & Irvin, 2009).

Brown (1996) called for more research and an expansion of what organizations have as priorities to the normal quality, cost, delivery, and flexibility tenants should include social responsibility with workplace safety as a primary dimension. Likewise, Alper and Karsh (2009) called for more research on what caused accidents to occur in the first place, as not every safety violation resulted in an accident, and more study of epidemiology of safety still needed. Research by Behm and Schneller (2011) found that health and safety metrics ignored in peer-reviewed literature.

Badri, Gbodossou, and Nadeau (2012) concluded in their study that the construction industry had the highest risk level even though they had more laws and regulations to try to improve in their area of safety. Other researchers recommended designing out hazards by employment of PtD that minimized occupational risks by eliminating the threats that caused accidents (Lamba, 2013; Schulte & Heidel, 2009; Young-Corbett, 2011). Abdul-Tharim, Jaffar, Lop, and Mohd-Kamar (2011) revealed five areas that needed safety improvement: (a) communication, (b) management control, (c) appropriate designs, (d) organizational training and education, and (e) written plans and goals. Brown (1996) believed that safety variables should also be included as a research topic as it fits with existing frameworks in the field of operations management.

Thorvaldsen (2013) investigated anglers and their high degree of risk that described with the metaphor of a thermostat that can dial in to the given situation that they are in now. The anglers' ways of dealing with risk can described as a balancing act. In their efforts to access, the resources hidden in the ever-changing sea they have to carry out continuous assessments and decisions related to fish, profits, and safety. Often accidents occurred even when someone's best effort to try to avoid them do not work (Thorvaldsen, 2013). Tak et al. (2012) recommended that mishap information listed tools, exposures, worker tasks, and conditions to record to compare risks, identify exposures, and determine the most appropriate intervention measures.

DeArmond and Chen (2009) found correlations between workplace sleepiness and occupational injury as being a complex subject in that it related to pain frequency and severity but not to injury frequency or severity individually. Dupont, Martensen, Papadimitriou, and Yannis (2010) confirmed that the estimated survival probability affected by accident-sized factors was by the type of opponents involved. Peng-Cheng, Guo-Hua, Li-Cao, and Li (2010) studied reliability and safety assessments and discovered that both hardware failure and human error needed to be explored for better understandings of accidents from operational systems. Humans run engineering systems that have caused serious accidents, and the results of such a study elucidated the need for workers' heuristics in the process of improving and gaining acceptance of the rules that guide safety (Otsuka, Misawa, Noguchi, & Yamaguchi, 2010).

Lundberg, Rollenhagen, and Hollnagel (2010) concluded that further research into safety must aim at the methods and tools to transition from strict analysis to the design of remedial actions. Namely, Villanueva and Garcia (2011) found that circumstances of work accidents combined with individual factors would dictate the risk of the injury becoming fatal or not. Simply put, DeArmond, Smith, Wilson, Chen, and Cigularov (2011) established that safety compliance and participation negatively related to occupational injuries. Namely, Bazargan and Guzhva (2011) conducted a series of statistical analyses to investigate the significance of gender, age, and experience in influencing the risk for errors and fatalities in the cause of accidents. Finally, López, Fontanedab, Alcántarab, and Ritzel (2011) identified the greatest concern among occupational safety researchers was to understand what the causes were that produced accidents.

Leung, Chan, and Yu (2012) provided three recommendations from their study to include stakeholders to set personal, specific, and long-term work goals; conduct a fair amount of training; and review guidelines for safety equipment use. These above items were some of the areas that needed further research in occupational safety but occupational health also needs further study (Leug et al., 2012). Cheung and Chan (2012) identified falls as being a major safety issue in construction and made suggestions on ways to improve this dangerous situation by building barriers to keep workers safe. However, Talbot, Fagerlind, and Morris (2013) determined distractions and inattention as being the prevalent factor in accident causation and no amount of engineering will prevent people from being hurt. Everyone employed should train in safety to reduce workplace accidents as models show that most accidents are preventable but it starts with the engineers who must design the systems to be safe (Gyekye, 2010). Gyekye (2010) also found that accidents will happen no matter what, but reduced safety problems resulted in cost savings, less accidents, and a safer environment to which to live in.

Wachter and Yorio (2013) found organizational effectiveness dependent on the safety-focused cognitive and emotional engagement of workers. They found that organizational managers implement the policies, plans, procedures, and processes prescribed by the American National Standard Instruction/American Industrial Hygiene Association (ANSI/AIHA) Z10 and the Occupational Health and Safety Advisory Services (OHSAS) 18001 standards. As a foundation, the worker's commitment would dictate success. Workers needed to put in the center of safety management systems so that they engaged and involved in maintaining a safe work environment to reduce accidents (Wachter & Yorio, 2013).

Lawson, Sharples, Clarke, and Cobb (2013) studied the ability to predict human response during emergencies that gave indications of what could go wrong and right during a crisis. Further, Chen and Zorigt (2013) found that safety improved when coupled with investment, management, stakeholders, regulations, and culture. Hadjikhani and Thilenius (2009) agreed that trust and commitment connected and built upon relationships. Shi (2009) investigated the controversy over where or not safety regulations improved performance. The study found that it reduced the frequency of serious accidents but not the overall mortality rate (Shi, 2009). Lipscomb, Schoenfisch, and Shishlov (2010) identified contact injuries as the largest occurring rate sustained in the past eight years, with the strategy to prevent these kinds of accidents requiring control mechanisms.

Arquillos, Romero, and Gibb (2012) concluded that the high level variables that made up an accident conditions to include age, type of work, size of company, length of service, place of accident, type of injury, and departures from procedures or rules. Other factors such as climatic zones, days absent, and day of week accident occurred, and miscellaneous environmental factors needed further study, as these issues not considered as accident factors (Arquillos et al., 2012).

Goerlandt, Ståhlberg, and Kujala (2012) identified fire, groundings, and collisions as the most common shipboard accidents leading to death, injury, and pollution. That was Yang, Bonsall, Wall, Wang, and Usman (2013) reported that 80-85% of all recorded maritime accidents caused by human error or were associated with human mistakes.

Rollenhagen (2010) agreed and stated that problems with risk and safety addressed from a human and organizational perspective instead of trying to modify technology.

Lindberg, Hansson, and Rollenhagen (2010) postulated that to prevent accidents in the future it was imperative to learn from previous incidents and accidents. However, they found that the literature was fragmented and a consolidated, unified, and integrated approach to learning from accidents was lacking. Feedback had not sufficiently provided to develop the strategies needed to prevent accidents in the future (Lindberg et al., 2010).

Gilkey et al. (2012) connected safety culture to having a direct effect on safety performance. MacIntosh and Doherty (2010) also correlated a connection with organizational culture. Nævestad (2010) concurred that cultures in organizations have to connect to safety culture. Safety culture was an important area of understanding for organizations as many factors could occur based on this condition.

Lipscomb et al. (2012) explored workplace violence and safety climate and found violence to be rare. McCaughey, DelliFraine, McGhan, and Bruning (2013) found that organizations that had high injury and illness rates also had high job dissatisfaction, high turnover, and personnel shortages. Law, Dollard, Tuckey, and Dormann (2011) found these psychosocial safety climate issues to be a new area of study that relates health and safety that management needed to understand to adapt to employee’s protection.

Interestingly, dos Santos Grecco, Vidal, Cosenza, dos Santos, and de Carvalho (2014) found safety culture to be a complex concept that required everyone’s attention to make people safe. There was no tool, which measures safety culture (dos Santos Grecco et al., 2014). Shi and Shiichiro (2012) discovered that safety culture contains abstract elements. Mengolini and Debarberis (2012) provided lessons learned from a nuclear reactor accident that came about because of a decline in an organization's safety culture. Likewise, Rollenhagen, Westerlund, and Näswall (2013) developed the research further upon the differences between safety culture and safety climate.

Johnstone, Quinlan, and McNamara (2011) identified a growing recognition that work influences the safety and health of employees. Mellor et al. (2011) agreed and called for more research in the area of health of employees as it related to culture. Myers, Nyce, and Dekker (2014) believed that using culture was just an excuse for not dwelling deeper into social factors. Nenonen (2011) found that accidents related to a variety of issues such as outsourcing, start-up work, and health of employees. The health of employees was the next area of major significance to discuss. Occupational health had just as many issues and challenges.

Occupational Health

Sweden had led the way in research on occupational health and accident prevention (Menckel, 1993). Unfortunately, most third world countries' engineers have not been able to improve upon the occupational health of its citizens (Bleck & Wettberg, 2012). Bleck and Wettberg (2012) found that it was difficult to study in Ethiopia where it would have improved the safety of waste collectors and recyclers. Venâncio, Heemann, and Chaves (2012) discovered by triangulation that ergonomics affects the wellbeing, fitness, and health of workers in the office. Therefore, health issues could be basic or complex depending on the context that they define under according to de Campos (2012). Hence, health studies could analyze with the concept of life balance to determine if one's own wellbeing was being adversely affected (Sheldon, Cummins, & Kamble, 2010).

Research by Behm and Schneller (2011) initiated that health literacy, wellbeing, and safety metrics ignored in peer-reviewed literature and some managers do not even report other information besides injury statistics though that additional information such as what caused the accident could help in the development of solutions. Likewise, Hansen, Hogh, and Persson (2011) studied that most stress at work was unnecessary; and poor work environments could also lead to negative mental health results of employees. All of these above factors adversely harm the health, mental capacity, and wellbeing of workers, and their ability to be fit-for-duty at their jobs and work locations (Kohanna, 2013). Therefore, Salmela-Aro, Mutahen, and Vuori (2012) found that the ability to reduce or even prevent work-related burnout and stress not easily achieved, if vital skills, goal setting training, and attainment of objectives not provided to individuals. Training and communication was the key to provide workers with the support they need.

A study of organizational education and training by researchers found large positive impacts addressed risk issues that involved occupational health (Robson et al., 2012). Generally, Furu et al. (2012) stated that workers often exposed excessively to harmful products or dangerous tasks that affected their health in their daily work, but worker's hazards often go unreported because of fear of job termination. There needed to be systematic hazard identification made, and then the ability to educate and train employees and the public to the hazards, evaluate risks, and identify appropriate prevention techniques conducted to make work safer (Moreau & Neis, 2009).

Badri, Nadeau, and Gbodossou (2012) discovered an approach to conduct reliable and complete evaluations of a product or project before managers could begin to identify risks and protect the health of workers and nearby residents. As a result, Zanko and

Dawson (2012) uncovered that organizations had a conflict between production and the protection of health for employees. Further, Rosskam (2011) research postulated that often management made sure that production gets all of the resources, attention, and support and safety only received the minimum deemed necessary. The health, environmental considerations, and safety aspects often underfunded or understaffed by the supervisors or management who looked to increase the bottom line (Rosskam, 2011).

Wartak et al. (2011) found that coronary heart disease was the leading cause of death in the USA. These authors discovered that only one third of patients could identify the seven components of cardiovascular health. These consisted of not smoking, conducting regular exercise, eating a healthy diet, keeping an ideal body mass index, maintain low cholesterol and blood pressure, and low blood glucose. Less than half of the patients knew that heart disease was the leading cause of death (Wartak et al., 2011). Engineers could help to educate the public by the systems they design and build to take into consideration the health of workers.

Waehrer, Dong, Miller, Haile, and Men (2007) found that occupational diseases were difficult to ascertain because they are not apparent until many years after exposure. As a rule, Keall, Guria, Howden-Chapman, and Baker (2011) identified a lack of emphasis placed on benefit-cost analyses in health research. Research on fatigue was also an area that needed further research as proposed by Merat and Jamson (2013) who found accidents from fatigue resulted in many serious injuries and deaths. While the consumption of alcohol, drugs, and overdoses of medications also known to increase the frequency of fatigue-related accidents, it was sleep disorders and drug dependency that needed a greater understanding in the health of humans and the effect sleep and drugs have upon the workplace's employees (Keall et al., 2011).

Hendrick (2008) identified after an experienced career, a responsibility to conduct cost-benefit analysis of ergonomic projects that improved the health and safety of workers for management's approval. As technology changed and the need for engineering designs made, ergonomics continued adapting to meet those changes (Hendrick, 2008). Work-system design was the area that had the greatest ergonomics challenges for the future (Hendrick, 2008). Theberge and Neumann (2010) called for further research of applying ergonomics science to the professional practice of engineering so that superior systems that do not harm humans can exist.

The researchers de Castro, Rebelatto, and Aurichio (2010) focused on foot pain as an area, especially in older women, that needed intervention, and a change in thinking of footwear for these workers. The largest work health injury was improper ergonomics that training could help rectified in giving workers the knowledge they need to protect themselves (Robertson, Ciriello, & Garabet, 2013). Galinsky and Matos (2011) recommended that employers help employees with health and wellness efforts that go beyond standard healthy eating, exercise, and smoking cessation. They recommended improvement in the work environment to promote wellbeing and to develop a strategy to benefit people and the planet (Galinsky & Matos, 2011).

Pressler et al. (2010) discovered a high dropout rate among workers in structured and unstructured Internet-delivered exercise programs. More research needed to determine how to promote better participation from workers (Pressler et al., 2010).

Health issues improvement by engineers still have a long way to be understood and enacted (Robson et al., 2012).

Greenspan and Noonan (2012) helped expand a linear model to allow feedback to measure how intervention strategies worked and to gain knowledge in what was not working. The model developed had four major steps that now all have feedback loops associated with each step (Greenspan & Noonan, 2012). In addition, Raj-Reichert (2013) questioned whether the health of workers improved with governmental regulation or organizational self-monitoring when communication between workers and management was poor. Further, Hämäläinen, Saarela, and Takala (2009) stated that work-related diseases were still a worldwide problem and the numbers had actually grown in the last 10 years. Finally, Hayes, Perander, Smecko, and Trask (2013) found that workplace safety related to job stress, psychological problems, physical complaints, and sleep issues. Many factors contributed to the health of employees within the workforce.

Pilkington, Marco, Grant, and Orme (2013) advocated for engineers and architects to expose to public health issues so that their designs could be improved the wellbeing of workers. Pilkington et al., (2013) believed that these students would be better at their jobs when they have a good understanding of health and wellbeing of their fellow workers. Likewise, Chau et al. (2010) identified sitting for long periods as a health risk to workers and that there was little interventions developed to address this health risk. Thorndike, Healey, Sonnenberg, and Regan (2011) concluded that worksite exercise programs could successfully implemented to improve the health of higher risk obese employees. Accordingly, Morgan et al. (2011) found that a program was feasible and efficacious by improvement of workers health with weight loss programs to improve health-related outcomes.

Health problems could influence performance of workers even when they were on the job (Cancelliere et al., 2011). If employees were not performing at a high level that they should be because of health issues then accidents could occur more readily (Cancelliere et al., 2011). The term "presenteeism" developed to describe workers who are at work but are not performing at their full capacity (Cancelliere et al., 2011). This could involve working at slower rate or playing games instead of doing actual work or being productive (Cancelliere et al., 2011). Ford, Bergmann, Boeing, Li, and Capewell (2012) found a strong correlation between healthy lifestyles (refraining from smoking, eating a healthy diet, and remaining active) that greatly reduced mortality. A targeted health effort to educate people to improve the health of the U.S. population by training and modifying the risk behaviors of adults should give all people an opportunity to live a healthier and longer life (Ford et al., 2012).

Panter, Desousa, and Ogilvie (2013) encouraged walking or cycling to work to promote health, prevents disease, and improves wellbeing while at the same time reducing noise, air pollution, and carbon dioxide emissions that may mitigate climate change issues. This same study found that just small increases in cycling or walking contributed to human health improvements significantly (Panter et al., 2013). Organizations needed encouragement in this type of commuter behavior by limiting available parking and encouraging walking and cycling into the journeys to work.

Gilson et al. (2013) found that automated systems effectively encouraged modest improvements and active strategies to those that need intervention the most. Further, Healy et al. (2013) discovered that sitting time reduction could achieve positive effects on health and work-related outcomes. Employers should seek ways to improve the health of their employees for minding available strategies that could at the same time improved productivity and enhance performance (Gilson et al., 2013). Standing stations, employee exercise programs, and diet education could improve the health of employees and their productivity (Healy et al., 2013).

In summary, health impacts were important to understand both from the problem of work causing health issues and employees who already have health issues affected their ability to perform at required levels. Engineers needed to understand the implications of health issues to prevent harm to workers in the designs that they produced. Not only prevention of unhealthy substances but also ways to help improve the health of employees needed focus to improve the health of employees. Engineers needed to design solutions that will help met these challenges. This same kind of approach could also use to improve upon the environmental sustainment efforts that included the earth's land, water, and air.

Environmental Sustainment

A study of financial-decision makers by Huang, Leamon, Courtney, Chen, and DeArmond (2011) discovered that environmental prevention considered a gap in training and funding. Likewise, a company's management staff with poor communication skills typically resulted in employees not reporting on-the-job environmental issues for fear of retribution (Cigularov, Chen, & Rosecrance, 2010). Vallero and Letcher (2012) found in their research that an understanding of what constituted an accident, disaster, or hazard was important for engineers and managers to understand. Platter (2011) studied the 2010

British Petroleum Deepwater Horizon oilrig blowout in the Gulf of Mexico to see how it compared with the 1989 Exxon Valdez oil spill in the Gulf of Alaska. Both released large amounts of oil, caused harm to humans, and the natural ecosystems impacts not fully understood in either disaster (Platter, 2011). Concern rose that these kinds of risks existed when trying to produce and transport hydrocarbon materials especially over great distances, accidents and spills have occurred more frequently at these times (Platter, 2011). Hence, Filion (2010) called for more environmental sustainment training for engineers so they could understand and improve in this area of impact awareness from manmade pollution.

These environmental topics could be complex with experts having many different opinions on what academic courses were best to prepare students for the workforce, but with the use of the Delphi method it was possible to come to a consensus (Jünger, Payne, Brearley, Ploenes, & Radbruch, 2012). These different opinions consisted of what subjects such as green chemistry, environmentally conscious design, and sustainable engineering were all important topics, but students might not be able to take them all (Aurandt & Butler, 2011). Kevern (2011) identified that there was a gap in the role of engineers in designing and developing sustainable and green buildings. The green movement had been helpful in borrowed ideas to improve safety and health as they all presented parallel challenges for human behavioral changes (Cunningham, Galloway-Williams, & Geller, 2010). Likewise, Rosness, Blakstad, Forseth, Dahle, and Wiig (2012) found no uniform approach in the literature for solving our planet's environmental sustainment challenges except for the continued improvement in education to train more engineers' understanding of the harm caused by poor engineering designs.

The International Convention for the Prevention of Pollution from Ships (MARPOL) covered a wide range of environmental areas, including prevention of pollution from oil chemicals and other hazardous substances, ballast water treatment, the reduction of harmful paints, the reduction of emissions from ships, and ship recycling (Heij, Bijwaard, & Knapp, 2011). Many shipping firms management teams have begun to respond to environmental concerns by embracing green shipping practices (GSPs) to green their operations (Lai, Lun, Wong, & Cheng, 2011). GSPs or greening are environmental management practices undertaken by shipping firms with an emphasis on waste reduction and resource conservation in handling and distributing of cargos to reduce carbon footprints and reducing environmental damage (Lai et al., 2011).

Merchant, Pirotta, Barton, and Thompson (2014) indicated that the noise levels in the oceans were increasing with adverse effects to the marine animals that lived in this environment. Air quality could adversely affected by shipping and have significant negative impacts on public health and global climate change especially in ports (Han, 2010). Indeed, Gilbert and Bows (2012) recommended a global policy for the reduction carbon dioxide from ships to improve the effects of emissions on climate change. Fujita et al. (2012) also recommended using ocean thermal energy conversion to provide an alternative source of power by using different temperatures in the ocean as a way to provide a clean energy source that was free of air pollution, ambient noise, and greenhouse gas emissions. This could go a long way to improve pollution by using clean renewable energy source that was sustainable and affordable (Fujita et al., 2012).

Ismail and Karim (2013) found that Europe recorded the highest volume of oil spills involving crude oil usually caused by human error. The short-term effects on the health of people, animals, and the environment were difficult to determine. A majority of the ships that broke up dumped all of the hazardous cargo into the ocean (Ismail & Karim, 2013). Neuparth, Moreira, Santos, and Reis-Henriques (2012) studied the status of environmental monitoring programs implemented after oil spills to determine the effectiveness and recommended further research to analyze the major gaps to be better prepared to respond to future mishaps. Yip, Talley, and Jin (2011) found that double hull-designed ships reduced the amount of oil spillage when accidents occurred, but that further research should examine other technical solutions for reducing spillages.

Thurstan, Hawkins, Neves, and Roberts (2012) investigated marine reserves and found that damage also occurred at these protected sites by recreational events. These protected sites only made up less the 1.6% of the global ocean surface but still damaged by fishing, pollution, and habitat destruction from boating activities, the introduction of foreign species, and other human activities (Thurstan et al., 2012). The researchers found that it was impossible to prevent all impacts even with restricting human access, but that further research could develop better methods to protect areas (Thurstan et al., 2012).

Cariou (2011) found by reducing speed, ships can reduce CO_2 emissions but this will only be sustainable if bunker prices remained high and owners were willing to delay shipping times. Lindstad, Asbjørnslett, and Strømman (2011) agreed that lowering speeds would reduce emissions and recommended imposing a speed limit on ships. In addition, Hall (2010) recommended that all ships in port use shore-power referred to as shore-side power or cold ironing to reduce the amount of emissions that ships would generate using ship's power. Air pollution causes many different health problems including lung cancer, cardiovascular disease, and birth defects; ships contributed to these problems but by reducing speed and using shore-power could reduce this danger significantly if done worldwide (Chang & Wang, 2012).

Man, Naidu, and Wong (2013) exposed a serious problem of electronic waste that generated toxic substances and heavy metals causing environmental pollution and affecting the health of humans and animals. A call to use natural biodegradable materials in the production of computer systems would help make more sustainable products (Man et al., 2013). Hunter, Church, White, and Zhang (2013) determined that climate change was increasing the ocean's sea levels by thermal expansion of seawater and the addition of water from melted land ice. Correspondingly, Gangolells, Casals, Forcada, and Macarulla (2014) found a gap in environmental impacts at municipal engineering works prior to the construction stage caused by poor engineering design and lack of planning.

Pontiggia, Derudi, Alba, Scaioni, and Rota (2010) found that hazardous gas released in urban areas was a major concern in industrial risk assessments. Even environmental pollution could cause serious problems in urban areas because of the dense populations and building not being equipped to prevent infiltration of contaminants (Pontiggia et al., 2010). The researchers found that models often overestimated or underestimated the magnitude of the impact of hazardous material released in an urban area (Pontiggia et al., 2010).

Topuz, Talinli, and Aydin (2011) found 70,000 synthetic chemicals that used in industrial production processes, products, and home household goods that are hazardous materials. There was a need for further study about the environmental and human health risks associated with these synthetic chemicals. Solutions for minimizing these chemical accidents included strengthening laws and regulations, development of science and technology, and provide educational programs on safe production, transportation, and the use of hazardous items (Duan, Chen, Ye, & Chen, 2011).

Munro (2013) investigated large-scale nuclear accidents such as Japan's Fukushima and Russia's Chernobyl disasters that not only created major environmental damage but also hurt the economies by lost assets. Wang and Chen (2012) reported that there are 433 nuclear plants operation with an additional 65 under construction or proposed to build. All nuclear power plants needed tighter regulatory oversight according to Wang and Chen (2012) to prevent future accidents. Engineers needed to understand nuclear energy complexity better in order to design for safety and reduce accidents and disasters from happening at these nuclear power plants (Boy & Schmitt, 2013).

Hurricane Katrina was one of the worst environmental disasters in U.S. history because the engineered levees and floodwalls were not strong enough to protect the people and property (Newberry, 2010). Newberry (2010) cited several engineering problems that engineers still needed to learn from Hurricane Katrina. Challenges existed in unanticipated failure modes, lack or misuse of information, faulty assumptions, resiliency, effects of time, balancing competing interests, interfaces, risk perception, and how past constraints impacted the present (Newberry, 2010).

Environmental sustainment impacted by the fossil energy chain, which included coal, oil, and natural gas (Burgherr, Eckle, & Hirschberg, 2012). Taylor (2012) provided lessons learned and called for more knowledge and better safety design processes. China had the worse safety record in the world and was the leading polluter from coal (Wang, Cheng, & Liu, 2014). Engineers needed more education in environmental sustainment to minimize the pollution generated (Cunningham et al., 2010).

There were two main kinds of environmental accidents identified, routine and surprises (Ismail & Karim, 2013). Some surprises included indoor air pollution problems that exist in buildings and homes that needed engineering solutions so human health was not affected (Gail, Carter, Earnest, & Stephens, 2013). The routine kinds could be just as deadly or harmful and can even exist in our planet's oceans such as toxic materials and substances that grow in nature because of human intervention (Bahtiarian, 2013). Bahtiarian (2013) reported that underwater noise levels have been doubling every 10 years primarily from human activities. Oil spills, increase ambient noise in the waters, and dumping can cause severe water pollution (Bahtiarian, 2013).

Brown (2012) in discussing lessons learned from the Macondo well Deepwater Horizon blowout that killed 11 workers and released 5 million barrels of oil into the Gulf of Mexico, stated that educating and training was important for a systems safety perspective. Interactive training with virtual reality provided a risk-free environment for all types of people in various positions that could learn in a simulated work setting (Goulding, Nadim, Petridis, & Alshawi (2012). Vallero and Letcher (2012) found that engineers have had a hard time characterizing and preparing for disasters regarding risk assessment and the proper responses to follow. Safety must be designed into engineering student's curriculum provided them with the tools, experiences, and knowledge to be able to protect worker's safety, protect them from hazards, keep them healthy, and safeguard our environment from damage (Vallero & Letcher, 2012).

Safety Engineering Curriculum

Most engineering curricula do not cover safety aspect for an engineer's education at most U.S. universities (Crede & Borrego, 2012). Safety engineering curriculum included all of the occupational safety, health, and environmental sustainment issues that engineers should have as a part of their education but currently do not at most accredited universities. It involved not only designing systems that were safe and do not pollute but also improved the safety and health performance of an organization (Hsu et al., 2012). Weber (2013) found that universities administrators were trying to offer new courses in safety and environment but that they were often just elective course subjects and introductory classes that were not required for graduation.

Boboc (2012) stated that U.S. schools lag behind in this engineering education and called for more research into the effective design, implementation, and evaluation of student-center curricula for engineers. Shafer (2010) found that students often pressured to take a wide-range of engineering courses, and were required to take the humanities to make them well-rounded students, but they were still not being equipped to handle future engineering challenges.

Ness (2011) warned that even though people were living longer it only created more challenges for engineers trained properly in new scientific discovery to build innovative safe environments for an aged population. Newson and Delatte (2011) investigation revealed that engineers still trained on deductive instruction instead of being educated on inductive learning as they should be learning and expanding their research training. This new kind of training relied on case studies such as the Kansas City Hyatt Regency walkway collapse as an example of how not to build something incorrectly, and what should have designed instead so that the students learn from the mistakes of others. Hopkinson and James (2010) recommended that engineers slowly be re-oriented in the development of sustainable developments instead of radically making drastic changes.

A study by Aurandt and Butler (2011) found two ways to expand engineering education. The first was to redesign existing courses, and the second was by the development of new advanced courses that related to sustainability, safety, and health. Bell, Gaililea, and Tolouei (2010) recommended a hybrid of learning approaches, whereas some other researchers recommended starting all over with brand new curricula (Barry & Ohland, 2012; Tough, 2010). No matter what type of engineering training identified, it needs blending in order to adapt to all students' learning styles and identify how each one retains the important information they can use in their careers (Martínez-Cartas, 2012).

One size does not fit all; therefore, engineering education needed to be made more interesting to a wider, more connected, and expanded global audience so that learning can take place in many different ways (Taras et al., 2013). The types of engineering education could be complex, tenuous, and diversified, but the key to improvement was in adopting the best-learned practices to be more effective when entering the technical profession. People learn in many different ways and a quintessential way to train was by employing as many methods as possible (Taras et al., 2013).

Spickett (1985) stated that the first formal discussions on courses in occupational safety and health took place in 1978 although informal discussions started much earlier. Vinodkumar and Bhasi (2010) identified that safety training was the most important consideration for safety management practice that predicts safety knowledge, safety motivation, safety compliance, and safety participation. The results of the study found strong empirical evidence for the theoretical model that antecedents, determinants, and components of safety performance were closely associated (Vinodkumar & Bhasi, 2010).

Not all training and education need conducted in the classroom. Sadasivan and Gramopadhye (2009) found that advanced technology and training in the workplace could be the best education for reducing problems and preventing accidents. Similarly, Kaskutas et al. (2010) identified that the training received at a schoolhouse was quite different from in the field in regards to safety education. In addition, Wu's (2011) perspective was that when developing safety curricula both internal and external members needed consideration. Further, Kaskutas, Dale, Lipscomb, and Evanoff (2013) suggested that training be learner-centered and contextually relevant for the students to improve safety behaviors, enhance on-the-job training, and improve safety communications at worksites. Arciszewski and Harrison (2010) recommended that engineering education be revolutionized to improve and make it more successful.

Filion and Hall (2009) found that engineering products, processes, systems, and infrastructures were responsible for human illness and environmental damage. Engineers needed education that would help them solve and prevent human health problems (Filion & Hall, 2009). Intellectual scope of engineering education needed to include public health and environmental concerns to be an effective force in addressing the environmental threats and public health issues of the 21st Century (Filion & Hall, 2009). Valdes-Vasquez and Klotz (2011) agreed that engineer's education needed expansion to include sustainability issues to help improve safety through design, more safety considerations, and a focus on safeguarding the health of humans and animals by protecting the planet's ecosystems. To improve the education of engineers an understanding of the different types of educational teaching methods that were available and which ones were more effective.

Types of Educational Training

Donnelly (2010) found that a combination of face-to-face and online educational training in a blended environment was best when done correctly in a problem-based learning (PBL) environment. Educators needed to find a balance between classroom and computer-mediated environments by taking advantage of strengths and eliminating weaknesses (Donnelly, 2010). A gap existed in a validated framework for designing instructional development for engineering educators to make changes to traditional models of engineering design and theory courses (Felder**,** Brent, & Prince, 2011). Kelley (2010) found that there was important consideration of the grade level of the student as how the engineering information taught in middle, high school, and during the student's college years. There was also a need to learn from the past so that mistakes could not repeat, and that the information from previous research used to develop frameworks to understand the different types of educational engineer training (Chen, Chang, Chou, & Mortis, 2010).

Kaber et al. (2013) found limitations by a situation awareness study of virtual environment-based training were the small sample size, experiment control, and flexibility of tools. Further research from this situation awareness study called for sensitivity of measurements, obtaining user feedback, establishing networks, using tablets, and using more databases (Kaber et al., 2013). Murray, Pérez, Geist, Hedrick, and Steinbach (2012) established that learning research was to show that students perform better online than during face-to-face instructor led courses as long as the online courses aligned properly. However, some students learned better with structure and with live instructors (Murray et al., 2012). Further research needed to identify how blended education constructed could help the most students learn engineering.

Shallcross (2013) used 27 case studies presented to students in an engineering program to teach the importance of safety, develop their presentation skills, and improved their general communication abilities. Arnó-Macià and Rueda-Ramos (2011) studied useful tools to educate engineers by autonomy, availability, openness, speaking skills, and content to provide the critical thinking needed for learning outcomes. Further research needed to look at how students used tools and specific materials to broaden their educational experience (Arnó-Macià & Rueda-Ramos, 2011).

Rojter (2012) had suggested that engineers should be considered marginalized because of the perception that the engineering professionals have caused more harm to the environment, applied negative safety advancement, and created danger to humanity than any amount of good. Historical and technological developments had allowed the exploration of different educational frameworks (Strobel, Wang, Weber, & Dyehouse, 2013). Behm, Culvenor, and Dixon (2014) had discovered that engineers-in-training have no room for new courses in their undergraduate degree programs, but by incorporation of knowledge into existing courses, blending it into the existing information, then there was a way to incorporate all or at least most of the necessary information for the engineers to learn in their undergraduate degree education.

Guo, Li, Chan, and Skitmore (2012) believed that current safety training methods and tools were unable to provide trainees with the hands-on practical training they needed, and suggested new game-technology products as a way to overcome the problem using a virtual environment for education. In addition, an area often overlooked was ergonomic training provided to all employees (Niskanen, Naumanen, & Hirvonen, 2012). Equally, another area often overlooked was for safety training in the workplace on violence prevention (Menéndez, Konda, Hendricks, & Amandus, 2013). Larson (2012) advocated for changing curricula to take evidence validated by research, and transformed the information to practice that students could immediately apply.

Centner (2011) found that reviewing U.S. state legislatures laws was another area of education to understand the rules and regulations that govern occupational safety, health, and environmental sustainment. No matter what students learned today, some form of technology appeared to be helping with their education (Burns, 2013). Lee (2012) discovered there were many ways of training such as textbooks, computers, handheld devices, lectures, online, and something new called augmented reality. Further research was to examine solutions for cost efficiently of providing needed education to engineers should examine all available aspects in the areas not historically not covered in traditional engineering programs such as occupational risk prevention matters (Lee, 2012).

Praslova (2010) adapted a four level criteria model for ways to go beyond standardized tests to evaluate student's knowledge and understanding. Colleges and universities needed feedback on how they are doing and this often-involved assessment, but other forms of feedback can provide to these institutions administrators, giving them the benchmarks they needed to continue to improve upon their educational practices. Stakeholders like the students, employers, and even the community could help these higher educational institutions' faculty, staff, and administrators to achieve the goals set out for them to achieve for their students (Praslova, 2010).

Aper, Reniers, Koole, Valcke, and Derese (2012) suggested a third alternative to classroom and online instruction to include what they call autonomous training with feedback from simulated customers and peers without direct supervision. This role-playing provided an increased array of new skills that students not usually exposed to in everyday life (Aper et al., 2012). No matter what kind of training provided, the ultimate goal was to reduce the fatalities, accidents, mishaps, and the costs associated with these events.

Costs of Accidents

Engineers understood very little concerning occupational injuries costs as estimates have had wide ranges (Miller & Galbraith, 1995). Past researchers estimated back in 1995 that workplace injuries cost $140 billion annually that made up of $17 billion in medical; $60 billion in lost productivity; $5 billion in insurance costs; and $62 billion in lost quality of life (Miller & Galbraith, 1995). Cagno, Micheli, Masi, and Jacinto (2013) discovered that the International Labor Organization (ILO) estimated that the impact of accidents and illnesses were at $1.25 million U.S. dollars per year. Matthewman (2012) found that the costs from a sociology perspective could be staggering in human prices and that the economic losses could exceed $690 billion per year from accidents.

Natural disasters averaged 250,000 deaths per year with $15 million to mitigate and recover from the damage caused (Oh & Oetzel, 2011). Some manmade disasters such as oil spills or cutting down of the rain forests were difficult to assess the actual damage but record profits were made in 2009 at $14 billion by the oil companies and forest lumber businesses with an unknown impact to the environment (Baura, 2010). The mental and physical aspects of accidents on individuals, families, and the environment needed further understanding (Matthewman, 2012). Rikhardsson and Impgaard (2004) estimated the workplace disruption cost was $10 billion and loss of quality of life estimated at $62 billion. Reduction of the cost of accidents was also a goal for engineers to improve upon.

Dyne (2013) showed that the cost of worker injuries had a significant impact to business operations. Baumeister, Knecht, and Hutter (2012) found that chronic back pain affected between 5-11% of the general population and could be very costly for any healthcare system to fund. Ikpe, Hammon, and Oloke (2012) identified that the cost of trying to prevent an accident or injury far outweighed that allowed in the damage to result without trying to stop it from occurring in the first place.

Insomnia had substantial costs associated with this disorder even if it was difficult to quantify, but estimates place in the billions of dollars of lost productivity (Léger & Bayon, 2010). Some damage were not even accidents such as the hearing loss that sailors and manufacturers exposed to loud noise over extended periods have caused $26,000 in lifetime cost per person (Tufts, Weathersby, & Rodriguez, 2010). Barros, Faria, and Gil-Alana (2010) found that even though they were rare, airline mishaps could also be very expensive events, even though overall, the airline safety record was superior to any other types of industries.

Manuele (2011) called for more research in the development of ratios of indirect to direct costs for better ways to determine the cost impacts of pollution, and having unsafe systems that adversely affect health. Some of the limitations of cost analysis research were that different conditions and situations would not allow for a standardized way of calculating expenses (Silva, Ishiwatari, & Takahara, 2014). Wenxing and Shuai (2012) and DeArmond, Huang, Chen, and Courtney (2010) all agreed with their respective study's findings that showed maintenance and operational costs must consider pollution, accidents, and energy in the mix of total ownership costs, but that the size of the firm does not matter. Another limitation of these financial impact studies were that the sample sizes were usually too small to qualify, and better methods of controlling and recording the business costs was needed that resulted from accidents (Marion & Meyer, 2011; Howell & Everett, 1998).

World trade is conducted 80% by sea and the monetary benefit of port safety inspections estimated to range between $70 and $190 thousand dollars (Knapp, Bijwaard, & Heij, 2011). Ng and Song (2010) research of the *Exxon Valdez* disaster, found that Exxon had to pay $2.2 billion for cleanup costs, $1 billion in settling lawsuits, and $300 million USD in lost wages to anglers and business firms. The British Petroleum disaster in the Mexican Gulf in 2010 was larger with $4.525 billion in fines and other payments were still pending from this disaster (Ng & Song, 2010).

Kramer et al. (2010) studied musculoskeletal disorders costing an average lifetime cost estimated at $74,296 with the average first year cost being $11,200. Waehrer et al. (2007) presented 2002 data that showed total direct costs for injury and death amounted to $11.5 billion. Niu (2010) research had the cost at $190 billion in U.S. dollars, direct cost of work accidents in Norway at 40 billion Norwegian Krones ($7.4 billion U.S. dollars), and £19 billion in the UK ($31 billion U.S. dollars). Jallon, Imbeau, and Marcellis-Warin (2011a) developed a model that would calculate the indirect costs of workplace accidents.

Jallon, Imbeau, and Marcellis-Warin (2011b) determined that on average across all industries, the per-accident indirect cost amounted to $1,156 (U.S. dollars) while the direct cost was $1,391 (U.S. dollars). Boccard (2014) calculated that all energy sources have pros and cons and that the cost needs calculation in what were the negative long-term impacts on the people and the environment. López-Alonso, Ibarrondo-Dávila, Rubio-Gámez, and Munoz (2013) studied the costs of accidents directly related to the total number of workers and subcontractors having a negative impact on health and safety budgets.

There was also a cost consideration for the development of the course materials to train engineers to protect the workers. Costs seem to vary greatly. Some are very expensive to develop and others were relatively cheap in comparison.

Costs of Developing Course Materials

Ku and Fulcher (2007) found that the cost to develop course material was negligible as compared to the derived costs gained from the knowledge gathered or obtained from the information provided. Christofferson, Christensen, LeBlanc, and Bunch (2012) had estimated the cost of developing an online course could range from $10,000 (U.S. dollars) to over $100,000 (U.S. dollars) for a typical course that would also test knowledge and understanding from the participants. A medical engineering training course developed for only $2,630 (U.S. dollars) that equated to $6.58 (U.S. dollars) per user in one single year (Moreno-Ger et al., 2010).

The length and complexity of the actual course determined the overall cost of development of a course (Martín-Gutiérrez et al., 2010). Herman and Banister (2007) found that online courses could reduce costs for everyone by being cheaper for the students and less expensive for the school to develop. Many engineering students preferred to have classroom instruction lead by an instructor even though it costs more (Churlyaeva & Kukushkin, 2012).

On average, there was $2.6 billion in property loss from nonresidential structural fires (Mitchell, 2013). Some of these fires could have prevented by training people who taught on the dangers of fire and safety prevention (Mitchell, 2013). Courses and periodic training could help people prevent some accidents from occurring (Mitchell, 2013). Fullarton and Stokes (2007) established that workplace accidents were costly for individuals, organizations, and to society, therefore finding ways to prevent them or at least minimizing the impact by them would have provided considerable benefit to all concerned. Huang, Leamon, Courtney, Chen, and DeArmond (2007) researched senior executives to see the value of improving workplace safety by providing training to increase productivity, reduce costs, improve retention, and increase satisfaction. The real cost of not doing any kind of safety training could not be currently be measured fully as the impact on the health of the planet and individuals will not be realized for many years to come (Perera et al., 2012).

Haling and Trout (2013) had estimated the saving of 43 worker's lives and $585 million in cost reductions and productivity improvements in educating employees about the dangers in the workplace. These kinds of informative courses that trained employees on how to conduct themselves correctly could help prevent accidents, injuries, and violations of regulations. Batz (2013) discovered that the cost of fatal vehicle crashes cost $41 billion (U.S. dollars) per year, and that many were work related but all influenced the workforce. The study by Yükçü and Gönen (2009) showed the importance of occupational accidents' costs effects on workers, employers, the national economy, and society but also showed that it could minimized with an investment into safety training.

Bahn and Barratt-Pugh (2012) found that some training was of unsubstantiated value and they call for better safety training to achieve greater impact on reducing work-related injury. A Korean model researcher calculated the average amount of social cost per death due to an industrial accident to be approximately $500,000 (U.S. dollars) in 2008 (Choi, 2012). Costs to organizations could also come in the way of fines by the Occupational Safety and Health Act (OSHA) regulators who levy high fines for safety violations, individual personal fines, and even jail time for willful violations (Bryan, 1999).

Cost was the most influential factor in the outcome of services or products in today's economy (Caprace & Rigo, 2012). Stuban, Mazzuchi, and Sarkani (2011) stated that by preventing cost growth, money could save by maintaining schedule and scope, so that no increase in additional costs would result. The costs to develop a course should consider the cost of doing business and this expense would recover each time the course offered and paid for by the engineering students who took the courses (Stuban et al., 2011). Of equal importance was when this education provided to the engineering student so they could use the information in a positive manner (Stuban et al., 2011).

Gordon, He, and Abdous (2009) found an increased demand for online courses; this was causing a reduction in the cost of production. Reported in the news were over 4 million students had participated in online courses at U.S. universities (Gordon et al., 2009). A complex course involved streaming video and interactive examination could run over $19,000 (U.S. dollars) but the price was coming down as the technology matures (Gordon et al., 2009).

Fox (2013) does not see a threat from massive open online courses (MOOCs) or even small private online courses (SPOCs) since they were better suited to supplement an existing traditional classroom environment instead of completely replacing face-to-face instruction. MOOCs and SPOCs could not replace face-to-face instruction but enhanced the training and education of students (Fox, 2013). This was a new technological tool supplementing classroom instruction and lowering costs for both the student and university's faculty and administrators while getting the information out (Fox, 2013).

In summary, there was a wide range of costs associated with the development of course materials but the trend was downward as more systems developed in making them affordable. The online courses that offered free to enrolled students were absorbed by the universities as a supplement to classroom training. The actual course materials, whether presented in a classroom or online, represented one of the smaller expenses a university must contend with when dealing with competition. Of much greater costs were the professor's salary and the facilities expenses that included overhead for the administrators and staff that were required to run a university. It all had to do with the timing of when these courses could implement for the students when they needed it.

Timing of Implementation

Determination of when safety, health, and environmental sustainment education provided to engineering students was a thought-provoking subject. Many schools of thought existed whether early education in high school or if undergraduate school was the most appropriate time when the safety training should be provided. Some researchers believed that specific training tailored to the type of engineer employed should be given focused training at the specific job sites where the individual would be working (Adams et al., 2011; Winn, 2014). This was so that engineers could become as knowledgeable, understanding, and safety aware as possible in the accepting of the specific hazards that they would face or must design to at specific workplaces.

Pisaniello et al. (2013) postulated that not everyone goes to college so teaching safety to all high school students was one way to prepare those entering the workforce right after high school. Tran and Nathan (2010) uncovered that those taking engineering in college needed to be better prepared while they were in high school. Yang, Chew, Wu, Zhou, and Li (2012) hit upon the fact that training provided right at the work sites helped to reduce accidents and improved safety performance for all employees no matter what their educational level were but that they all needed the information about occupational safety and health.

O'Neill, Porter, Pankow, Schuchardt, and Johnson (2010) found that the timing of training and education is important when provided to the target students, employees, and even retirees could use the information about falls and staying healthy. Rovai and Downey (2010) showed that with online courses, students must have good time management skills to keep up with assignments and doing the work independently and to self-motivate themselves. Educated engineering students in the multidisciplinary issues of accident causation and system safety will help establish safety competence and accident awareness before they enter into the workforce (Saleh & Pendley, 2011). Ismail et al. (2012) also unearthed the importance to train engineers on the job to address specific safety issues and to indoctrinate them to an organization's safety culture. Yang et al. (2012) case study research discovered that the identification of systems at worksites could greatly help with accident prevention efforts.

Controversy existed between researchers on the identification of the critical elements of planning, designing, implementing, and evaluating educational programs. Martín-Gutiérrez et al. (2010) found in their research that technological advances could allow for training provided at any time day or night at any skill level desired. Carruth et al. (2010) agreed that early and lifelong training was the most beneficial type of training for everyone. Nor (2012) advocated for distance learning as being the best overall type of training but admitted that it might not be the most appropriate for everyone. The debate extended to employers and obligations to workers concerning the health and lifestyle decisions made by their employees, and identified who was responsible for what in regards to safety (Robroek, van de Vathorst, Hilhorst, & Burdorf, 2012).

However, a study by Williams (2013) did not look at engineers while they were at a university but found that the timing for training conducted at all times in an engineer's career. Williams (2013) stated that not just in a school setting but in the workplace, engineers needed continuous training. An accident could happen anytime and anywhere as one survivor of an arc flash that burned his face so much that he was unrecognizable to even his family members, recommended that everyone should train with interactive hazard recognition exercises to improve their safety knowledge (Walker, 2013).

Most organizations health protection programs were separate from other training programs, which was a mistake that could reduce the effectiveness to maximize the overall health and productivity of a workforce, so says Hohn (2013). Ismail, Doostdar, and Harun (2012) agreed, stated that awareness and communications were the keys to providing workers the attention and information they needed concerning continuous safety matters. The burden of being safe fell on the workers though engineers could help by designing systems safer (Hohn, 2013). If people violated the proper procedures, then harm could result, but at least the engineer designed it as safe as possible.

Walaski (2013) unearthed that social media had now made communication instantaneous 24-hours a day, and had changed our sociological structure to engage with the public. Wan (2013) postulated that mobile learning, also called "m-learning", was the future of training with an estimate of 1.3 billion by 2015 were to be trained in this method, which is fast, portable, and cheap. Recent litigation had determined that organizations needed to provide training to all employees in a timely manner to prevent injury and illness (Craig, 2013). Schiavi (2013) came across that safety audits were an excellent tool to help control work related incidents, deaths, and costs by identifying unsafe behaviors or conditions, but that done often, and continuously to be most effective and allowed to develop lessons learned to make workplaces safer with less accidents.

Williamsen (2013b) stumbled on the fact that annual safety stand-downs were vital training evolutions for all hands to participate. It would help the wellbeing of employees if conducted often enough to have the desired effect of improving a company's safety record (Williamsen, 2013b). Young safety professionals would benefit from a structured internship to provide them with field experience at organizations, where managers were looking for ways to improve safety (Winn, Williams, & Heafey, 2013).

Siller and Johnson (2010) uncovered the issue of when engineers should receive safety training to be a part of a larger discussion on what course material should be offered to all engineering students. When training was conducted correctly, people could learn as the instructor desired when a holistic injury prevention effort required by a multi-disciplinary group action (Forman, Watchko, & Seguí-Gómez, 2011). Love, Lopez, Goh, and Tam (2011) researched timing and schedule delays that caused cost growth and made it harder to meet requirements as pressures mounted and safety could be jeopardized, which contributed to accidents being caused more frequently. Lei and Gupta (2010) realized that lifelong learning was everyone's objective, and distance education was beneficial to help to achieve this goal even for naval engineers.

Older person's understanding of health issues and fall prevention was lacking in many developing countries and a need existed for better training as people get older (Kalula, Scott, Dowd, & Brodrick, 2011). MacLaurin and McConnell (2011) saw this as a global problem that needed immediate response in developing safety and quality improvement initiatives. Yeung and Chan (2012) identified the growing elderly population that were working and living longer, and must be cared for in new ways to provide the quality of life that they would be demanding as they got older. Further research needed to determine the optimal timing of implementing safety training for engineers. Safety training conducted often and at all levels of employees' and students' education appeared to be the optimal amount (Winn, 2014). This was especially the case for naval engineers' education, not only for the undergraduate engineering students, but also for experienced naval engineers currently in the workforce (Winn, 2014). Safety, health, and environmental protection training handled mostly by on-the-job training but naval engineers needed more education in all of these topics (Winn, 2014). Naval engineers were the focus audience for this research since they make up of many kinds of engineering educational backgrounds.

Naval Engineers

The literature was practically void on the subject of naval engineers as a type of professional degreed engineer as many have achieved their engineering education in other disciplines such as civil, computer, electrical, mechanical, or ocean engineering, just to name a few. Many of the issues surrounding engineers in general applied to naval engineers in particular. Winn (2014) understood that engineers were underprepared to enter the workplace in research-based leadership positions, and lacked a good understanding of occupational safety. Naval engineers needed to be versed in many different engineering disciplines like safety, health, environmental sustainment, and industrial hygiene (Cortés et al., 2012; Rice, 2013).

Many studies have called for improving engineering education (Adams et al., 2011; Asteris & Neofotistos, 2012; National Academy of Sciences, 2010). There was a need to understand who naval engineers were in the context of the type of work they performed, and why occupational risk prevention was not currently made a part of his or her training, and the required overall education needed (Duderstadt, 2008; Kirschenman & Brenner, 2011). In the early days of the U.S. Navy, naval engineers were a lower separate class of individuals from the regular U.S. Navy line officers who drove and fought the ships (Glaser & Rahman, 2011). There is still a great divide between the various U.S. Navy warfare specialties and between the engineers and other groups within the naval service (Glaser & Rahman, 2011). Adams et al. (2011) recommended a way to engage engineers of the future to examine the process, negotiate ideas, and use cross-disciplinary discovery to illuminate principles and the value of having multiple perspectives.

Naval engineers had to have a broad understanding of engineering as the industry crossed many technical disciplines. Saleh, Marais, Bakolas, and Cowlagi (2010) recommended that more research undertaken on accident causation, system safety, and accident investigations to make open with partnerships and more interaction with engineers. Chowdhury and Alam (2011) stated engineering education was an important investment for developing countries as it was necessary for progression economically, socially, and politically for the engineers to be properly trained.

Asteris and Neofotistos (2012) discovered that engineers needed a more efficient pipeline for an improved educational framework that was flexible, strong, and broad enough. Musto (2010) used case studies to research how engineers built in safety margins to compensate for cheaper materials, and proved that weaker designs that were cheaper to build. This could lead to bad designs as further reductions in safety matters created hazardous conditions since it was too costly to overdesign systems any longer (Musto, 2010).

Hassel, Asbjørnslett, and Hole (2011) identified a serious issue in underreporting of maritime accidents creating risk and the inability for engineers to resolve safety issues not readily known. Stieb (2011) found a similar issue with engineers not having a bill of rights and placed in the political position of intervention for the benefit of the public interest. Walker (2012) identified reformers who argued that engineers needed to improve society by first gaining additional education and better communication skills. Conservatives would prefer to allow the engineers to focus on industrial technological innovations and keep the politics out of the engineering career path (Walker, 2012).

Lathem, Neumann, and Hayden (2011) reported that engineers have had their education evolved into project-based learning, experiential education, systems thinking, and service learning to promote higher order thinking skills. Future engineers were going to need positive attitudes, dispositions, and habits-of-mind that were all important attributes needed in the development of students during engineering undergraduate education (Lathem et al., 2011). Lathem et al. (2011) found that the timing of reform efforts was important, as students who would resist change were already in the middle of their degree program and would not want any changes made to their educational requirements.

Hollnagel (2013) stated that engineers needed to study why things go right. Current focus was on studying why things go wrong (Hollnagel, 2013). Engineers no longer needed to design to just avoid systems that go wrong, but instead ensure that systems continued to go right (Hollnagel, 2013). Hollnagel (2013) acknowledged that systems that engineers design were reliable, but safety sometimes traded-off by ineffective operating procedures, inadequate training, and efficiency that could be a limited factor. The scientific study of safety by engineers should focus on situations where nothing goes wrong instead of trying to respond to accidents after they occur and trying to solve existing problems by making fixes to existing designs (Hollnagel, 2013).

Dong, Choi, Borchardt, Wang, and Largay (2013) found it imperative to assist design engineers and safety professionals in determining the effectiveness of existing safety equipment and training to help avoid accidents by those who operate them. Wu and Shaw (2011) determined that ship design was a very complex task, iterative in nature that required naval engineers to have a sound knowledge base in many disciplines. The unofficial term called "sailor proofing" when you want to design something that an operator might try to modify which could cause an accident, so additional designing to prevent these departures from specifications were considered sound engineering design.

Fernández and Pardo (2013) recommended that naval engineers look to concrete to replace steel, aluminum, and glass reinforced plastic to improve on reliability, strength, and maintenance. Naval engineers do not usually recommend this radical replacement of existing materials. Kang, Yang, Choi, Lee, and Lee (2013) further suggested that naval engineers use risk-based design methods though noted that naval engineers were not familiar with this methodology and often there was a lack of required information available. It costs more to cover contingencies design systems so engineers attempt to provide the minimum requirements in order to save money (Kang et al., 2013).

Valencia, Person, and Snelders (2013) in their case study found a conflict with managers and engineers/industrial designers over many aspects of a product's development. Knudsen (2009) determined that naval engineers do not like paperwork when it distracts from actual engineering work even when it involved safety matters. Waterson and Kolose (2010) identified a long history of engineers who rejected human factors and ergonomic considerations in their engineering designs.

Bhattacharya and Tang (2013) found that self-regulation was difficult to manage when not all levels of management and employees were onboard with such a policy. Engineers often left out of the discussion of additional ways to improve safety because it was often felt that engineers would drive up the costs unnecessarily (Bhattacharya & Tang, 2013). Employees needed to participate and to communicate to the engineers and management when issues involved safety appeared in the equipment and systems they operated (Bhattacharya & Tang, 2013). Communication was the key to successful improvements and future designs but the engineers needed to be in the loop so that they could know what the safety, health, and environmental sustainment problems were so that they could help fix the problem if not in compliance or tolerance.

Summary

There were problems with engineers not trained in occupational risk prevention (Bell, 2013; Blair, 2013; Edwards et al., 2013). This also concerned safety culture, definitions, interconnections, and engineering trained in sustainability (Frazier et al., 2013; Guldenmund, 2010; Pater & Remmo, 2012). How to make work safer, frameworks for effective training methods, how policies and practices related to outcomes, and a better understanding on how to safeguard the environment where all must live were also areas needing additional training (Felder et al., 2011; Neumann & Dul, 2010; Probst et al., 2013; Todorovic et al., 2012; Tompa, 2009). Researchers had seemed to reach a consensus that engineers needed to modernize their type of training methods they received to include occupational safety, health, and environmental sustainment to incorporate other aspects than simple design criteria (ASSE, 2012; Cortés et al., 2012; EASHW, 2010; NIOSH, 2009). More needed research was required as these exploratory studies have just documented the issue as problem areas and have not provided the specific details on how to make the corrections needed.

Safety culture, health, and the environment must also be included in any training for engineers (DeArmond et al., 2011; Heese, 2012; Kevern, 2011). Others have asked that engineers should receive training to be better communicators (writing and public speaking) so that they can express themselves better so that their designs could be better understood (Fortenberry, 2011; Gnanapragasam, 2010; Merli, 2011; Shafer, 2010). Naval engineers also needed to become better at estimation of costs and evaluation of the total ownership costs of systems that they designed (O'Neil, 2011). Organization's managers needed to establish trust to have an effective safety program that would improve health, reduce accidents, and protect the environment (Kath et al., 2010).

This literature review made it clear that safety, studied in a more holistic manner, to make work safer and to include naval engineer's training as part of additional research (Veltri et al., 2013). One area not explored in this literature review was the legislative and regulatory frameworks for the naval engineering industry that included the shipping industry (Knapp & Franses, 2009). Knudsen and Hassler (2011) disputed Knapp and Franses (2009) study's claim that the International Maritime Organization (IMO) and the International Labor Organization (ILO) conventions have led to declines in accident rates. Another area not examined was accident investigation methods and practices (Lundberg, Rollenhagen, Hollnagel, & Rankin, 2012).

Hsiao, Drury, Wu, and Paquet (2013) found that safety had evolved from accident investigation to more proactive safety measures such as recurrent audits. Another area not examined in this literature review was the exploration of differences and similarities between organizational culture and climate that examined by Denison (1996) and Asif (2011). Yang (2012) also suggested that further research conducted on information literacy for effective safety management to collect, analyze, assess, and synthesize. Underwood and Waterson (2013) determined that there was a gap between research and practice but by applying the systemic accident analysis approach this situation could correct itself by practitioners. These additional topics could be for new research studies.

Irani and Kamal (2014) found that the USA leads the way in generating intelligent solutions in the construction industry. Klein (2014) stated that safety prevention was a complex subject where the variables were too many and "untrackable" as they changed over time (p. 141). McDonald, Lipscomb, Bondy, and Glazner (2009) said it was best when they found that everyone's job involved safety. Haviland, Burns, Gray, Ruder, and Mendeloff (2010) concluded that OSHA saw a 20% reduction in injuries when standards and safety equipment used properly in operational settings.

DeJoy, Della, Vandenberg, and Wilson (2010) recommended that managers find better ways to improve upon employee's commitment to safety. Accomplished in a number of ways but one-way was by supporting all safety and health initiatives throughout the company (DeJoy et al., 2010). They would also support additional safety initiatives when implemented by employees (DeJoy et al., 2010). Gittleman et al. (2010) agreed with this approach as they found managers always had a more positive perception of the safety climate than did the workers. Regulations and rules were unavoidable in trying to help protect workers (Gittleman et al., 2010).

Further research were needed to determine what were the causes of accidents and a database developed that could catalog health and safety risks (Gangolells, Casals, Forcada, Roca, & Fuertes, 2010). Kines et al. (2010) recommended further studies on coaching of supervisors and improvement of feedback at all organizational levels. Gangolells et al. (2014) called for further research on the analysis of cumulative impacts in order to achieve more accurate, realistic, and consistent assessment. Constantinides (2013) called for further research in emergency failures of foresight and exploring the implementation of decision making during times of crisis. Hopkins (2011) identified two areas that need additional research in risk-management and rule-compliance, which could considered in tandem instead of done separately.

De Castro, Gracia, Peiró, Pietrantoni, and Hernández (2013) stated that to be very important in the nuclear industry, as the International Atomic Energy Agency had been researching the subject for the past 25 years, found safety culture lacking in most organizations. Kwon and Kim (2013) summed up the problem when they reported that there have been insufficient studies on safety climate. A survey of manufacturing employees found that safety knowledge, safety compliance, safety motivation, and safe working environment were the main factors affecting safety awareness (Kwon & Kim, 2013).

Stober (2014) stated the problem of getting people to change bad habits even when safety improvements were involved. By understanding the people and knowledge of the essential innovation characteristics, people could move to adopt new safety practices (Stober, 2014). Tristan and O'Connell (2014) found that the same safety training does not work on everyone. Serious injuries and fatalities have remained constant while minor injury rates have continued to decline (Tristan & O'Connell, 2014). More research to understand why this phenomenon was occurring (Tristan & O'Connell, 2014).

Zwetsloot, van Scheppingen, Bos, and Dijkman (2013) found that many values contributed to health, safety, and wellbeing to include adaptively, fairness, justice, resilience, respect, and trust to name just a few. Bliss, Rice, Hunt, and Geels (2014) discovered that narrow escapes were actionable sources of information that could improve an organization's safety, health and impact on the environment. Dewar and Astrachan (2009) provided two different views of computer science education in the

USA; one saying it needed improvement and the other stated that it was just fine the way it was and depending on the perspective, both opinions were correct.

This study hoped to elucidate this conflicting information discovered during the literature review. The study's data also compared with that from the previous Spanish study (Cortes et al., 2012). The literature review results and the results from this study combined to triangulate and reach the research's recommendations and conclusions. This study will be another part of the literature to allow future researchers to continue this important study. Engineers need to be educated to make systems safer so they could not harm life or the environment.

This study's research methods will also contribute to the literature in it will obtain expert opinions from naval engineers on ways to improve the safety outcomes of the designs they build. The literature review provided much information on the dangers caused by accidents, human errors, and bad designs. The gap in the literature was in how to rectify these educational and training problems and come up with solutions so that these negative occurrences by engineers do not continue to happen.

The major themes identified during the literature review consisted of safety culture, occupational safety and health, environmental sustainment, engineering safety curriculum, types of educational training, costs of accidents, costs of developing courses, timing and how all these topics relate to naval engineers. This study will expand these themes into subthemes based on the results from this study. The recommendations and conclusions can then derive from these themes and subthemes. The research method will delineate how to conduct this study and gather the data needed to draw the recommendations and conclusions.

Chapter 3: Research Method

The problem for this qualitative study was that U.S. naval engineers in Washington, D.C. were not trained in occupational risk prevention and this situation impacted their ability to effectively design or teach naval engineering as a holistic subject (Adams et al., 2011; Davis, Yearly, & Sluss, 2012; Immelt, 2011). The purpose of the study was to find out what additional education and training naval engineers needed to reduce accidents, protect worker's health, and better protect the environment. The study achieved the purpose by forming an expert panel of naval engineers and professors who taught naval engineering to reach a consensus on what occupational risk prevention involved and how to incorporate the subject matter into current education and training.

The research questions were twofold:

Q1. What additional education do U.S. naval engineers in Washington, D.C., need in occupational safety, health, and environmental sustainability (also known as occupational risk prevention) to improve their capabilities and technical acumen to prevent accidents?

Q2. How could occupational risk prevention, integrated into undergraduate engineering degree programs, professional development, continuing education, or offered by other means to naval engineers, to provide the best educational experience at the most affordable cost?

These were the two main research questions answered during this study. It took 10 separate individual panel questions, listed in Appendix A, in the form of a questionnaire to help derive the answers to these questions. As answers obtained to the questions then new questions emerged during subsequent round of a questionnaire.

This USA study replicated the basic steps of the previous Spanish study (Cortés et al., 2012). The authors of the Spanish study concluded that it was essential to improve the safety culture within a company or workplace everywhere in the world for engineers to have this mandatory safety education (Cortés et al., 2012). The replicated study's procedures followed the same Delphi method, but with an initial sample size of only 17 individuals in Washington, D.C., and with only U.S. naval engineers and naval engineering professors being on the panel. Refining of the panel's questions eliminated the implied bias and removed the European focus of compliance with a European Union law that the Spanish study predicated on but replicated for the USA.

Qualitative research methods explored a topic of this kind or similar combined technical and academic subjects in nature (Hallowell & Gambatese, 2010). The Delphi method was chosen because it allowed for the best determination of an answer to the research questions by a panel of experts on the issue of educational enhancement for naval engineers in an academic and professional work setting (Bañuls & Turoff, 2011; Bouckaert, Loyens, & Maesschalck, 2011; Cortés et al., 2012). The advantages and limitations of the Delphi method were discussed in several studies as a way to improve the understanding of problems and to overcome design weaknesses (Chang & Yang, 2010; Dalal, Khodyakov, Srinivasan, Straus, & Adams, 2011; Hasson & Keeney, 2011). I was the facilitator for this study who gathered the panel's feedback on the questionnaire rounds and provided encouragement to come to a consensus on the merits of educating naval engineers in occupational risk prevention as was cited accomplished for a good Delphi method study (Parente & Anderson-Parente, 2011). The Delphi method provided a construct to come to an agreement with a panel of experts.

Research Method and Design

I conducted a qualitative Delphi method study as the Spanish research did because this problem was still in the exploratory stage and needed additional defining. To answer the complex questions of what and how, a qualitative research method was required (Levasseur, 2011). The Delphi method design allowed the input from experts in the field that could give a consensus to the research questions. This qualitative Delphi approach was the best framework to accomplish this research of solving a practical and applied research problem.

A quantitative methodology study explored a subject in detail and involved the use of theory (Levasseur, 2011). A quantitative or mixed method approach would not be suitable for this study because of the type of data collected in this exploratory stage of discovery. Since the phenomenon under study was not well known, the constructs to investigate it dictated a qualitative investigation (Goluchowicz & Blind, 2011). A qualitative investigation was the best method to research for this exploratory topic in the USA, by the use of the Delphi method was to replicate and emulate the previous Spanish study (Cortés et al., 2012). The Delphi method enabled a panel's members a convergence of their opinions to lead to a shared conclusion (Zio & Pacinelli, 2011).

The Delphi process found to be an effective tool for allowing researchers to develop curriculum for courses (Valani, Yanchar, Grant, & Hancock, 2010). It was widely used to select performance indicators in many fields but required multiple investigations to achieve consensus of the expert opinions (Ma, Shao, Ma, & Ye, 2011). The main premise of this technique was the fact that multiple collective beliefs were more trustworthy than the opinions of a single or just a few individuals (Steurer, 2011). It should be noted, however, that experts' attitudes and opinions changed over time, and that new knowledge might mitigate improvements in knowledge, so old rules may need to be reviewed and updated to reflect what was known now (McCray, Oye, & Petersen, 2010).

It was interesting to note that the changes recommended for the Delphi method from one of the original developers had come to fruition to include using computer systems to conduct the technique and using cross-impact analysis to understand the results (Helmer, 1989). The true value of the Delphi technique was the ability to avoid dominant individuals influencing the group decision (Bolger & Wright, 2011). Delphi was best when used with practitioners and academics for a structured way of assessing and combining human judgment reached by consensus (Rowe & Wright, 2011).

The specific topic of training engineers in occupational safety, health, and environmental sustainability issues was an important one for worker's wellbeing and safeguarding the environment where we all must live and work. The Delphi method was also the same method used in the previous Spanish study (Cortés et al., 2012). In order to perform a proper replicated study, the same method must be applied, otherwise, the data cannot be compared properly (Landeta, Barrutia, & Lertxundi, 2011).

Other qualitative research designs (such as, action research, narration, ground theory, ethnography, phenomenology, and case study) were not appropriate because they would not help replicate the previous Spanish study. Only the Delphi method allowed the expert opinions on this subject of naval engineers' additional educational requirements. The Delphi method advanced this investigative research and developed needed curricula with meaningful scenarios in the USA as compared to Spain (Nowack, Endrikat, & Guenther, 2011). The other qualitative methods used to build a theory but this was applied research to solve a problem so no theory was established. Many of the other techniques expanded on a phenomenon but this study was exploring what was missing instead of what currently existed.

Population

Even though the goal was 100 participants out of the 844 invited, only 17 individuals responded positively that they were willing to participate in this study. One dropped out when he realized that the focus was on USA education and this individual had received his education in Europe. Four other invividuals never completed the required preliminary questionnaires. A total of 17 individuals ended up participating in this study for the first round and 12 participants responded to the second round of questions.

Individuals as part of a field test were to comment on the Informed Consent Form and the website structure planned to use to collect data from participants. Only 14 individuals provided comments or stated that they did review the document and website and found no problems or issues. The few that actually did provide comments, the issues they addressed were minor but incorporated just the same. Before the study began, I decided that a consensus is a majority rule of at least 51%.

The population for this study came from naval engineers who belonged to the American Society of Naval Engineers (ASNE). Appendix B contains permission obtained from the ASNE Executive Director to use the ASNE membership database to access the population of panel members used for this study by e-mail (see Appendix B). The ASNE Executive Director first invited the individuals to participate in the study and to contact me directly to avoid any privacy issues. The database for the Flagship Section

(Washington, D.C. area) made up of 841 individuals 13 of whom did not have valid e-mail addresses. I allowed a full week for a response and allowed an additional week for them to complete the demographics and first round questionnaire. Only 17 individuals agreed to participate in the study initially with 80% male and 20% female. This low 2% participation rate is an indication of the non-volunteer general nature of engineers who are typically introverted and hesitated to join groups or outside activities not directly related to their work (Hallowell & Gambatese, 2010).

The previously discussed Spanish study had 59 participants, but to make a good Delphi method study a minimum of 10-20 participants were enough to participate in a qualitative Delphi study with a questionnaire sampling (Dalal et al., 2011). There were 72% active engineers with 28% retired. The participants in this study consisted of 15 males and 2 females (plus an additional male who withdrew after completing the demographic survey). Medium age range was in the 50-59 age groups but a majority was 60 or older. All but one had graduate degrees and one had a bachelor's degree. Table 1 shows a breakdown of the formal educational degrees of the participants. Appendix G provided more details on the demographics of all of the panelists. One participant withdrew because he obtained his education in Europe and did not feel qualified to comment on USA educational institutions. His information was included in the demographic questions but not in the first round or second round questionnaire responses. Though he did not actually help on this study, he did have a willingness to help and if the study ever expanded to include a comparison of USA engineering school curriculums with that of Europe, he stated that he would be willing to help with that kind of study, as it is a logical follow-on study. At the end of this dissertation, I recommended that this research continue. Years of experience and education made the volunteers an ideal group to participate in this study.

Table 1

Educational Degrees of Participants

Mechanical Engineering (5 participants with 3 obtaining a masters and one PhD)
Electrical Engineering (2 participants)
Naval Engineer Nuclear Option (1 participant)
Civil Engineering (2 participants)
Naval Architecture and Marine Engineering (4 participants with 2 obtaining masters)
Engineering & Engineering Administration
Marine Engineering and Transportation
Solid Mechanics
Engineering Science and Mechanics (both a bachelors and a masters)
Biophysics
Aerospace Engineering

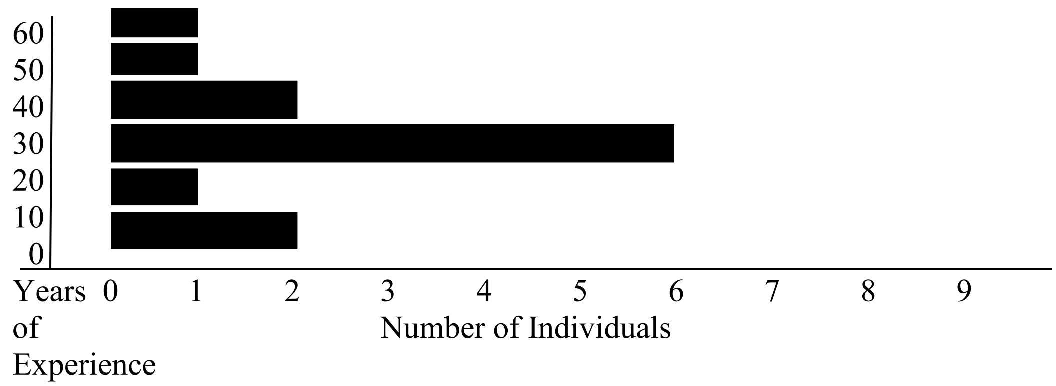
Sample

The sample recruited from the membership database of the American Society of Naval Engineers (ASNE) and the sampling method was one of convenience since it predicted that members who belong to ASNE were all working within the naval engineering industry. ASNE's Executive Director sent out over 800 invitations but only 17 acceptances received. This dismal 2.3% is reflective of the non-voluntary nature of naval engineers. Only one did a self-exclusion when the participant realized this study focused on USA education and he had obtained his engineering education in Europe. Participants used a ten-question questionnaire posted on the software application Survey Monkey® to provide a fill-in the blank questionnaire to those who agreed to participate in the study. This prevented other panelists from trying to influence others with their responses.

The design steps were as follows, approved by the Institutional Review Board (IRB) to proceed with the dissertation study:

1. The ASNE staff notified the local section membership personnel that I was conducting a study and was looking for volunteers to participate in the study. As individuals contacted me expressing an interest to participate, I send them the Informed Consent Form and a demographic survey.
2. Once all permissions and approvals received from the stakeholders, I sent out the approved survey questions to the already identified participants giving them a deadline to respond back in 2 weeks' time from the initial e-mail invitation depending when they first contacted me to volunteer.
3. Consolidated and analyzed results of the consensus reached in first round of questions.
4. The second round conducted just to answer the research questions and to open up related topics requiring exploration or came up in the first round questionnaire.
5. Averages of the results aligned into a table format so that comparisons and ratios could result from the data.
6. Conducted an analysis of the results and reported them out.

The naval engineers and professors who taught naval engineering subjects for at least 10 years made up the panel of engineering professionals. They all had an extensive engineering background, but all had chosen to work in the naval engineering field. These individuals all had engineering degree and were either currently worked in the naval engineering industry, were retired, or taught the subject at an accredited university. They also had to be located in the Washington, D.C. area and be U.S. citizens and graduated from a U.S. accredited university. The actual participants numbered 17 in total after some dropping out for various reasons. When the participants, asked if they were currently working in the naval engineering industry, and if so, how many years, the majority was yes for an average 53 years (see Figure 1).



(Assumed that the four No responses were that these individuals that were now retired.)

Figure 1. Years of Experience and the Number of Individuals Who Answered

Materials/Instruments

The primary data collection instrument planned was a questionnaire tool developed from an online software system called Survey Monkey®. There were many other online questionnaire services that I explored but this one provided the most familiarity and ease of use. The price of no cost was also a major consideration. There were 10 questions in total and all provided qualitative narrative space for panel members to provide their comments. The panel member's responses provided their opinions and thoughts on what kind of additional training naval engineers needed in the way of occupational risk prevention education. The structure of the questions was subsequent to one another but the panel members were able to go back and change their initial comments before submitting the entire questionnaire package. Appendix A provided a listing of all of the questions used initially for the first round questionnaire.

Data collected from participating professors and naval engineers who had worked in the naval engineering industry immediately achieved a consensus so additional rounds of the same questionnaire were not required. The questionnaire instrument tool included a web-based application that was able to capture the participants' responses anonymously so that no privacy violations could result from this study. No one could know the identity of who provided which response to include myself, the facilitator. A subsequent round was not required since a consensus reached immediately after the first round.

Survey Monkey® had recently collaborated with NVivo® to help analyze text responses from the open-ended questionnaire responses. NVivo® allowed for conducting in-depth analysis by highlighting, categorizing, and visualizing the responses received to discover themes, uncover connections, and make evidence-based conclusions. By using NVivo®, I uncovered fact-based discoveries from the expert panelists' responses, developed summaries, and provided feedback to the panel in a subsequent final round. The software helped me to justify findings, discover connections, and make sense from the multiple open-ended responses. It also allowed for the complete privacy of the participants so that not even I knew who provided which response, but secured enough that uninvited participants not allowed providing input or distorting the results. Only authorized participants could input data. When the data collection period ended, I closed the database to prevent any panelist from making changes.

Benchmarking used in this study to explore further the subject material. Benchmarking was an effective tool to improve any program (Dunbar, 2013). According to Dunbar (2013), the purpose of any benchmarking study is to collect qualitative data off targeted participants. After the information collected, I began the data analysis. Often it was helpful to summarize the findings in a matrix format for ease of presentation. This summary data compared to the literature review results and other studies to determine if any major correlations or discrepancies existed. Recommendations, conclusions, and limitations addressed in this study could allow for the continuous study and improvement of safety training and educating of naval engineers in the future. The second round questionnaire questions completely changed to be new set of questions to allow the panelists to reach a consensus to these different questions posed. The initial questionnaire questions closely matched that with the Spanish study conducted in 2012 so that differences between these two studies identified.

Data Collection, Processing, and Analysis

Data collection used exclusively in this study by means of a questionnaire (using Survey Monkey®) to capture participant's responses. A simple majority of 51% would determine consensus. A field test conducted on a smaller group of 14 individuals provided feedback on the questions and provided preliminary results that did not become a part of the official study's data. A field test made sure the U.S. participants understood the questions and could easily input data to the secure website. Appendix D was the invitation to a different group of naval engineers to review the Informed Consent Form and the website with the initial questionnaire. The field test helped to test the questions to make sure they were clear for the participants.

The participants continually reminded that they could elect to stop their participation at any point in the study and one individual actually did when he realized the study was focusing on U.S. colleges and universities and he had been educated in Europe. The goal was to reach a consensus among 51% of the panel members to be a majority. The previous results from the original study indicated that the answers to the questionnaires did not change between rounds, but the researchers did indicate that the reasoning provided by some of the participants was beneficial (Cortés et al., 2012). I coded the qualitative inputs just as the original study researchers did so that a comparison between the two studies could be achieved (Saldaña, 2010). This involved making connections and grouping similar responses together. I used the Delphi method to develop responses to the intervention activities (Oyewole, Haight, Freivalds, Cannon, & Rothrock, 2010). The results put into a table format so that comparisons could derive from the data and better conclusions made.

The process took only one round to reach a consensus on the discussion items. Data gathered in a total of 4 weeks' time. The study questions were open-ended, meaning the participants could add as much information in the response box as space was available. Some of the questions allowed the participants to consider, from a list of alternatives, where they could pick from more than one response or add their own information as text. A summary of each round extracted in subsequent questionnaire rounds to see if everyone or at least 51% agreed with the summary pulled from all of the previous participants' responses. This was the case after the first round and the second round asked new questions to clarify the panel's position and to help answer the research questions.

The results compared to the results from the Spanish study to see if similar results occurred; and they did with the exception to one specific issue. These results were compared to the Spanish study's data to see if it is relevant for comparison with the U.S. naval engineers and professors who teach naval engineering. The compared results and conclusions could apply in a different country to test the suitability of the analysis and generalized results (Cortés et al., 2012).

I initially envisioned sending out the questionnaire to over 100 naval engineers and professors who teach naval engineering but this number ended up being 17 participants. I allowed them 2 weeks to provide their comments back for each questionnaire. I analyzed the results and coded the data obtained to make a summary of all of their responses. I then formulated the follow-up questions providing a synopsis of their collective input from the previous first round. This process ended after the second round as consensus reached immediately after both rounds without any need for further discussion.

The data collected using Survey Monkey© questionnaire portal and processed by downloading the information. The participant's responses were coded and analyzed. Themes and sub-themes developed from the data. Recommendations and conclusions formulated and then reached and reported. The data collection proved the easiest step whereas the reporting the most difficult.

Assumptions

The assumption of the chosen population was that they have an openness of mind. They would be answering questions completely and truthfully on the question of whether occupational safety, health, and environmental education should be a part of engineers' curriculum, and if so, what and how should it include? A prediction that this study would fall well short of the goal number but that a minimum of 10 desired and achieved. That is why this sample started out with many participants invited to participate as assumed that a great number would select not to participate or drop out even after the initial screening by ASNE headquarters. It assumed the participants would provide their best opinions and would eventually agree with the majority on what the best responses should be for each of the questions. This assumption proved to be correct.

Another assumption was that there was a need for occupational risk prevention education for naval engineers. This assumption established from the Spanish study could be expanded to identify what kind of information should be included was the next logical step for this study. Another assumption was this study would allow me to be able to formulate what additional safety educational information taught and how best to incorporate it into existing lesson plans or new courses that I would recommend in the findings chapter.

I prevented myself from inserting my own personal bias and opinions and being interjected into this study by following the strict protocols and using the qualitative analysis software to help formulate the themes and summary information from only the data. I did not have to present back to the panel of experts since the consensus immediately reached after the first round and second rounds so no additional feedback to the participants was required. The results compiled from the panel member's inputs and I even used the minority opinion to show the other side of the debate even though there was little controversy or differing of opinion on any of the issues.

Limitations

A potential limitation was that the engineers and academic professors would not understand the need of safety, health, and environmental education since they probably were not required to take any courses when they were students and may not have any knowledge of what the information involved. This was not the case as a clear majority agreed to the need. One course of action was to allow participants to withdraw if they did not feel comfortable with the types of questions posed to them. Because the Internet system used to capture responses would be completely anonymous, no adverse influence posed to gather responses. In the subsequent round, only new information asked and again no coercion or manipulation used to gather the subsequent responses from the participants.

Another potential limitation of this study was the lack of occupational health reporting and investigations of workers as a need for epidemiological studies, screening programs, and other medical surveillance systems were lacking to be able to recognize chronic, delayed, and latent problems on the health and safety of working people (Behm & Powell, 2014). A limitation was identified in the literature was that underreporting of accidents, injuries, and mishaps is a significant problem for the naval engineering community where demands for efficiency decrease reporting of problems (Ottedal & McArthur, 2010). Probst and Graso (2013) identified that underreporting was a prevalent phenomenon and that interventions must developed as a way to stop this trend.

Elvik (2013) identified a limitation for studies, which findings in one geographical area may not apply in other geographical areas because of differences in culture, attitudes, and beliefs. This was applicable to this study because of focusing on the naval engineering industry and the Washington, D.C. location. These two factors affected the generalization of the study's results so one of the recommendations was to include other geographical locations in the conduct of this study. The ASNE organization has separate sections spread out all across the USA so this study could replicated in other geographical locations. The additional naval engineers could provide their expert opinions on these same research questions.

No limitations discussed in the paper report of the Spanish study occurred. However, because initially conducted in Spain, it could have a limitation of a natural origin just as this study had a USA origin (particularly in Washington, D.C. area). There are also limitations of using the Delphi method of keeping panel members in isolation and possibly making it harder for them to reach a universal consensus when all they see was the summary data from the other panel members. By not doing face-to-face interviews, I missed the other insights that could have drawn out if I had conducted in-depth interviews or chosen another research design. What was missing was the interaction and face-to-face debate among the panelists. On the other hand, this did not hamper the possibility to reach a consensus for all of the panel members.

Delimitations

Engineers make up a vast array of different kinds of disciplines such as aeronautical, civil, electrical, environmental, mechanical, ocean, and different kinds of engineering specialties. For this study, the focus was just on one kind of naval engineer who live in the USA and were located in Washington, D.C. The panel participants presented the scope of data recorded and analyzed when obtained. One delimiting factor was the picking of only naval engineers and the professors who teach naval engineering as the only participants for this study. This group did not absolutely represent the entire engineering community though it was a fair representation of the naval engineering community in one specific geographical location. However, it was a start to understanding the needs of all engineers once the needs of naval engineers were established. Though the work conducted by the different kinds of engineers varied greatly the education that all go through was comparable with one another. However, there is a need for risk management education for engineers (Galloway, 2011) and as identified in this study.

Ethical Assurances

I ensured that no harm came to the panel participants as their inputs were voluntary and they could have withdrawn at any time. They consented to participate in the study by either signing a consent form or entering into the website that acknowledged that they agreed to the consent form. Their identities kept in strict confidence and I did not know who provided what comments. The panel participants' responses coded using and alphanumeric symbol so that trends and the grouping of similar ideas could formulate general ideas and consensus among the different responses received. These results underwent further analysis to summarize the findings.

This study complied with the standards of conducting ethical research as appropriate to the research design proposed. Informed consent from each of the panel participants obtained prior to the beginning of the research. Appendix C contains the Informed Consent Form that used for this study. Since ASNE prescreened the participants and their overall willingness to participate, I included a summary of the Informed Consent Form on Survey Monkey® website so that those already having agreed to participate could acknowledge this by entering the website to complete the questionnaire after they have filled out the demographic questions. Each participant's identity held in strict confidence so that no one even I was aware of who provided what response. The responses coded so as not to mix separate comments, still, it was impossible to identify a particular participant with the separately coded comment. No attempt to cross-reference individuals with their comments occurred during this study.

IRB approval obtained before the research commenced. This study remained as unbiased as possible with no outside influence over the participants. In subsequent rounds, an attempt to reach consensus on specific topics of interest occurred with positive results. Participants treated with honesty and their integrity respected, with no attempts to harm them in any manner. Participants allowed withdrawing at any time for any reason that they might have had for not completing the study.

I commenced the study after Northcentral University's Institutional Review Board and my committee chair had approved for me to begin my study. The approval from each of the participants of the Informed Consent Form provided in Appendix C gave me the authorization to begin the task of collecting data. All data was on a password-protected computer accessed only by me to protect the data. For at least 5 years after my defense, the data will remain secured and if not needed then all data destroyed by shredding and deleting all electronic files.

Summary

This qualitative research study allowed the most efficient way to achieve a rigorous and comprehensive analysis of the important issue of educating naval engineers in safety design issues, public health, and protection of the environment, using the Delphi method from a panel of experts (Stake, 2010). Engineers had the challenge to increase their practical engineering, technology experience, and communication skills along with safety practices (Dubikovsky, Goodrich, & Sterkenburg, 2010). All employees, not just naval engineers, needed to train in safety and disaster preparedness to help avoid injury, disease, death, or even negative impacts upon the environment. It is the engineers' job to design safe systems but everyone needs to train to operate and function in life in a safe and proper manner (Möller & Hansson, 2008). Not all systems were designed for safety purposes in mind, and engineering education does not currently incorporate this occupational safety, health, and environmental sustainment protection as part of its' curriculum. Qualitative research was needed to determine what a panel of experts thinks is needed in the area of educating naval engineers in occupational risk prevention since it is important to learn the problem first hand (Stake, 2010).

The purpose of this qualitative study was to explore with a panel of experts what additional education U.S. naval engineers in Washington, D.C. need in occupational safety, health, and environmental sustainability, also referred to as occupational risk prevention, to improve their capabilities and technical acumen. The brief review of the literature found much information supporting the need for engineering educational reform and the need for including occupational risk prevention into engineering curriculum. This research design of using the Delphi method was ideally suited with a panel of naval engineering experts to reach a consensus on educational issues. This data obtained in the USA compared with the data from the study conducted in Spain. This exploratory research conducted with qualitative methods. The results answered the research questions, contributed to the literature, and laid the groundwork for further research conducted to continue the understanding of the needs of naval engineers' educational requirements. The conduct of this study contributed to a positive social change in the business practice of saving lives, improving health, and helping to protect the environment for generations to come by the engineering community.

The shortage of skilled engineering talent was a contemporary topic of national U.S. concern (Adams et al., 2011). Coupled with continuous technological advances, the curricula of undergraduate technology and engineering programs were having a difficult time keeping pace with advances (Atman et al., 2010; Barnett, 2011; Dawy, Husseini, Yaacoub, & Al-Kanj, 2010). The lack of information in teaching topics concerning occupational safety, health, and environmental sustainment created the need for further study (Deffree, 2012; Graham, 2012; Herman, Loui, & Zilles, 2011; Hull, 2012; Matthews, 2012; Morrison et al., 2011; Taslidere, Cohen, & Reisman, 2011).

This study was intended to show what additional education for naval engineers needed in the USA to allow the design of systems safer, health conscience, and environmentally sound so as not to pollute and damage the oceans, land, or air. This study can expand to include other kinds of engineers besides naval ones such as civil, mechanical, electrical, ocean, safety, nuclear and the multitude of other kinds of engineers educated in U.S. universities and through professional development programs. Further research in other areas of the country and around the globe will help to take into account geographical considerations. More findings besides this study and the Spanish one will help to understand the educational and training needs of all engineers. All questions' responses by the expert panelists had a consensus obtained after only their respective first rounds.

The literature review, as discussed earlier provided the background information to understand the concepts and issues surrounding the education of naval engineers in occupational safety, health, and environmental sustainment. Safety aspects, health issues, the sustainment of the environment, course information, timing, costs, and the implementation facets were all major themes researched. To understand naval engineers' educational experiences and the lack of specific skills not obtained as part of the literature review. These findings made by using qualitative methodology and thematic analysis examined how related to each other. Hundreds of primary references read and coded to establish the basis of understanding the issues. The themes and subthemes generated from the actual research conducted by the Delphi method using thematic analysis. The Delphi method with thematic analysis allowed the achievement of the research goals and objectives.

The panel members who provided the expert opinions were highly qualified to participate in this study. Their background, experience, and years of experience made them ideal participants. All 17 who participated in the first round and the remaining 12 who participated in the second round provided their opinions on these educational and other issues affecting naval engineers. This population number of 17 and 12 was satisfactory for the Delphi methodology. The materials and instruments also proved to be satisfactory for this study. The Survey Monkey® was easy to use and provided some graphic representations of the data used in this dissertation. The NVivo® software proved to be less user friendly but also provided graphics representations used in this dissertation report. The thematic analysis tool allowed for the themes and subthemes identified from the data to code and synthesize together.

The data collection, processing, and final analysis were all satisfactory for the scope of this study. Everything came together at the end to provide a final report satisfactorily capturing the naval engineers' expert opinions from the Delphi method used. This data correlated with the findings from the literature review and the previous Spanish study. The research study goals and objectives were achieved by the population, tools, methodology, and analysis used in this study.

Chapter 4: Findings

The purpose of this qualitative study was to explore with a panel of experts what additional education U.S. naval engineers in Washington, D.C. need in occupational safety, health, and environmental sustainability, also referred to as occupational risk prevention, to improve their capabilities and technical acumen to prevent accidents, disasters, and environmental sustainment. The problem for this study was to understand how naval engineers in Washington, D.C., lack the training in the fields of occupational safety, health, and environmental sustainability, which poses a threat to the safety, health, and wellbeing of workers and operators related to the naval industry (Cortés et al., 2012; Popov et al., 2013). The findings achieved by a panel of experts in naval engineering providing their consensus on the subject of occupational risk prevention training for naval engineers. Respondents referred as Participant 1, 2, 3, and so on if quoted or a summary of their words provided in the following paragraphs. The research questions were twofold:

Q1. What additional education do U.S. naval engineers in Washington, D.C., need in occupational safety, health, and environmental sustainability (also known as occupational risk prevention) to improve their capabilities and technical acumen to prevent accidents?

Q2. How could occupational risk prevention, integrated into undergraduate engineering degree programs, professional development, continuing education, or offered by other means to naval engineers, to provide the best educational experience at the most affordable cost?

Results

The demographics and first round results came from a panel made up of 17 participants in the first round and only 12 participants in the second round. One individual realized that he had obtained his education in Europe, and with the focus of this study on U.S. education, he withdrew from the study. All participants belonged to the American Society of Naval Engineers and considered themselves as naval engineers. Therefore, only 17 individuals ended up participating and responded in the first round. In the second round, only 12 participants participated. By this point, they had already reached consensus, and the second round focused on the two initial research questions and new related topic areas.

The responses placed into NVivo® software and then analyzed manually. The main themes emerged from the data and thematic analysis used to identify, analyze, and report the patterns and themes within the data. This study used Braun and Clarke's (2006) guide to the six phases of thematic analysis to include:

1. Become familiar with the data.
2. Generate initial codes.
3. Search for themes.
4. Review the themes.
5. Define and name themes.
6. Produce the report.

The answers to all of these questions helped establish the need for further education in the topics identified in this study for naval engineers to learn. The first round of questions reached a consensus right away. They all contributed to answering the first research question of vitality of education in occupational safety, health, and environmental sustainment. There were an occasional outlier but for the most group the panel agreed with one another on the answers to the questions posed. All but one agreed for a 94% consensus to the first question posed of whether occupational risk prevention was important for naval engineers. Participant 1 agreed but commented on the terminology of the question. The participant did not like the "risk prevention" terminology because it implies that zero risk was achievable and would prefer the terms "risk mitigation", "risk management", or "minimizing risk" as opposed to preventing risk. Participant 2 did not agree, stating that education could provide some potential to avoid some risks but because they are infrequent, it is not vital in this participant's opinion. The major subtheme generated from this question was risk knowledge.

The second question of the first questionnaire dealt with whether occupational risk prevention should be included in education provided to naval engineers. The results were a unanimous yes. All 17 participants agreed to this issue with many providing comments. Participant 3 said that safety, sustainability and applicability were all essential elements in the art and design of engineering. Participant 4 thought that risk was a big issue and should be part of core curricula that would include all types of risk such as occupational, operational, financial, and environmental. The major subtheme generated by this question was that safety was essential to the technical effort and had to be integral and inseparable parts as it relates to health, environmental sustainment, education, costs, and timing or schedule.

The third question asked whether occupational risk prevention not integrated in, other courses or made, as a separate course, because the contents are not well known. This question came from the replicated Spanish study and the majority of Spanish participants agreed, however, in this study a majority of the participants disagreed with the statement. Eleven participants disagreed for a 64% majority, five agreed for a 29%

minority, one participant said not enough information was given to make a decision so he said "yes, no, maybe". The majority of the participants disagreed stating that the subject contents are well known and easily incorporated into training materials. The pattern from the participants' responses was that hazards known and other reasons prevented the integration of the subject into existing engineering programs.

The fourth question asked how occupational risk prevention should be included in courses or continuing education. Participant 5 skipped this question but the other 16 responded as shown in Figure 2 results summary below. The majority called for a blended learning experience as the best way to incorporate occupational risk prevention into the training or educational material for naval engineers. Blended learning defined as using many teaching methods to help pass the knowledge onto the students. Participant 6 stated that on-the-job training was a part of blended learning and gave the best relevant training experience in the field instead of a classroom where the students may not fully understand the significance of the safety information. The major theme generated by Question 4 was that a blended education was best to train students and practicing engineers alike. Having a variety of teaching methods will have a better chance to get through to the majority of students who all have different learning skills and ability to learn information. Though Participant 2 was not certain what a blended learning experience consisted of, they all agreed that different teaching methods do provide engineers a better learning experience. Teaching methods that engaged with the students by interact with them and having this accomplished face-to-face were the most effective for students, according to research (Pisaniello et al., 2013).

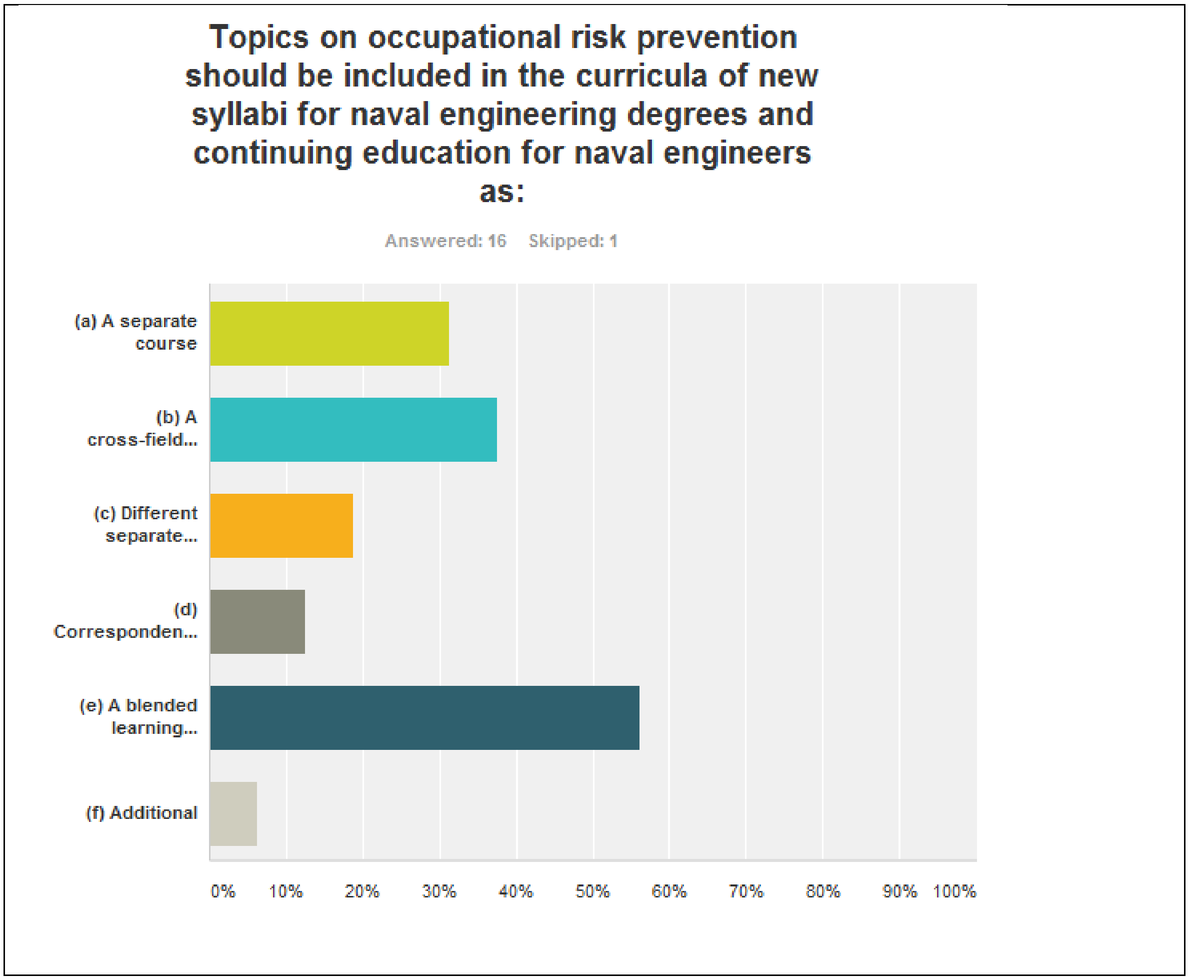


Figure 2. Results from Panel on how Material Incorporated

Table 2 below shows the percentage responses. One participant stated that courses must provide on-the-job training to reinforce the material and help with the learning. The majority consensus called for a blended learning approach meaning numerous teaching strategies to help educate the students and practicing naval engineers. This method of using various teaching strategies would allow for a greater number of students in getting the information. One participant admitted that he was not sure what a blended learning experience actual would involve and another stated that it had to have an element of continuing education to be effective for naval engineers.

Table 2

Material Incorporated Responses and Comments

(a) A separate course	31.25%
(b) A cross-field subject in a number of courses	37.50%
(c) Different separate courses specific to the student's course of instruction	18.75%
(d) Correspondence/online class material to be done at student's own pace	12.50%
(e) A blended learning experience	56.25%
(f) Additional	6.25%

Total Respondents: 16 (one participant skipped this question)

The next question, Question 5, dealt with how the course material provided to students. The majority, which only made up of only a little over a half of the participants, agreed that the course material should be mandatory. Figure 3 shows the bar graph and Table 2 the accompanying 51% participant responses stating it should be mandatory. Participant 7 stated that engineering societies should play a larger role than they do now and Participant 8 said that training should combine with environmental risk prevention in a majority of naval engineering courses since naval engineering systems are normally always associated with the oceans and waterways and adverse pollution could cause damage to the ecological environment. The major theme generated by this question was one of what material was required to be made a part of a students' and practicing naval engineers' training and education. It included topics relating to occupational safety, health, and environmental sustainment. The literature review also had many researchers advocating for additional mandatory education for engineers in safety design (Popov et al., 2013).

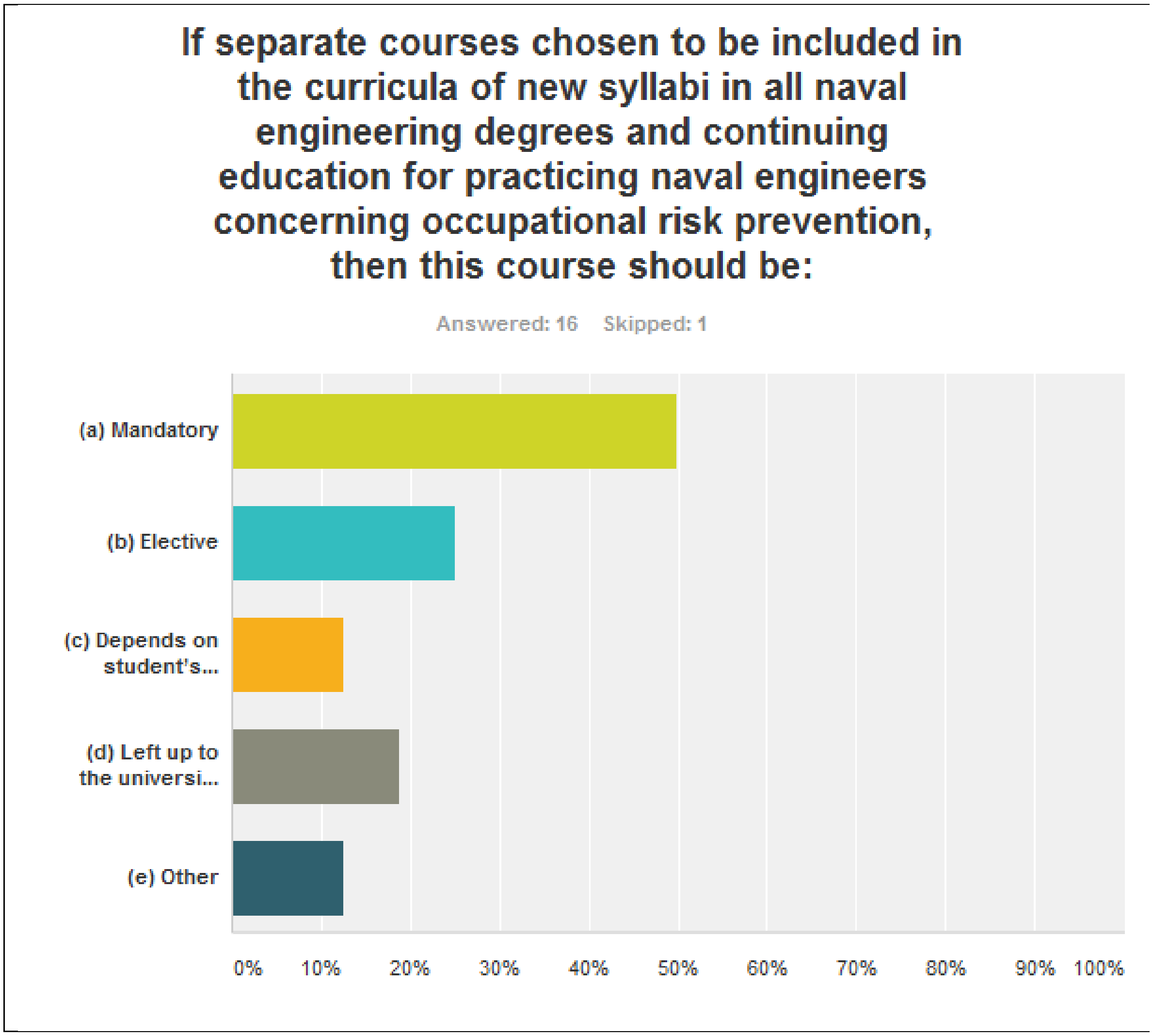


Figure 3. Course Requirements

Table 3

Course Requirements Responses

Mandatory	51%	9
Elective	25%	4
Depends on student's course of instruction	12%	2
Left up to the University or Organization	18.5%	3
Other	12%	2

Total number of participants 16 (some answered more than one answer; one skipped)

Eliminated from this study was the naming of a course title, Question 6, which I determined to be too difficult of a question for this panel to take on. Everyone had their own ideas, the Spanish study had already agreed to occupational risk prevention, and I had already named the title of my dissertation to be involving occupational safety, health and environmental sustainment. However, it became apparent that the participants had some suggestions and they provided for any further research that might want to conduct on this topic. Appendix E provided the question, responses, and the comments on this naming issue that is not an official part of this study's determination but provided for any follow-on research in this area and as an example of the system used. Participant 9 simply stated, "Stay Safe," which could be a good course title.

The panel of participants agreed on the types of information, Question 7, which should be included in the training or education. The panelists agreed with the previous Spanish study stating the topics that made up the subjects were all-important and should all be included in some fashion. This list of topics provided in Figure 4 with the accompanying Table 4 included both the responses percentage breakout and a synopsis of the actual individual topics provided by 16 participants. Participant 10 stated that occupational risk is a serious problem aboard Navy warships. Participant 11 thought students and practicing naval engineers would like to learn about both good and bad past examples and safety issues. Participant 12 thought that case studies and lessons learned taught. Participant 13 though everything should be included including costs, safety at sea, probability, and statistics for credible risk assessments. The major subtheme generated by this question was that a variety of subjects needed to be included in the education and training of naval engineers regarding occupational risk prevention.

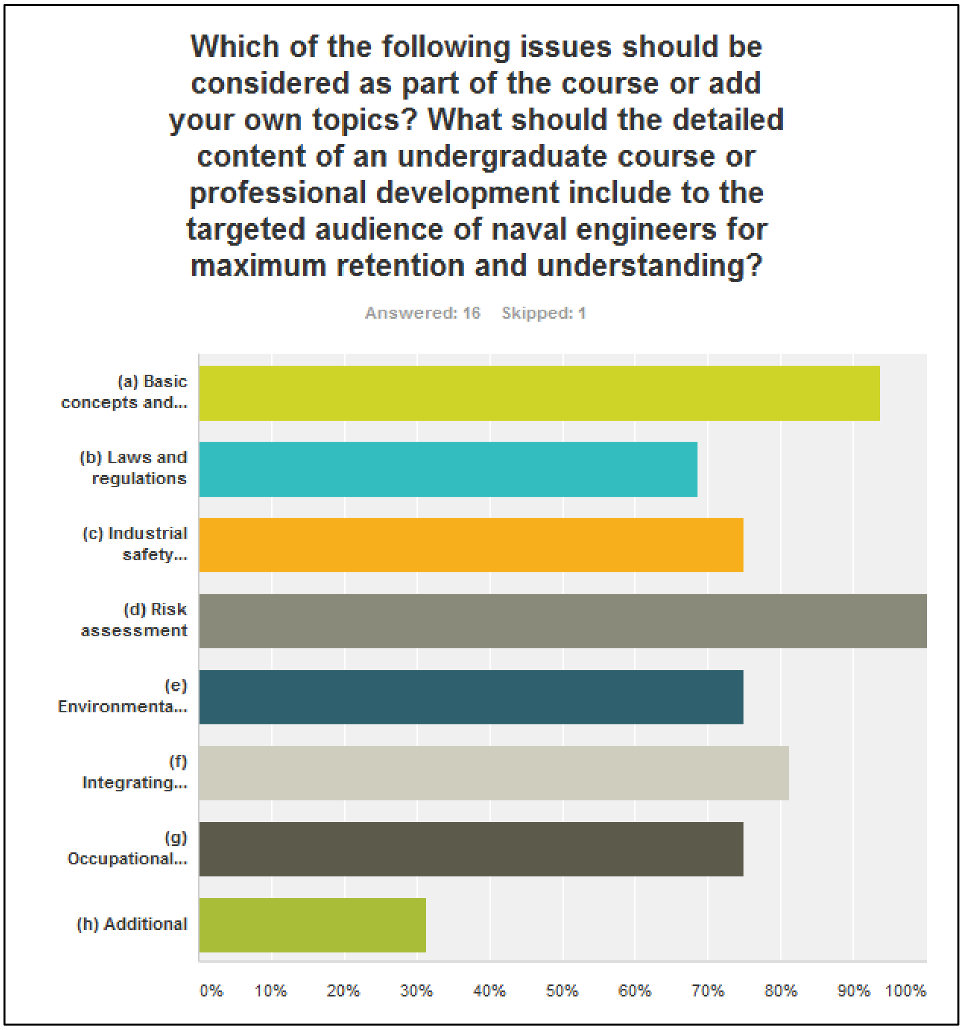


Figure 4. Course Topics

Table 4

Course Topics Answer Choices and Responses

Answer Choices	Responses	
(a) Basic concepts and terminology	93.75%	15
(b) Laws and regulations	68.75%	11
(c) Industrial safety considerations	75.00%	12
(d) Risk assessment	100.00%	16
(e) Environmental, health, and safety planning	75.00%	12
(f) Integrating occupational risk prevention in the production process	81.25%	13
(g) Occupational risk prevention at the work site	75.00%	12
(h) Additional	31.25%	5
Total Respondents: 16		

The next question, Question 8, asked if the participant was a teacher, would he/she be willing to incorporate the safety topics discussed in this study into his/her educational program. If they were not a teacher but a naval engineer, would they have benefitted in a course on the topic of occupational risk prevention? The consensus was yes for an 82% majority but three participants said no for an 18% minority. Participant 14, who was also an instructor, answered both questions. This individual said that he would be willing to incorporate the topics in his classes and that he would have personally benefitted from such a course as part of his own educational experience, agreeing with the majority. The negative answers from three of the participants were addressed from personal experience that they did not require this knowledge but two specifically stated that a classroom setting was no place for such a course. Participant 15 disagreed with these three minority panel members stating that he would have benefitted from a course that focused on occupational risk. Participant 17 stated:

> I included material on risk analysis, assessment, and mitigation as part of a lecture I give on Load-Strength Interference. It does not specifically address "occupational" risk, but it would be easy to include that aspect of risk. In fact, this survey is making me think about how to do that.

The second to last question, Question 9, dealt with costs. It asked what the costs were from accidents and separately what costs were associated with course development. One participant skipped this question but the consensus was that the cost was extensive. One participant stated the problem was educating folks on how to quantify risk, so that corrective action taken to resolve the safety issues. The cost of developing a course is much cheaper than the costs from occupational hazards according to another panel member. The major subtheme generated was that accident costs were substantial. More research needed to determine how this can accomplished. Appendix I contain a codebook on the themes and subthemes continued in further research. The costs associated and when to give the training to engineers, generated many unique ideas from the panel members. Many panel members did not have specific details on the specific costs but it was a consensus of the group that the costs to provide the education and training would be cheaper than the costs of the accidents that could result if the training was not provided. Table 5 provides a summary of this cost issue.

Table 5

Cost Summary

- Local continuing education higher payoff; accidents are costly; morale suffers
- Lost production/productivity; lawsuits; costs more than preventive measures
- Mission and schedule impacts; price tag grows; immeasurable; costs huge
- Courses costs low; must quantify risks; need more studies; injuries costly
- Training costs are lower than the high costs of accidents; on-the-job training
- US universities need to incorporate safety, health and environmental issues
- Continuing education must keep naval engineers relevant and educated

The last question in the first round of questions dealt with timing. The consensus from the panel members was that later on in their undergraduate education and then periodically when they became more experienced as a practicing naval engineer are the best times to provide training and education. Galloway (2011) agrees and suggests more education at the graduate level to achieve a Master's degree in engineering before an engineer considered a true engineer. Table 6 provides a summary of the expert panel-timing consensus. This timing correlates with the literature review (Chak, 2011; Nakayama, 2012; Bryan, 1999; Boboc, 2012; Thomas, 2012; Saleh & Pendley, 2012).

Table 6

Timing Consensus

- Senior year of college; every 2 years; annually; tailored as needed; 5-10 years
- Graduate school; as required for the position; continuing education
- Sophomore; undergraduate and graduate school; professional development
- On-the-job training; periodically as a refresher for all naval engineers

The second round had only two questions that specifically related to this study. They happened to be the two research questions that the whole study was based upon. I wanted to see what kind of responses I would receive from the panel of experts on these two specific questions. I asked these two questions and received the responses from only 12 participants. I lost five participants due to vacations and work scheduled conflicts. Three naval engineers contacted me after securing from data collection asking to participate, but I had concluded that part of the research and thanked them for their willingness to participate. The remaining questions in this second round provided by the panel members themselves or were offshoots from some of the issues raised or observed while conducting this study. These responses not related to the specific subject made a part of this study. The questions asked in the second round are in Appendix F.

Research question 1. Research Question 1 asked what additional education does U.S. naval engineers in Washington, D.C., need in occupational safety, health, and environmental sustainability (also known as occupational risk prevention) to improve their capabilities and technical acumen to prevent accidents. The majority of 10 for an 83% agreed that occupational risk prevention training needed at all levels. One participant thought the safety training had logically tailored to the naval engineer's responsibilities. The other topics suggested included:

(1) Basic knowledge on possible hazards;

(2) Basic knowledge on variability of human behavior that can lead to accidents;

(3) A good primer on applicable laws and legal precedents; and

(4) Physical and mechanical hazards addressed Navy policy and best practices.

Another suggested the role of warranted principals for safety (PFS) and probability (known or derived), and decisions under uncertainty. The consensus was that education and training on occupational safety, health, and environmental sustainment needed at the undergraduate and practicing naval engineering levels. This question validated the Spanish study that additional education in safety matters needed to better prepare engineers for actual design work in their engineering fields.

Research question 2. The second question from the second round considered integration of occupational risk prevention into existing school curriculum and how a course should be presented to practicing naval engineers at an affordable cost. The consensus again was a blended approach, which was the main theme for this question. Participants 5 and 7 suggested the safety related subject to be introduced as a topic at the undergraduate level, but the biggest impact learning will be continuing education in combo with exposure to shipyard environments on a regular basis throughout the engineer's career. Participant 11 proposed a compilation of laws on the books and implementing guidance from the government (EPA, OSHA, etc.) and the Navy tailored based on the needs of the student. Participant 2 encouraged a trip to a shipyard and some sea time as the best way to gain the perspective of safety, health, and environmental considerations in a marine medium.

Participant 8 recommended a standalone course, which would introduce an overview level: probability and statistics, design margin, decision-making, modeling, financial management, human systems integration (HSI), process management, systems engineering, and quality assurance. Participant 12 urged a more pragmatic approach might be to introduce it as an elective into graduate programs in naval/marine engineering and/or offer professional-development courses on occupational risk through organizations, such as ASNE.

Participant 11 added that it would be interesting to offer such a course in conjunction with an ASNE symposium and see how many folks signed up to attend. Participant 7 answered that the course should be integrated "probably not as a separate/unique course, but rather integrated into the curriculum for undergrad degree or as Web based training probably the most cost effective." The consensus was to incorporate occupational safety, health, and environmental sustainability as part of undergraduate engineering curricula as well as offering professional development courses focused on requirements and case studies to practicing naval engineers.

Research question 2 generated themes relating to safety, health, environmental sustainment, curriculum, continuing education, and costs and training. They also established the subthemes of how to generate these topics into training programs for the naval engineers. The subthemes consisted of a number of related subjects to the major themes. Table 7 provided the overall subthemes in this study developed from the coded responses. These subthemes compared to the overall study's themes and combined where appropriate to develop the study's overall theme and subthemes combined. By synthesis these themes and subthemes were melted together to develop the study's theme.

Table 7

Subthemes

- Learning is applied and risk knowledge is important for naval engineers to learn
- Risk analyzed at all times and safety understanding is essential for naval engineer
- Protect people from known hazards is a naval engineer's responsibility at all times
- Blended education is best to instruct naval engineers who learn differently
- Need formal policies, instructions, standard operating procedures in safety matters
- Material is mandatory in undergraduate education and continuing education after
- Variety of subjects need to be included in the naval engineering curriculum
- Costs are substantial and cheaper to train to mitigate risks than to allow accidents
- Continuing education is needed, safety is integral to design; requirements
- Responsibilities; mitigation essential; time constraints; oversight; priority
- Education/training on occupational safety, health, and environmental sustainment needed for naval engineering industry naval engineers.

All of these subthemes can be married up to the major themes identified and coded during this research. They include the major subjects of occupational safety, health, environmental sustainment, curriculum, continuing education, costs and timing. Naval engineers are at the center and included both the students and the practicing engineer in the naval engineering industry.

Evaluation of Findings

The findings indicated that a majority of these panel members agreed that education and training in occupational risk prevention was lacking and needed for U.S. colleges and universities that teach engineering that leads to naval engineers. They also revealed that practicing naval engineers need continuing education in the subjects of occupational safety, health, and environmental sustainment. With the help of NVivo® software, I printed the reports on word frequency (Appendix H) and node structure, which is the codebook, included in Appendices I. The first word frequency analysis shows all of the data of both questionnaires and the demographic information. The second word chart was just for the first questionnaire. The node structure followed the literature review topics, but the coding did not always follow this same pattern. I found when I coded the data it took a completely different form in the word frequency outcomes.

My interpretation of the data is that a consensus by the panelists on the need for training and education on occupational safety, health, and environmental sustainment for naval engineers reached immediately in the first round. This research study adjusted to the U.S. context and was still able to compare with the Spanish study. The research study questions modified significantly to accommodate the American Society of Naval Engineers desire to learn about the needs of existing naval engineers and not just about students. I had aimed at obtaining the same number of panel members as the Spanish study but fell well short of the 59 participants compared to this study's 17 participants. The results compared to the Spanish study completed in 2012. An analysis made to see how the USA study compared with that data that developed from the Spanish study.

The results were similar to the Spanish study with the exception of one question. This question asked why occupational risk prevention did not already exist and incorporated into existing curriculums. The Spanish study researchers found that it was because of a lack of information and understanding of the material that made it difficult to include into existing curriculums (Cortés et al., 2012). This U.S. study data did not agree with this assessment as the participants agreed that the information existed but never incorporated, as it was not a priority before. The U.S. panel members agreed that it was time to start incorporating occupational risk prevention topics and to include in continuing education for practicing naval engineers. This coincided with the findings of the Spanish study on the need to implement the additional training on safety education for engineers. The panelists of this study agreed that the naval engineering industry needed to make safety a priority and improve upon the education and training of occupational risk prevention for the naval engineering community in both a university setting and a continuing education environment for practicing naval engineers.

The literature review found a similar need for continuing education as a deficiency in knowledge and skills can lead to accidents and incidents (Prasad, Baldauf, & Nakazawa, 2011). McTavish and Stallard (2011) found that problem-solving skills by engineers are fundamental to an engineering education and should not rely on software learned but problems solved. Roeser (2012) called for engineers to engage in morally responsible engineering to live up to being moral responsible for their work. Engineers need to design for safety and when disasters do strike, have designed in the ability to rescue people that maybe trapped (El-Tawil & Aguirre, 2010).

All of these subthemes can be married up to the major themes identified that coded during this research. They include the major subjects of occupational safety, health, environmental sustainment, curriculum, continuing education, costs and timing. These were major theme connections resulting from this thematic analysis study. Naval engineers are at the center and included both the students and the practicing engineer in the naval engineering industry. Figure 5 provides the major themes from this study. They consisted of safety, health, environmental sustainment, curriculum, continuing education, and costs and timing all surrounded by the major focus on naval engineers. These topics were also the same heading used during the literature review. These were the major themes for this research and the recommendations and conclusion address the research questions.

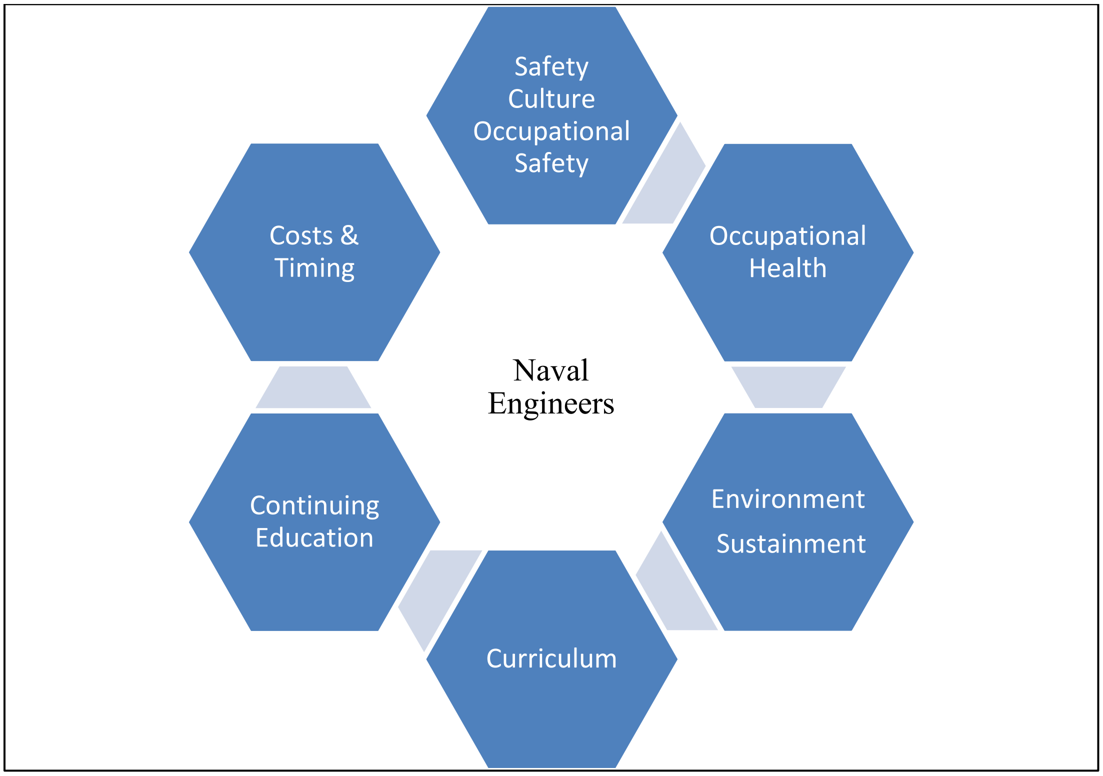


Figure 5. Major Thematic Connections

Safety had many dimensions from cultural aspects and the many various times of issues. One participant described them from running the gambit from paper cuts to death in a shipyard or at sea. Engineers needed to understand these perspectives and design safety into the systems that they have constructed. Safety also influences many of the other themes but often takes priority though the participants acknowledge health issues are also important aspects of occupational risk prevention. The literature review supports this study's findings as the same thematic connections identified in the study also identified in the literature review. Themes of environmental engineering (Basri, Zain, Jaafar, Basri, & Suja, 2012), safe design (Behm et al., 2014), safe practices (Dubikovsky et al., 2010), and health correlate.

Heath issues such as exposure to harmful substances, constant motion from human system integration causing long-term adverse health impacts hurt the naval engineering industry. The lack of understanding by naval engineers of the health impacts of the materials they use in their designs were all cited by the participants as educational and training opportunities that needed to be provided to naval engineers so that they can remain healthy on the job. Engineers need to be better educated in health issues was a consensus by most of the panel members of this study. The literature review also stressed the importance of health issues of the public influenced upon by engineers. The trainers are more effective when qualified in understanding engineer's perspectives (Wilkins, 2011).

Sunthonkanokpong (2011) vision for engineers' education is one that improves health, solves population growth, disease, shortage of food and water, and contributes to the well-being of humanity. It is true engineers have helped extend human life on the planet but continued new challenges will require even more innovation from engineers (Vaz, 2012). Human values must influence engineers' education and professional development by continuing education (Daniela, Marius, Andreea-Ramona, & Oana-Alina, 2013; Ramirez, Seco, & Cobo, 2011).

Environmental sustainment related to health issues but has the added dimension of adversely affecting the biosphere and affects all living things. Naval engineers need to find solutions to pollutants and sustainable systems that will not damage the environment. The participant's consensus is that naval engineers need better education on environmental sustainment issues. Felder et al. (2011) recommended changes to engineering instructional development to handle rapid advances in technology and the worldwide movement to cleaner more efficient systems.

The question on curriculum also reached a consensus that the same topics identified in the Spanish study should also be included in the U.S. university courses. This included topics in basic concepts and terminology, laws and regulations, industrial safety considerations, risk assessment (at 100% of the participants agreeing to these topics), planning, production process, and risk prevention. Naval engineering undergraduate degree programs need to include occupational safety, health, and environmental sustainment issues as deemed by a consensus of panel members. Galloway (2011) also identified sustainability, risk and uncertainty, and risk management as traits that engineers will need for in the 21st century. Likewise, continuing education for practicing naval engineers needs to be at 5-year increments so that they can remain proficient. Professional societies cited as the best organizations to provide this training.

The literature review also found a consensus on engineering curriculum issues. Asteris and Neofotistos (2012) identified what engineering and design constitutes in their research and found that changes were in engineering curriculum programs. More project-based design courses were needed and to expand engineering programs to 5 years (Asteris & Neofotistos, 2012). Coze (2012) researched to conclude that a multifaceted safety constructivist program was to explore limits on information processing and cognition for the field of safety. Vaz (2012) stated that the goal is to educate engineers with broad perspectives and skills to take on the world's problems.

Summary

This study answered the research questions, with the exception of one panel question, validated the results of the previous Spanish study. This study used a smaller number of panel members, which consisted of exclusively naval engineers some of whom had also taught on the subject of naval engineering. It was the consensus of the group that occupational risk prevention that included occupational safety, health, and environmental sustainment taught to naval engineering students and practicing naval engineers periodically so to reinforce the need to design in safety, human health, and safeguarding of the environment. Appendix J provides a summary of the results of both questionnaires that reached immediate consensus after the initial rounds.

As previously mentioned, this study corresponded well with the previous Spanish study with the exception of one question dealing with the lack of knowledge about the subject hindering the integration of the subject into courses. The Spanish study participants agreed that this was a problem. This U.S. study's participants did not think this was the issue. The other comments from the Spanish study such as prioritization, academic overload, and excessive contents indicated in this study's panel. The other question withdrawn in this study concerned the naming of the course. The Spanish study had a 52% panel members strongly agreeing to the occupational risk prevention name. This study of panelists could not immediately agree to a single name but most proposed their own unique name. I withdrew this question to avoid the controversy that did not contribute to this study's understanding of what the overall topic name should include.

This study also correlated well with the literature review. Melles, Howard, and Thompson-Whiteside (2012) recommended in their study that additional education in design thinking provided to improve the capability of working designers. Engineers need to approach nature with imagination and humility according to Schexnayder and Anderson (2011). Grau, Back, Mejia-Aguilar, and Morris (2012) conducted an experimental study and found educational intervention in weak areas of engineers' capabilities can improve and create positive change in the work practices of engineers.

Weaver, Rosen, Salas, Baum, and King (2010) found that a culture of safety was critical for safe, effective, and efficient teamwork to create a more positive working environment for all. Fortenberry (2011) advocated for standards-based tools to improve engineers' education. Cheville and Bunting (2011) also recommended reform to help students develop into engineers by looking through many different theoretical lenses. This study also correlated well with the Spanish study (Cortés et al., 2012).

Figure 6 listed the agreed to concepts from the Spanish study and current study combined. The consensus was that mandatory training in occupational risk prevention needed at U.S. universities just as it was determined to be mandatory at Spanish universities. It needs integration and made relevant to the young engineering student. Then practicing naval engineers also must have periodic continuing education so they maintain their proficiencies. As time passes, this will help improve working conditions and the overall safety culture of organizations. Therefore, mandatory information on occupational safety, health, and environmental sustainment was necessary for naval engineers to do their jobs successfully.

Undergraduate education and continuing education must expand to include the topics of occupational risk prevention. Appendix K provides a more detailed comparison between these two studies. The one different between these two studies was that the

Spanish study said that the reason not already incorporated was that the topics were not known. The USA study differed with this assessment stating the safety information already known and should be included into existing curriculum.

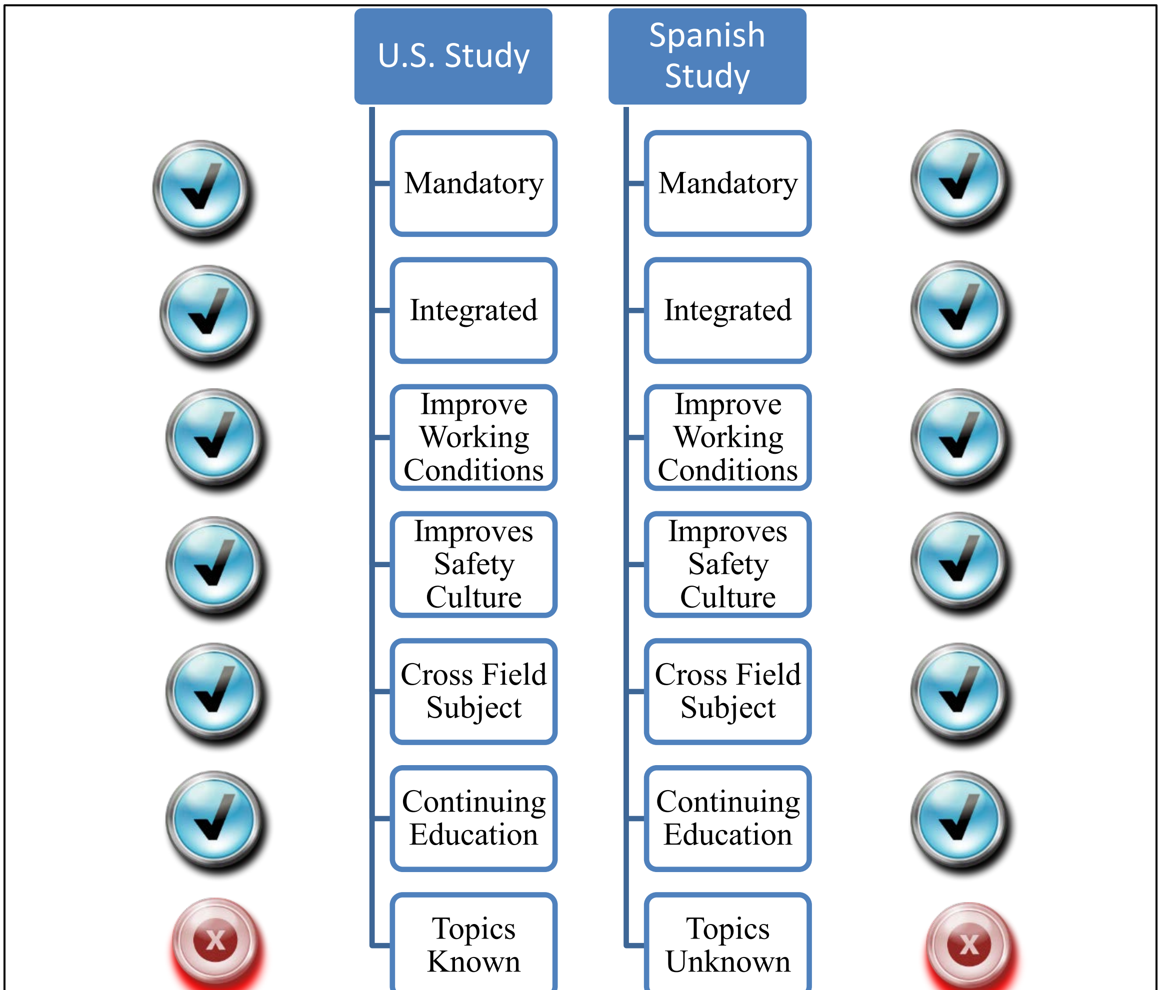


Figure 6. Study Comparison

Jensen (2012) argued that engineering education has to start earlier with children as they quickly grasp the properties of materials and how the engineering process is an iterative process. Male, Bush, and Murray (2009) stated, "Engineers contribute to economic success, quality of life, and protection of environments" (p. 455) but more improvements were needed relating to teaching, assessment, and the awareness of students and the educational staffs that gender typing in engineering is wrong.

The research questions answered after the two rounds of questionnaires. The answers from the findings correlated well with the Spanish study and supported the literature review findings. The first research question regarding what additional education needed answered with a long list of topics as shown in Appendix L that support the education and training of naval engineers in various occupational risk assessment.

Examples of some of the topics include basic concepts and terminology, laws and regulations, industrial safety considerations, risk assessment, planning, risk prevention, and the majority as needing taught about engineering costs. Participant 5 added that lessons learned and real life examples of adherence or neglect of occupational safety, health and the environment in practice would help in this education and training of engineers who could be the practical application of their trade.

The second research question asked how occupational risk prevention integrated into existing education and training could become educational programs for naval engineers. The majority of the expert panelists agreed that it needed combination with existing undergraduate education but also started as a continuing education program for practicing naval engineers. Participant 4 advocated for field trips to shipyards and at sea, to see firsthand the real life dangers and safety issues that the maritime industry personnel faces every day. Participant 9 suggested:

> As a standalone course which addresses at an overview level: probability and statistics, design margin, decision making, modeling, financial management,

human systems integration (HSI), process management, systems engineering, and quality assurance.

The themes identified by this study are safety, health, environment, curriculum, training, costs and timing. The findings for this study clearly identified the need for naval engineers taught on these subjects in occupational safety, health, and environmental sustainment. The subthemes included many aspects of risk, identification of hazards, blended education, and the variety of safety subjects that the engineers of the 21st century will need for their jobs. This included mandatory additional education in occupational safety, health, and environmental sustainment. Both at the undergraduate level and throughout a naval engineers' career, this educational and training aspects must apply. Continuing education on a variety of topics that are relevant for the naval engineers should provide at designated times and when required. The consensus was that 5-10 year intervals for specialized training be required for naval engineers. What has been lacking in most engineers' education and training are costing and financial aspects.

Additionally the topics of: (1) Basic knowledge on possible hazards; (2) Basic knowledge on variability of human behavior that can lead to accidents; (3) A good primer on applicable laws and legal precedents; (4) Physical and mechanical hazards, which addresses Navy policy and best practices; (5) Role of warranted Principals for Safety (PFS); (6) Probability (known or derived); (7) Decisions under uncertainty; (8) Probability and statistics; (9) Design margin; (10) Decision-making; (11) Modeling; (12) Financial management; (13) Human systems integration (HSI); (14) Process management; (15) Systems engineering; and (16) Quality assurance should be included in the additional education of naval engineers. The panelists suggested these topics.

Chapter 5: Implications, Recommendations, and Conclusions

The purpose of this qualitative study was to explore with a panel of experts what additional education U.S. naval engineers in Washington, D.C. need in occupational safety, health, and environmental sustainability, also referred to as occupational risk prevention, to improve their capabilities and technical acumen to prevent accidents, disasters, and environmental sustainment. The problem for this study was to understand whether naval engineers in Washington, D.C. lack the training in the fields of occupational safety, health, and environmental sustainability, which poses a threat to the safety, health, and wellbeing of workers and operators related to the naval industry (Cortés et al., 2012; Popov et al., 2013). A panel of naval engineering experts answered two rounds of questionnaires but reached a consensus after the first round.

The Delphi method with 17 panelists made up of retired, practicing and teaching naval engineers. The expected limitations of using the Delphi method with a thematic analysis, naval engineers as a disadvantage group, and the geographic area of Washington, D.C. were all limitations that ended up not becoming an issue in this study. No ethical mishaps occurred during this study. All participants handled their responses in an ethical manner. Participants' identities protected throughout this study. The participants were able to withdraw at any time for any reason. One participant did withdraw when he determined he obtained his education in Europe and was not qualified to speak on U.S. educational institutions naval engineering education. This final dissertation chapter includes the implications, recommendations, and conclusions for this study. Chapter 5 summarizes the research questions and draws detailed analysis on the results from the data obtained. The recommendations pose areas that need further research and analysis. The panel members also helped to provide suggestions and recommendations. The conclusions wrap up the entire study providing what information and concepts learned and developed by this study.

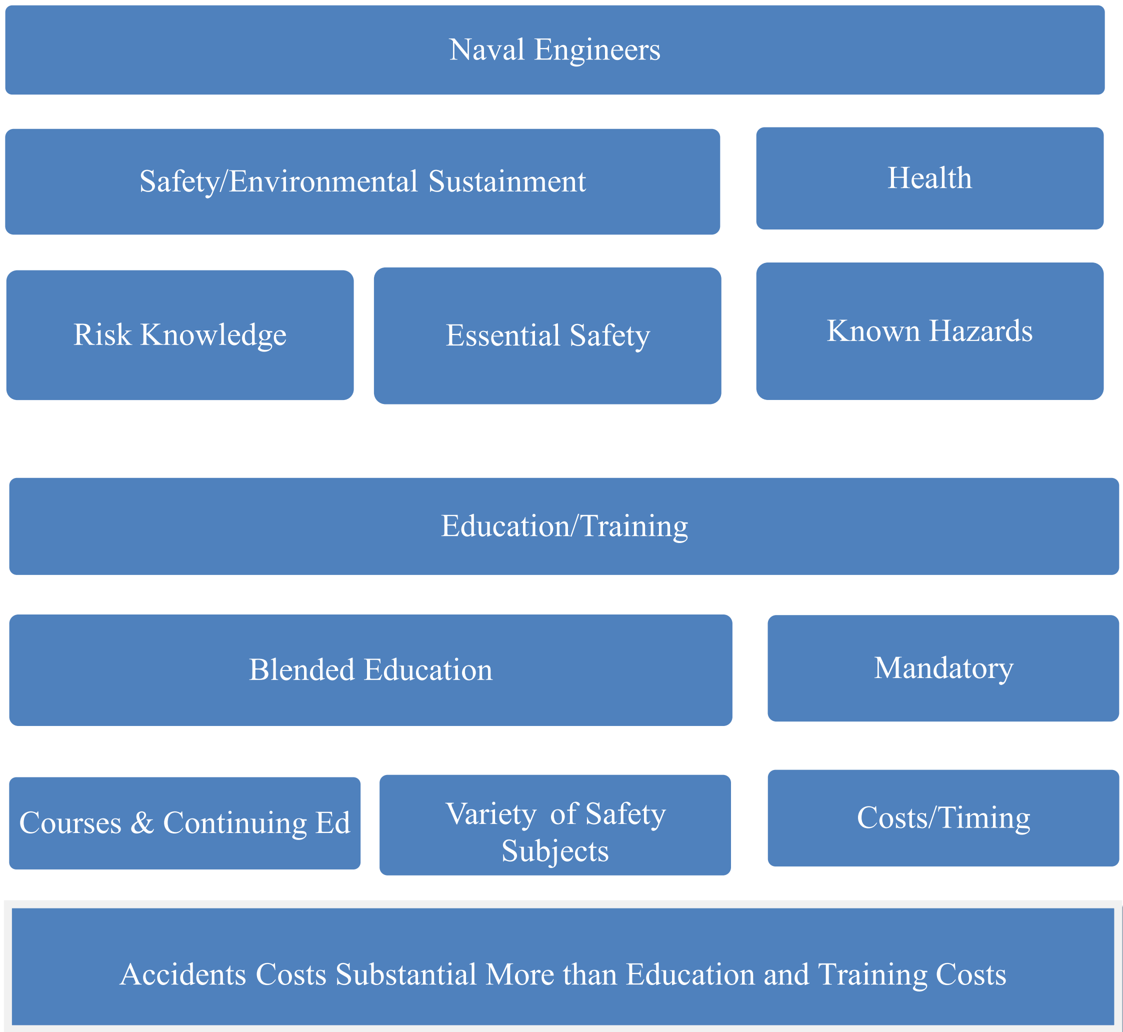
Implications

The research questions for this study included:

Q1. What additional education do U.S. naval engineers in Washington, D.C., need in occupational safety, health, and environmental sustainability (also known as occupational risk prevention) to improve their capabilities and technical acumen to prevent accidents?

Q2. How can occupational risk prevention, integrated into undergraduate engineering degree programs, professional development, continuing education, or offered by other means to naval engineers, provide the best educational experience at the most affordable cost?

The panel members, asked to comment on each of these questions, provided their expert opinions. The pattern of the responses indicated that naval engineers do need education and training in occupational risk prevention to some level depending upon what their work entails. The integration issue also formulated by the USA panel that naval engineers at various levels in their career will need this training and education specified for the work they are doing and their experienced gained. This was the same conclusion that the Spanish study authors made and it is interesting to see that both studies ended up with similar answers and results. Figure 7 highlights the overall summary results from this research study of the important themes and subthemes that provide the big picture of the results from this study.



Subthemes:

- Continuous learning in risk knowledge is important for naval engineers to learn
- Risk analyzed/safety understanding is essential for naval engineering education
- Protecting people from known hazards is a naval engineer’s responsibility
- Students learn differently with blended education ideal to instruct naval engineers
- Organizations need formal policies, instructions, standard operating procedures
- Mandatory education required for naval engineering undergraduate education
- Safety subjects need to be included into the naval engineering curriculum
- Costs are high but cheaper to train to mitigate risks than to allow accidents
- Continuing education needed for practicing engineers, safety is integral to design
- Responsibilities to safeguard life and the environment by naval engineers required

Figure 7. Combined Themes and Subthemes from this Study

The study's limitations did not have any effect on the interpretation of the results. The panel members fully understood the need for occupational risk prevention except for one that disagreed on every major discussion point. The different geographic locations did not appear to create any differences in the results except for one question that did have a different consensus response. The Delphi method issue is not a limitation either. Both the Spanish and the U.S. study's authors used this method and according to Davidson (2013), this method is becoming popular research design for doctoral dissertations.

Challenges included the difficulty of forecasting, timing and commitment, panel membership, and bias (Davidson, 2013). Advantages include ease of problem definition, clarification through round iteration, avoidance of group thinking, and panel anonymity (Davidson, 2013). The main limitation with this U.S. study was the small number of only one kind of engineer. Though naval engineers, made up of many different kinds of engineers, they all are in one industry that might not reflect all of the other engineering industries or professions. Follow on studies may use these different types of engineers in other industries to see if the same results occurred.

Using only one research method could also been deemed as a limitation. A mixed methods research would have involved both research methods to explore this topic more holistically. Further follow on research could use additional methods to see if the results continue validation. A quantitative method study also compared with these qualitative ones to make validation comparisons but using a different methodology.

A consensus reached in this study by the expert panel demonstrated that there was a lack of education and training for naval engineers in the area of occupational safety, health, and environmental sustainment. The purpose of this study achieved using qualitative methods. The panel members provided their ideas of additional education and training for naval engineers and shared thoughts on how to implement these ideas. The significance of this study illustrated the need for additional education and training to naval engineers to save lives, prevent accidents and injuries, and help protect the environment. This study adds to the body of knowledge in this area of occupational risk prevention training and education for engineers.

The implications of this study match the synopsis of the literature review in that there was a lack of understanding by engineers in occupational risk prevention (Rice, 2013; Winn, 2014). Additional education and training needed to instruct the members of the naval engineering profession. Universities in the USA and professional societies need to incorporate occupational safety, health, and environmental sustainment into their core curriculum and commence the training of naval engineers in this subject. The conclusions from this study confirmed the Spanish study that engineers should mandated to learn how to protect people and the environment in the areas of occupational safety, health and environmental sustainability. This achievement at the university level for students and at the professional level for practicing naval engineers was the best approach.

Appendix L lists some of the information that naval engineers need expanded education on. It was the consensus of the panel of experts that a blended approach to education and training was the best approach to integrate the course material into existing programs. The area of occupational safety, health, and environmental sustainment needed to be a mandatory course or fully integrated into existing courses. Continuing education needed for practicing naval engineers every five years to maintain their proficiency. The literature review identified other areas, such as improving communications skills, being more sympathetic to the public that engineering design's affect and providing systems that preserve life and do not pollute. This answers the two research questions and provides the basis for additional recommendations.

Recommendations

The overall recommendation is to continue the study of occupational risk prevention to gain expert opinions from other geographical areas. Further research on cost engineering, weaknesses and strengths of naval engineers, and attrition in the engineering field needed for a better understanding (Hunt, 2010). These two topics of naval engineering impacts upon society; and how to recruit more women engineers into the field of naval engineering, recommended for further study (Hunt, 2010). Previously suggested in this dissertation was for a new study that compared USA and Europe engineering education. Another recommendation was to conduct this same study in other geographical locations in the USA. ASNE has Sections and Chapters throughout the continual U.S. that this study replicated to gather more data of expert opinions from other naval engineers.

The Delphi method needs strengthening in initial planning by providing objectives, identifying participants, and explaining the process better upfront (Diamond et al., 2014). All experts were outstanding, but the results were limited to the small number of panelists who volunteered to participate in this study. A consensus reached on all but one question that one eliminated, so no controversy resulted in how agreements reached among the panelists. The research results matched those from the previous Spanish study conducted in 2012. Further research should focus on the specific aspects taught and better understanding of costs and other understudied topics identified in this study. The practical recommendations of this study are that universities teachings naval engineering subjects and professional societies, which support naval engineers, need to incorporate occupational risk prevention material into the education and training programs. Appendix I could expand and used to develop a codebook for further research. Wirth and Sigurdsson (2008) recommended behavioral safety interventions to fill the gaps in literature about the knowledge gained by engineers through proper training. Three recommendations are as follows:

(1) Continue research in this area of occupational risk prevention for engineers;

(2) Universities investigate how they can incorporate education in engineering programs that cover occupational risk prevention;

(3) Professional societies that support engineers investigate how they can incorporate training in occupational risk prevention in their continuing education programs.

Conclusions

Naval engineers need additional specialized training in occupational safety, health, and environmental sustainment subjects, also known as occupational risk prevention. The Spanish study and this study conducted in the USA came up with similar results with the exception of one question concerning the known safety material for a course. The main theme was that education and training was beneficial at all levels of a naval engineer's development was verified. The panel of experts determined that tailoring the information to be applicable for the naval engineers would mitigate the adverse risks associated with their specific positions or jobs. Further studies will help foster the advancement of this issue at universities, professional societies, organizations, and the individual engineers in adapting and growing their knowledge to include additional safety areas that should be mandatory and in their undergraduate curriculum and continuing education when they are practicing engineers.

The study validated that naval engineers are a smaller group in the engineering profession but the panel of experts determine the importance of their training needed to include occupational risk prevention. The results of the research by Cortés et al. (2012) were validated, but additional studies are needed to address and validate what specific education and training naval engineers needed to be better at designing systems that are safe, do not cause harm to health of humans, and systems that are environmentally sustainable. Appendix J makes a comparison between the USA and Spanish studies that shows a strong correlation between the data.

The literature review supports the conclusions reached in this study. Boone et al. (2011) identified the need for engineers to design safer systems. The authors, de Vries et al. (2010) discovered that safety not taught to engineers. Carillo (2012) asserted that organization's managers must continually communicate the safety message to all employees. Palferman, Webster, and Kelly (2011) recommended more research on health aspects. Healy et al., (2013) found standing stations, exercise programs and diet education as ways to improve health. Vallero and Letcher (2012) found engineers not trained for disasters or making risk assessments. Filion and Hall (2009) stated that engineers need education on human health, safety and the environment. Aper et al., (2012) recommended autonomous training where engineers receive continuous education. Jallon, Imbeau, and Marcellis-Warin (2011b) calculated actual costs of accidents. Gordon et al., (2009) found costs for development of course materials to be decreasing. Wan (2013) advocated for m-learning for all that was a blended approach to learning skills. Winn (2014) stated that engineers were underprepared to enter the workplace and needed more training. Heese (2012), DeArmond et al. (2011), and Kevern (2011) all called for engineers to be better educated in occupational safety, health, and the environment. Appendix L is a start to this listing of information engineers need to be educated in that they currently were not in safety related subjects at most universities.

This study contributed to the field of research in providing data indicating a deficiency in a disadvantaged class of engineers in the maritime industry and the need for further education and training in safety material. It replicates and confirms a Spanish study conducted in 2012. It acknowledged the Delphi method as a reliable tool for reaching a consensus and the use of thematic analysis to establish themes and subthemes in qualitative methods. Naval engineers are a small group of individuals in the maritime industry who need further education in occupation risk prevention so that they can design safer, healthy, and systems that will not harm the environment.

This study was significant in that it documents an area in naval engineers' education and training that falls short in the occupational risk prevention area. The findings from this study has the ability to advocate for change in the education and training of naval engineers in the future so that they may provide a positive change in better protecting society from harm and the environment from detrimental effects of pollution. Major themes included all forms of safety issues, health, environment, curriculum and different forms of training, costs, and timing. All of these main themes focused on the naval engineers. Subthemes included risk, hazards, blended learning, variety of mandatory subjects, and financial aspects. Engineers needed this additional education to better prepare them for the challenges of designing systems that will improve conditions and protect life. Further research should take these themes and subthemes to expand the research in future studies that can look at ways of blending the information into existing engineering curriculum to improve the education of engineers.

The conclusions and recommendations from this study indicated that naval engineers needed to be educated further in occupational risk prevention matters both at the undergraduate level and as practicing naval engineers every 5-10 years as listed in Attachment L. The practical implications from this study are that naval engineers need specific training in occupational safety, health, and environmental sustainment to safeguard human life and protect the environment for generations to come. Engineers need to learn how to protect and save lives and the environment better if we have any hope for the human race to last and continue in our journey of existence.

If the engineers do not remain relevant then the future may be very bleak indeed for us all and for the planet that we live on. Engineers need to expand their education and keep up with technology and the dangers that the world faces. It starts with education and continues in life-long learning pursuits for practicing engineers to improve upon engineering designs to protect human life, health, and the environment. This education and training is mandatory and provided often every 5-10 years intervals to ensure engineers are current in their technical skills and continuously hone these skills to provide the best and safest designs to protect human life and that of the environment where we all must live.

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Appendices

Appendix A: Annotated Questions for U.S. Participants (First Round)

1. Do you agree with this statement, why or why not? Education and training for naval engineering graduates and practicing naval engineers regarding occupational risk prevention is vital for the integration of risk prevention in the production process, which in turn, improves working conditions, protects the health and safety of individuals, and improves the environment.

Comments: ____

2. Do you agree with this statement, why or why not? Occupational risk prevention should be included in the curricula of new course syllabi or continuing education because naval engineering graduates and practicing naval engineers need to understand safety, health, and environmental sustainment impacts that their designs may have on society.

Comments: ____

3. Do you agree with this statement, why or why not? The main reason hindering the integration of occupational risk prevention as a cross-field subject in other technological courses or as a separate continuing education course is the difficulty of integrating contents that are not well known.

Comments: ____

4. Topics on occupational risk prevention should be included in the curricula of new syllabi for naval engineering degrees and continuing education for naval engineers as:
(a) A separate course
(b) A cross-field subject in a number of courses
(c) Different separate courses specific to the student's course of instruction
(d) Correspondence/online class material to be done at student's own pace
(e) A blended learning experience
(f) Additional:______________________________________

Comments: ____

5. If separate courses chosen to be included in the curricula of new syllabi in all naval engineering degrees and continuing education for practicing naval engineers concerning occupational risk prevention, then this course should be:
(a) Mandatory
(b) Elective
(c) Depends on student's course of instruction
(d) Left up to the university or organization
(e) Other:______________________________________

Comments: ____

6. What name would be best for the new course, if one determined to be necessary for naval engineers to take? If you have no preference to the name or think it should left up to the professor/school or organization then just leave your answer blank. Feel free to create your own unique name, if desired. Add any comments you have on this topic of a course name.
(a) Safety/Health/Environment Studies
(b) Occupational Risk Prevention
(c) Industrial Safety and Associated Outcomes
(d) Environment, Health, & Safety (or some other order of these three words)
(e) Occupational Safety, Health, and the Environment Sustainment
(f) Environmental, Safety, and Occupational Health Course
(g) Engineering Risks
(h) Other: ____

Comments: ____

7. Which of the following issues should consider as part of the course or add your own topics? What should the detailed content of an undergraduate course or professional development include to the targeted audience of naval engineers for maximum retention and understanding?
(a) Basic concepts and terminology
(b) Laws and regulations
(c) Industrial safety considerations
(d) Risk assessment
(e) Environmental, health and safety planning
(f) Integrating occupational risk prevention in the production process
(g) Occupational risk prevention at the work site
(h) Additional:____

Comments: ____

8. If you are a professor who teaches a course in engineering or technology: Are you willing to integrate occupational risk prevention into the courses you teach, why? If you are a naval engineer, do you think you would have benefitted from such a course on the health, safety, and environmental protection of the environment in your academic studies? Please explain your answer.

Comments: ____

9. Using your own knowledge and experience, what are the associated costs with accidents and separately the cost of developing a course on this subject of safety, health, and the environment for undergraduate naval engineering students or continuing education for practicing engineers?

Comments: ____

10. What is the timing when this course material should be given to the targeted audience of naval engineers and should it be repeated, and if so, how often and to what level of degree? Please just express your opinion on this matter.

Comments: ____

Appendix B: Permission to Use Membership Database and Replicate Study

AMERICAN SOCIETY OF NAVAL ENGINEERS

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To Whom It May Concern,

Dr. David R. Stevenson, ABD has my permission to use individuals chosen from the American Society of Naval Engineers membership database to conduct his dissertation research. To comply with our privacy policy, I will make the initial contact with the selected members to confirm their willingness to participate in this research. I understand there are intended to be a total of 100 participants for this study.

Sincerely,

Dennis K. Kruse
Executive Director

verizon

Verizon Message Center

Tuesday, May 6 at 1:05 PM

From: "Eugenio Pellicer" <pellicer@upv.es>

To: drstevenson@verizon.net

Subject: RE: Request to Replicate Integration of Occupational Risk Prevention Study in the United States of America

Dear Mr. Stevenson:

You have our permission to replicate in US the study explained in our paper:

Cortés, J.M., Pellicer, E., Catalá, J. (2012) "Integration of occupational risk prevention courses in engineering degrees: a Delphi study". Journal of Professional Issues in Engineering Education and Practice (American Society of Civil Engineers, ISSN-1052-3928), volume 138, number 1, pages 31-36.

We would like to receive your complete research, so we could cooperate in the future in this line of research.

Best regards,

Eugenio Pellicer
Associate Professor
School of Civil Engineering
Universidad Politecnica de Valencia
Camino de Vera, s/n, 46022 Valencia (Spain)
Phone # +34.963.879.562
Fax # +34.963.877.569
http://personales.upv.es/pellicer/

De: drstevenson@verizon.net [mailto:drstevenson@verizon.net]
Enviado el: martes, 06 de mayo de 2014 14:33
Para: pellicer@upv.es
Asunto: Request to Replicate Integration of Occupational Risk Prevention Study in the United States of America

Dear Professor Pellicer: My name is David Stevenson and I am a doctoral graduate student at Northcentral University in Prescott Valley, Arizona though I work in Washington, DC and live in Falls Church, Virginia. I am interested in replicating the study that you, Senors Cortés and Catalá conducted on the integration of occupational risk prevention in Spain here in Washington, DC for my dissertation. My school's Institutional Review Board requires that I obtain your official permission to replicate your Spanish study here in the United States of America and to use your same research questions and methods that you and your co-authors did in conducting your research. I will be glad to share my completed research with you and your co-authors if you are interested in receiving it. Please respond back either by attached letter or e-mail that I have your permission to replicate your study as you suggested in your paper published in the *Journal of Professional Issues in Engineering Education and Practice* in 2012.

Respectfully yours,

David Stevenson

Appendix C: Informed Consent Form

Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability

Note: Signatures are not required unless desired by participant. By entering the website portal, you acknowledge your rights of informed consent. You may still withdraw at any time. There is no compensation or benefit to you for participating in this study.

Purpose. You are to participate in a research study conducted for a dissertation at Northcentral University in Prescott, Arizona. The purpose of this study is to replicate a previous study that explored integrating occupational risk prevention material into naval engineering degree programs for under-graduate college education and continuing education for current naval engineers. There is no deception or alternative motive for conducting this study. The researcher is interested in your perspectives, recollections, and suggestions into this matter. The framework will be using the Delphi method to gather your opinion on ten questions. Subsequent rounds will try to reach a consensus among the experts participating on this panel developed from members of the American Society of Naval Engineers Flagship Section.

Participation requirements. You can participate in a panel group. After the panel group has completed, you will receive a written copy of the panel's input. The panel group questionnaire should take no more than approximately 30 minutes of your time to fill out. However, there may be multiple rounds as the questions are revised or amplified based on the previous round inputs. The study should take no more than three months in total to collect all of the data. This study will run during the summer of 2014 and should end before the end of August 2014.

Research Personnel. The following persons are involved in this research project and you may contact them at any time:
Principal Researcher: Dr. David "Dave" R. Stevenson, ABD
drstevenson@verizon.net or phone (cell): 703-403-0531 / Fax (202) 488-1951
Dissertation Chair: Dr. John S. Johnson, jjohnson@ncu.edu, 317-373-8650

Potential Risk/ Discomfort. Although there are no known risks in this study, some of the information is personally sensitive and includes questions about your educational experiences that might contain both successes and failures. Discussing these topics might be distressing for some people. However, you may withdraw at any time and you may choose not to answer any question that you feel uncomfortable in answering.

Potential Benefit. There are no direct benefits to you for participating in this research. No incentives offered. The results will have engineering interest that may eventually have benefits for other people who pursue a naval engineering degree or continue their education.

Anonymity/Confidentiality. The data collected in this study is confidential to the extent provided by secure Internet communication. You will be welcome to use a screen name during the focus group and during any follow up discussion to keep your identity private. At the conclusion of the study, any recorded documentation that would enable someone to match a response in the questionnaire, to a particular individual will be destroyed. In addition, all online material will be erased and all hard copies will be shredded for your security and privacy.

Right to Withdraw. As previously stated, you have the right to withdraw from the study at any time without penalty. You may omit questions in any panel group session if you do not want to answer them.

I would be happy to answer any question that may arise about the study. Please direct your questions or comments to the principle researcher, David R. Stevenson, at the e-mail address listed or call him on his cell phone at any time.

I acknowledge that I have read the above description of the Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability Informed Consent Form and understand the conditions of my participation. My signature or entry into the Survey Monkey® website indicates that I understand the Informed Consent Form and agree to participate in this qualitative study and that I acknowledge that I may withdraw at any time for any reason with no questions asked.

Researcher's Name: David R. Stevenson

Synopsis:

- This is voluntary research where participants may withdraw at any time for any reason.
- The subject chosen to identify new educational areas needed for naval engineers.
- My role is one of researcher, facilitator, monitor, collector of data, and writer of results.
- The purpose is to see how occupational safety, health, and environmental sustainment should incorporate in U.S. engineering universities curriculum and what subjects for continuing education should provide to current naval engineers.
- Procedures will involve filling out a questionnaire; repeating as a consensus reached.
- Only minimal amount of your time (1.5 hours) and discontinuing involves no penalty.
- There are no known potential conflicts of interest for the facilitator and any participants.
- Participants should keep a copy of the Informed Consent Form for their own records.
- No compensation provided in volunteering to participate in this Delphi research study.
- Confidentiality will maintain for all participants and any comments provided.
- There are no anticipated benefits to participants or any others from this research study.
- No foreseeable risks or discomforts should result in participating in this research study.

What if I have questions about my rights as a research participant or complaints?

If you have questions about your rights as a research participant, any complaints about your participation in the research study or any problems that occurred in the study, please contact the researchers identified in the consent form. Alternatively, if you prefer to talk to someone outside the study team, you can contact Northcentral University's Institutional Review Board at irb@ncu.edu or 1-888-327-2877 ex 8014.

Appendix D: Field Test Invitation

verizon
Verizon Message Center

Thursday, Jun 26 at 12:12 PM

From: "Stevenson, Dave (CGI Federal)" <Dave.Stevenson@cgifederal.com>

To: "drstevenson@verizon.net" drstevenson@verizon.net

Cc: "Stevenson, Dave (CGI Federal)"

Subject: Field Test of Dissertation Website for Dave Stevenson

Dear ASNE Supporters – As some of you know I am working on my dissertation and could use your help in reviewing my Informed Consent Form (attached) and website that I will be using to collect data. Your help will not be a part of the official results. If you would like to be invited to participate in the actual study, please let me know either by responding to this e-mail. Feel free to add any comments to the following survey monkey site or respond separately with any comments you may have on the attached form and the website. Thank you for your participation but just like the real study it is completely voluntary and you may withdraw at any time for any reason. Here is the website link: https://www.surveymonkey.com/s/YSN3LKB

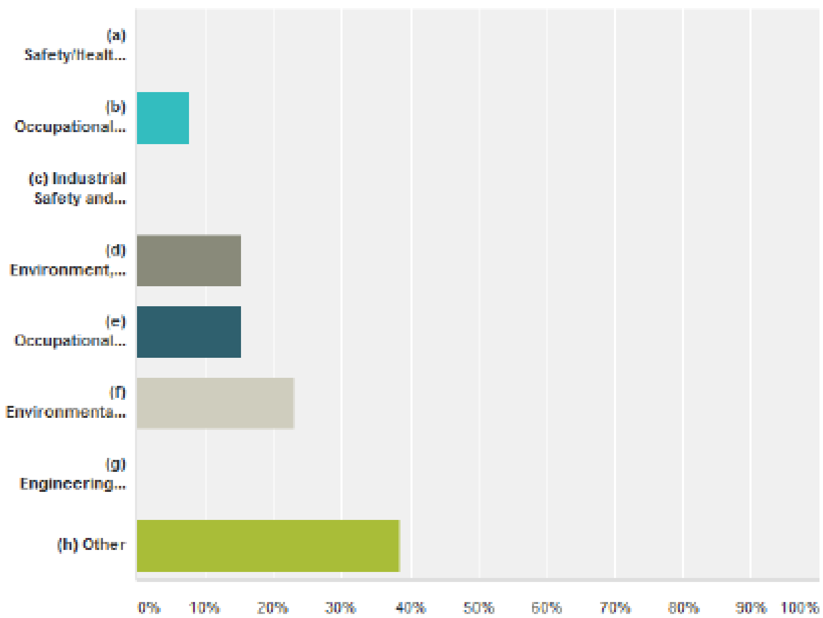
Thanks, Dave

David R. Stevenson
Senior Engineer
CGI Federal
U.S. Federal Market
1100 New Jersey Ave SE
Suite 800
Washington, DC 20003
Phone (202) 314-4262
Fax (202) 488-1951

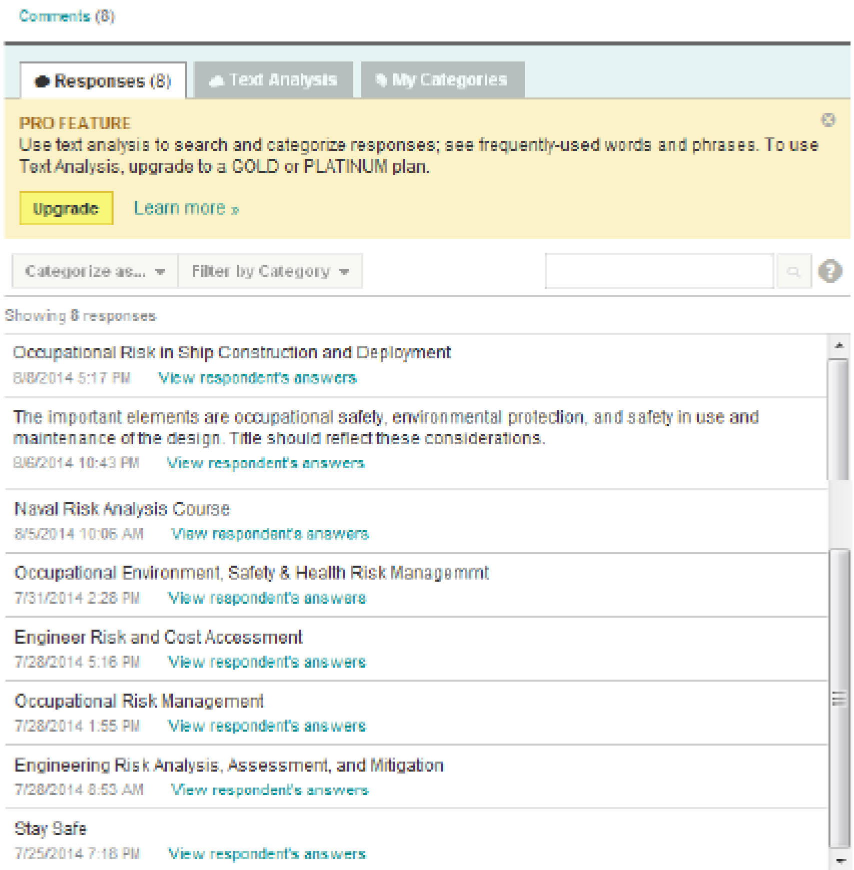
Appendix E: Naming Question (Withdrawn)

What name would be best for the new course, if one is determined to be necessary for naval engineers to take? If you have no preference to the name or think it should be left up to the professor/school or organization then just leave your answer blank. Feel free to create your own unique name, if desired. Add any comments you may have on this topic of a course name.

Answered: 13 Skipped: 4



Answer Choices	Responses	
(a) Safety/Health/Environment Studies	0.00%	0
(b) Occupational Risk Prevention	7.69%	1
(c) Industrial Safety and Associated Outcomes	0.00%	0
(d) Environment, Health, & Safety (or some other order of these three words)	15.38%	2
(e) Occupational Safety, Health, and the Environment Sustainment	15.38%	2
(f) Environmental, Safety, and Occupational Health Course	23.08%	3
(g) Engineering Risks	0.00%	0
(h) Other	38.46%	5
Total Respondents: 13		



Researchers Note: Because no clear majority existed for this naming and deemed not to be an important issue to pursue to try to reach a consensus for the purposes of this study's research, this question withdrawn from consideration for this study. The data provided for new researchers who may want to study this topic and to spend additional time in formulating a name for this research subject. This study used the Spanish study occupational risk prevention along with the title of this study, occupational safety, health, and environmental sustainment interchangeably. Participant 12 proposed title from above as Stay Safe is a short and succinct title for this very important topic.

Appendix F: Second Round Questionnaire

Q1. What additional education do U.S. naval engineers in Washington, D.C., need in occupational safety, health, and environmental sustainability (also known as occupational risk prevention) to improve their capabilities and technical acumen to prevent accidents?

Q2. How can occupational risk prevention, integrated into undergraduate engineering degree programs, professional development, continuing education, or offered by other means to naval engineers, provide the best educational experience at the most affordable cost?

Q3. Should naval engineers train in cost estimating and risk assessments as part of their overall education? Why or why not?

Q4. A similar study conducted in Spain reached the conclusion that "education and training in occupational risk prevention has a direct impact on improving working conditions; it is considered essential for the necessary creation of safety culture". Do you agree or disagree with this statement?

Q5. While predicting the future of marine transport and as a lesser included activity warship, submarines and craft, it would seem clear that unmanned transports are certainly in the future. I think it relevant to ask what additional knowledge base will be essential for design of marine transport in the next 50 years.

Q6. Do you agree with the statement that most naval engineers are weak in the areas of probability and statistics?

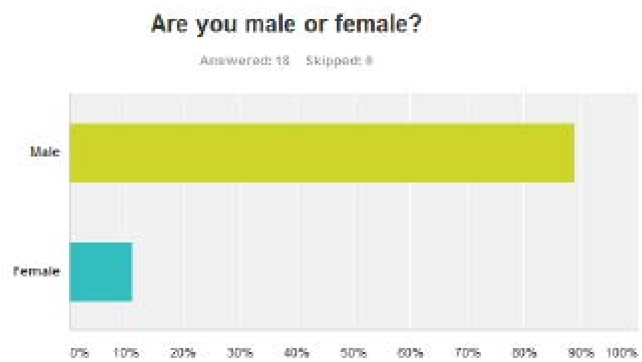
Q7. Why do you think many naval engineers end up leaving engineering and going into program management or another specialty?

Q8. Not very many naval engineers obtain their professional engineering (PE) license. Why do you think this is so?

Q9. Why do you think naval engineering is a male dominated industry and why do not more women become naval engineers?

Q10. Is there anything else you would like to conclude with regarding this study, some of the unrelated topics involving naval engineering, or anything else that just happens to be on your mind?

Appendix G: Additional Demographics Information Not Reported On Above



Answer Choices	Responses	
Male	88.89%	16
Female	11.11%	2
Total		18

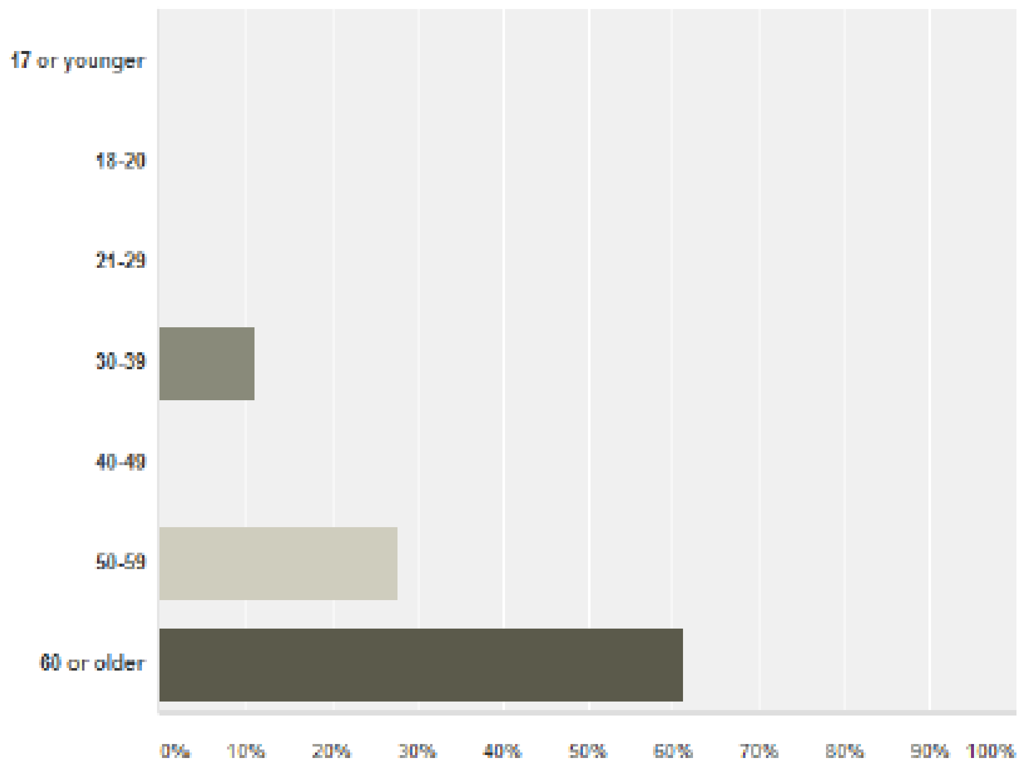
When asked if they ever taught naval engineering and, if so, what subjects the following responses provided:

- 13 responded negatively

- 5 said yes with the following subjects: Reliability Engineering, Operations Research, Advanced Naval Architecture Ship Systems Engineering, and Cost Engineering for Naval Ships, Fluid Mechanics, and Introduction to Thermodynamics, Applied Thermodynamics, Gas Dynamics, Turbomachinery to Engineering Majors, Principles of Naval Engineering, Fluid Dynamics II, and Turbomachinery.

Which category below includes your age?

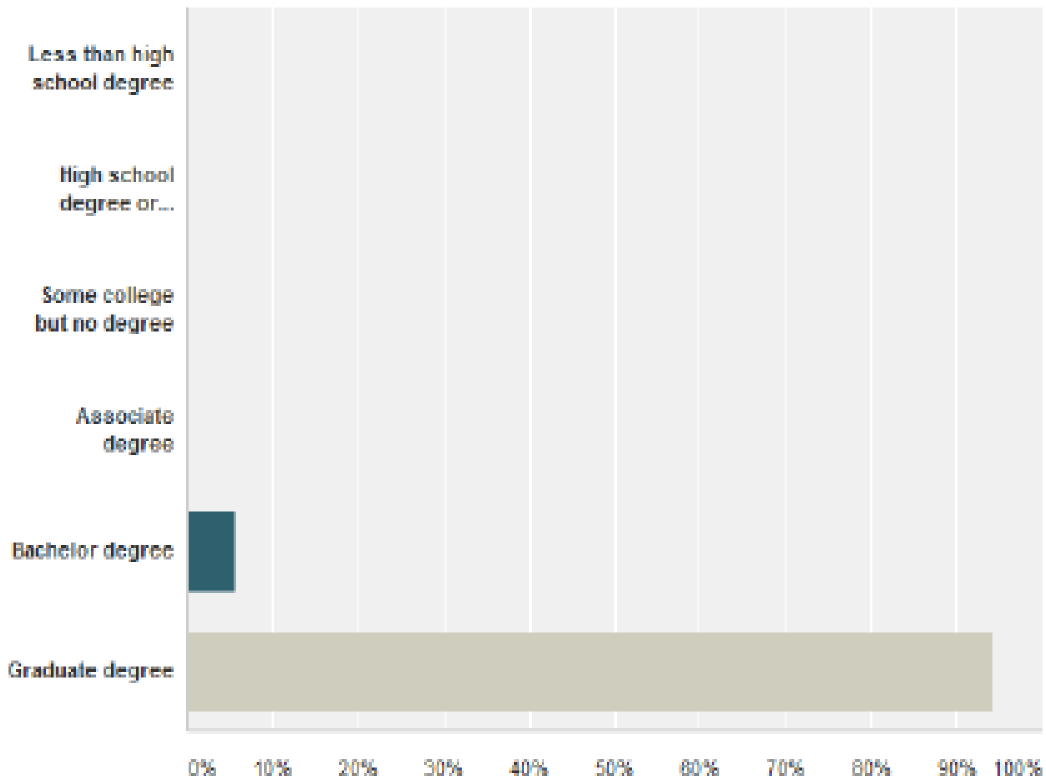
Answered: 18 Skipped: 0



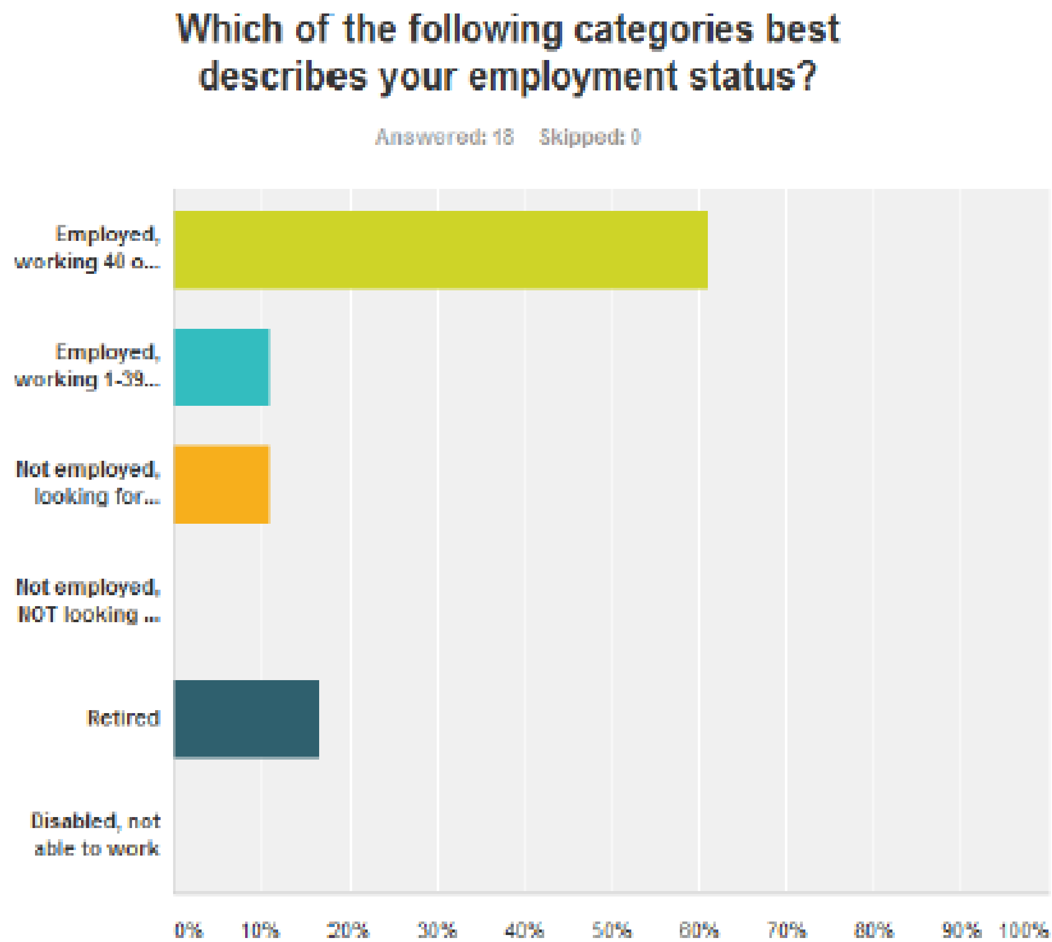
Answer Choices	Responses	
17 or younger	0.00%	0
18-20	0.00%	0
21-29	0.00%	0
30-39	11.11%	2
40-49	0.00%	0
50-59	27.78%	5
60 or older	61.11%	11
Total		18

What is the highest level of school you have completed or the highest degree you have received?

Answered: 18 Skipped: 0



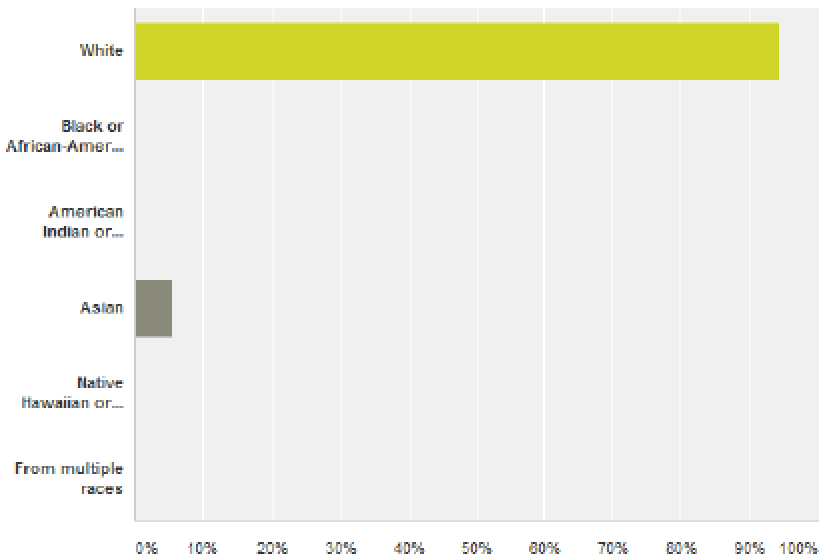
Answer Choices	Responses	
Less than high school degree	0.00%	0
High school degree or equivalent (e.g., GED)	0.00%	0
Some college but no degree	0.00%	0
Associate degree	0.00%	0
Bachelor degree	5.56%	1
Graduate degree	94.44%	17
Total		18



Answer Choices	Responses	
Employed, working 40 or more hours per week	61.11%	11
Employed, working 1-39 hours per week	11.11%	2
Not employed, looking for work	11.11%	2
Not employed, NOT looking for work	0.00%	0
Retired	16.67%	3
Disabled, not able to work	0.00%	0
Total		18

Are you White, Black or African-American, American Indian or Alaskan Native, Asian, Native Hawaiian or other Pacific islander, or some other race?

Answered: 18 Skipped: 0



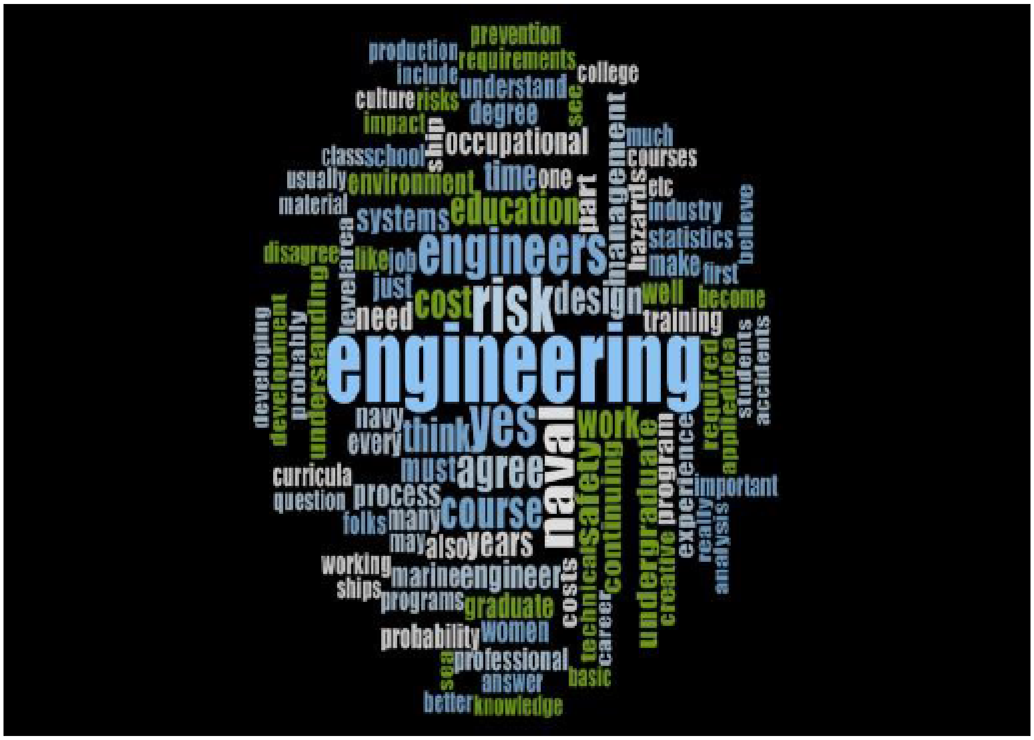
Answer Choices	Responses	
White	94.44%	17
Black or African-American	0.00%	0
American Indian or Alaskan Native	0.00%	0
Asian	5.56%	1
Native Hawaiian or other Pacific Islander	0.00%	0
From multiple races	0.00%	0
Total		18

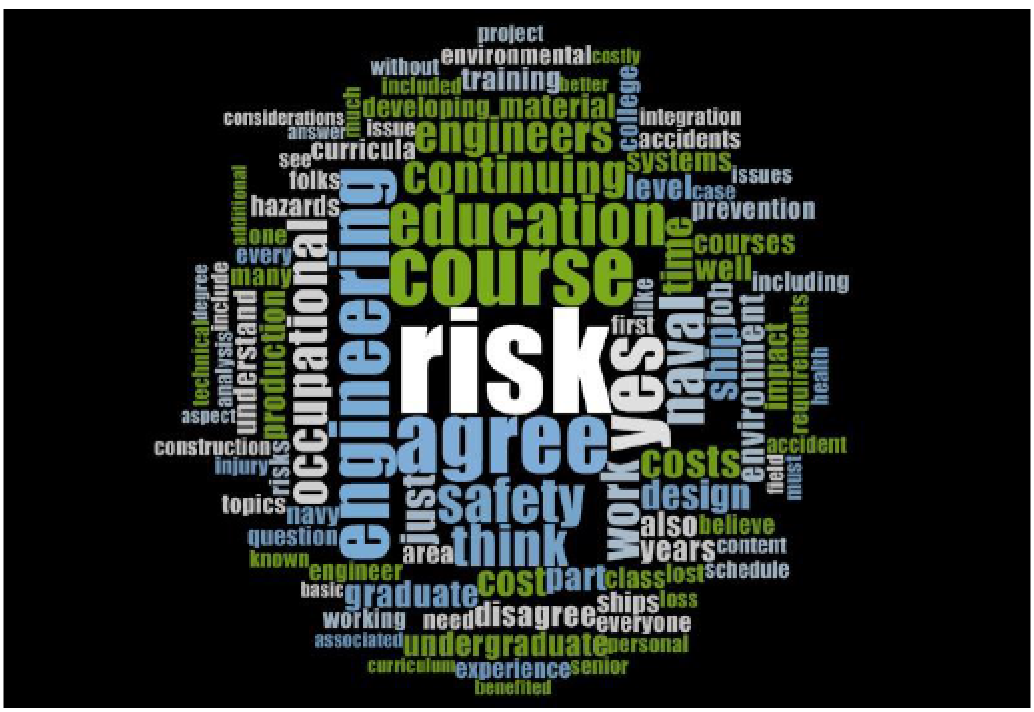
Comments (0)

When asked if they had to do it all over again, would they still have chosen to work in the naval engineering field, the following is how the participants responded:

- Yes, replied 17 participants with some providing absolutely and definitely responses; one said “I think so, yes”; another “no regrets”
- Only one replied “no”.

Appendix H: Word Frequency Analysis





Appendix I: Code Book with Nodes

Hierarchical Name	Nickname	Aggregate	User Assigned Color

Node

Nodes

Hierarchical Name	Nickname	Aggregate	User Assigned Color
Nodes\\Costs & Timing	C	Yes	Orange
Nodes\\Costs & Timing\Accidents	CA	No	Orange
Nodes\\Costs & Timing\Implementation	CI	No	Orange
Nodes\\Educating Naval Engineers in Occupational Safety, Health, and		No	None
Nodes\\Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability (Field Test)\1. Do you agree with this statement, why or why not Education and training for naval		No	None
Nodes\\Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability (Field Test)\10. What is the timing when this course material		No	None
Nodes\\Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability (Field Test)\2. Do you agree with this statement, why or why not Occupational risk prevention should		No	None
Nodes\\Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability (Field Test)\3. Do you agree with this statement, why or why not The main reason hindering the		No	None
Nodes\\Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability (Field Test)\8. (a) If you are a professor who teaches a course in engineering or technology Are you		No	None
Nodes\\Educating Naval Engineers in Occupational Safety, Health, and Environmental Sustainability (Field Test)\9. Using your own knowledge and experience, what are the associated costs with accidents		No	None
Nodes\\Environment	E	Yes	Red
Nodes\\Environment\Sustainment	ES	No	Red
Nodes\\Health	H	Yes	Purple
Nodes\\Health\Occupational	OH	No	Purple
Nodes\\Naval Engineers	N	Yes	Yellow
Nodes\\Naval Engineers\Practitioners	NP	No	Yellow
Nodes\\Naval Engineers\Students	NS	No	Yellow
Nodes\\Other Issues	O	Yes	Pink
Nodes\\Safety	S	Yes	Green

Hierarchical Name	Nickname	Aggregate	User Assigned Color
Nodes\\Safety\Culture	SC	No	Green
Nodes\\Safety\Occupational	OS	No	Green
Nodes\\Training	T	Yes	Blue
Nodes\\Training\Curriculum	CT	No	Blue
Nodes\\Training\Types	TT	No	Blue

Appendix J: Questionnaire Results

Questionnaire & Question No.	Agreement Percentage	Strength of Consensus
Questionnaire 1-Question 1	94%	Strong
Questionnaire 1-Question 2	100%	Strong
Questionnaire 1-Question 3	64%	Strong
Questionnaire 1-Question 4	56%	Medium
Questionnaire 1-Question 5	51%	Medium
Questionnaire 1-Question 6	N/A	N/A
Questionnaire 1-Question 7	100%	Strong
Questionnaire 1-Question 8	82%	Strong
Questionnaire 1-Question 9	94%	Strong
Questionnaire 1-Question 10	94%	Strong
Questionnaire 2—Question 1	100%	Strong
Questionnaire 2—Question 2	100%	Strong
Questionnaire 2—Question 3	92%	Strong
Questionnaire 2—Question 4	100%	Strong
Questionnaire 2—Question 5	N/A	N/A
Questionnaire 2—Question 6	N/A	N/A
Questionnaire 2—Question 7	58%	Medium
Questionnaire 2—Question 8	N/A	N/A
Questionnaire 2—Question 9	N/A	N/A
Questionnaire 2—Question 10	N/A	N/A

Key: Only 14 of the questions calculated by percentage. The remaining 6 questions could not be calculated and received an N/A rating.

Appendix K: Comparison of Spanish and USA Studies

Spanish Study Question	USA Questionnaire	Results
1. Education and training for engineering graduates regarding occupational risk prevention is vital for the integration of risk prevention in the production process, which in turn improves working conditions.	1. Do you agree with this statement, why or why not? Education and training for naval engineering graduates and practicing naval engineers regarding occupational risk prevention is vital for the integration of risk prevention in the production process, which in turn, improves working conditions, protects the health and safety of individuals, and improves the environment.	Same; both groups strongly agree with these statements
2. Occupational risk prevention should be included in the curricula of new syllabi because graduates in Spain receive professional competences upon completion of an engineering degree.	2. Do you agree with this statement, why or why not? Occupational risk prevention should be included in the curricula of new course syllabi or continuing education because naval engineering graduates and practicing naval engineers need to understand safety, health, and environmental sustainment impacts that their designs may have on society.	Same; both groups strongly agree with these statements
5. The main reason hindering the integration of occupational risk prevention as a cross-field subject in other technological courses is the difficulty of integrating contents that are not well known.	3. Do you agree with this statement, why or why not? The main reason hindering the integration of occupational risk prevention as a cross-field subject in other technological courses or as a separate continuing education course is the difficulty of integrating contents that are not well known.	Disagreed; the only question that had different results. The Spanish study had 53% agree and the USA had x% disagree with this statement.
3. Topics on occupational risk prevention should be included in the curricula of new syllabi for engineering degrees in Spain as…	4. Topics on occupational risk prevention should be included in the curricula of new syllabi for naval engineering degrees and continuing education for naval engineers as…	Agreed; both groups strongly agreed with this statement for a separate course for engineers.
4. If a separate course is chosen to be included in the curricula of new syllabi in engineering degrees, this course should be…	5. If separate courses chosen to be included in the curricula of new syllabi in all naval engineering degrees and continuing education for practicing naval engineers concerning occupational risk prevention, then this course should be:	Same; both groups strongly agree that it should be mandatory.

8. Which of the following issues should be considered as part of the course?	7. Which of the following issues should consider as part of the course or add your own topics? What should the detailed content of an undergraduate course or professional development include to the targeted audience of naval engineers for maximum retention and understanding?	Agreed with most strongly agreeing and just some in agreement to all of the topics suggested.
6. If you are a professor who teaches a course on engineering technology: Are you willing to integrate occupational risk prevention in the course you teach?	8. If you are a professor who teaches a course in engineering or technology: Are you willing to integrate occupational risk prevention into the courses you teach, why? If you are a naval engineer, do you think you would have benefitted from such a course on the health, safety, and environmental protection of the environment in your academic studies?	Same; both studies strongly agreed that it should be incorporated into existing courses.

Notes:

1. The Spanish study only had eight questions whereas the USA study had 10.

Appendix L: List of Related Safety Material to be Included in Course Info

☐ Safety issues
☐ Health impacts
☐ Environment considerations
☐ Engineering Curriculum
☐ Different forms of training
☐ Costs and timing
☐ Risk
☐ Hazards
☐ Blended learning
☐ Variety of mandatory subjects
☐ Financial aspects
☐ Basic concepts and terminology
☐ Laws and regulations
☐ Industrial safety considerations
☐ Risk assessment
☐ Basic knowledge on possible hazards
☐ Basic knowledge on variability of human behaviorthat can lead to accidents
☐ A good primer on applicable laws and legal precedents
☐ Physical and mechanical hazards, which addresses Navy policy and best practices
☐ Role of warranted Principals for Safety (PFS)
☐ Probability (known or derived)
☐ Decisions under uncertainty
☐ Probability and statistics
☐ Design margin
☐Decision-making
☐ Modeling
☐ Financial management
☐ Human systems integration (HSI)
☐ Process management
☐ Systems engineering
☐ Quality assurance