Dust-Control Usage: Strategic Technology Interventions

Justin Weidman

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Deborah Young-Corbett
C. Theodore Koebel
Christine M. Fiori
Kevin R. Miller

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ABSTRACT

An intervention to improve adoption of dust control technology is designed, implemented and evaluated using three theoretical frameworks: the Health Belief Model (HBM), Diffusion of Innovation, and the Technology Acceptance Model. A quasi-experimental design (pretest-posttest, with control group) was used to evaluate the effectiveness of the intervention. An integrated conceptual model, employing key constructs from these frameworks, was developed to predict and describe "adoption readiness". Adoption readiness combines the attitudes and perceptions about a technology with the capacity to implement the technology. The primary hypothesis was that the key construct scores of the three theoretical models would improve post-intervention, particularly, "adoption readiness". Workers in the drywall finishing industry have been found to be at risk of developing respiratory disease and disability. Studies have shown that drywall finish workers have been subject to overexposure to dust concentrations that contain respiratory heath hazardous particles including silica, talc, mica, and calcite. Prevention through Design (PtD) solutions, which are effective at reducing dust levels, do exist for these operations. Some of these PtD solutions include using vacuum sanders, wet sanding methods, pole sanding and using low dust joint compound in lieu of using personal protective equipment (PPE) as a primary form of exposure protection. Previous studies have determined barriers to adoption of current PtD solutions for dust exposure reduction. Usability, productivity, quality of finish and cost were all identified as barriers to adoption. An intervention directed at those involved in the drywall industry is needed to increase the usage of engineered dust control.

This dissertation project developed, implemented, and evaluated three interventions to address the barriers to adoption through education and marketing strategies. Development of the interventions included strategies to improve industry usage of dust control technologies. The interventions targeted workers, small companies, and large companies involved in drywall finishing.

Key Words: Drywall, Dust, Intervention, Trust, Technology, Health, Belief, Diffusion, Innovation, Adoption

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CHAPTER 1

1 INTRODUCTION

The construction industry presents many health hazards for those who are involved. Workers are exposed to health and safety hazards that need to be controlled. Drywall dust exposure is of particular concern in relation to the health of drywall finishers. Prevention through Design (PtD) solutions for dust control technologies have been found effective in reducing the levels of drywall dust to which finishers are exposed (Mead et al. 2000). Previous studies have shown that the usage of PtD solutions is not widely implemented in finishing operations (Young-Corbett and Nussbaum 2009b). Interventions are needed to improve the usage of dust control technologies. This chapter gives the background of the problem, the rationale for the research, the objectives covered as the interventions are developed, and the hypotheses for the project.

1.1 Background of the Problem

Reporting of accidents and illness in construction is complicated, due to the large number of small contractors and subcontractors who do not fall under federal reporting restrictions. As a result of the numerous small companies, only about one third of all accidents and illnesses are reported (Sauni et al. 2003). Addressing safety and health concerns in the construction industry is difficult due to the changing nature of the work. The daily workplace for construction workers is always changing due to varying stages of project completion. The complexity of the projects and organizational structure of construction companies can pose difficulties in implementing and evaluating health and safety interventions. Health and safety implementation is also complicated by the high work demand and little worker involvement in the design and selection of products and processes (Kramer et al. 2009). Work-related health and safety issues can be decreased by combining changes in design, tools, materials and methods (Jensen and Kofoed 2002). One major health concern is the amount of dust construction to which workers are exposed. The optimal method of preventing occupational illnesses, injuries, and fatalities is to "design out" the hazards and risks; thereby, eliminating the need to control them during work operations. The practice of designing out hazards has been termed Prevention through Design (PtD). This approach involves the design of tools, equipment, systems, work processes, and facilities in order to reduce, or eliminate, hazards associated with work. Prevention through Design (PtD) has been defined by Schulte et al. (2008) as:

> The practice of anticipating and "designing out" potential occupational safety and health hazards and risks associated with new processes, structures, equipment, or tools, and organizing work, such that it takes into consideration the construction, maintenance, decommissioning, and disposal/recycling of waste material, and recognizing the business and social benefits of doing so (Schulte 2008).

1.2 Statement of the Problem

Despite the development of effective PtD solutions, workers are still being exposed to high levels of dust (Miller et al. 1997; Young-Corbett and Nussbaum 2009a). A survey of drywall finish workers and owners of drywall finishing companies found that the PtD solutions including vacuum sanders, wet methods, pole sanding, and low dust compounds that have been developed are not widely used (Young-Corbett and Nussbaum 2009b). The research showed that the most commonly used method for protecting workers from dust exposure is the use of personal protective equipment in the form of respirator masks. Respiratory protection is not the OSHA preferred control method for reducing exposure to inhalation hazards because it places an burdens on the worker and can require medical clearance, proper fitting, and training (Young-Corbett and Nussbaum 2009b). The responsibility placed on the worker is a reason that engineered methods of controls should be used instead of relying on the workers to protect themselves (Miller et al. 1997).

Many barriers affect the implementation of new innovations. The lack of information and cost of technologies or methods could create barriers to adoption (Ling 2003). In a study performed by Young-Corbett and Nussbaum (2009a) to determine usage rates of drywall dust PtD solutions, the perception of reduced quality and productivity were the primary barriers to adopting new dust control technologies or methods for drywall finishing (Young-Corbett and Nussbaum 2009a). Other barriers to adoption found in the study included usability of vacuum sanders, the existence of power cords limiting worker movement, lack of power sources on projects, and the initial cost of implementing the new controls.

A health and safety intervention is simply defined as any attempt to change how things are done within the workplace in order to improve safety (Robson et al. 2001). The nature of construction work presents challenges to the implementation of worker safety and health interventions due to the changing nature of construction work. Construction workers move from jobsite to jobsite and are not typically working at one project location for long periods of time (Sorensen et al. 2007). Health and safety interventions are intended to bring about change in human behaviors and often designed to increase the information about health and safety practices by personalizing the message to the affected group (Robson et al. 2001). Health and safety interventions have been shown to be effective in promoting behavior changes within many occupations (Sorensen et al. 2007).

There is a need for interventions that will increase knowledge about drywall dust PtD solutions and improve dust-control technology transfer into the drywall finishing industry. Increased adoption of dust-control technologies and methods is needed to protect drywall finish workers from over-exposure to dust concentrations that could lead to respiratory disease or disability. While there has been considerable attention to the effectiveness of dust control methods, the implementation of these methods needs to be increased (Miller et al. 1997; Young-Corbett and Nussbaum 2009a). Workers and business owners in the drywall finishing industry are potentially unaware of the health risks associated with drywall dust as well as the benefits of adopting new technologies (Young-Corbett and Nussbaum 2009a).

1.3 Rationale

Drywall finishing operations expose workers to dust concentrations that could result in respiratory disease or disability. Workers, small firms and large firms need to adopt dust control methods to protect workers and promote the health and safety of the construction industry. The construction industry has and will continue to be at risk for worker injuries and health concerns due to the nature of the work. With increased attention to design of hazard controls such as the Prevention through Design Initiative announced in 1990, the health and safety risks to workers and companies can be reduced. Effective interventions need to be developed to provide a safer environment for the workers in the construction trades. If successful, the interventions can then potentially be adapted to other safety and health concerns within the construction industry.

This dissertation research, which builds upon previous work related to drywall dust and dust control PtD methods and tools, was aimed to develop and evaluate interventions to improve the intent to adopt PtD solutions in the construction industry, specifically vacuum drywall sanders. These Dust-control Usage: Strategic Technology Intervention (DUSTI) interventions which have been sponsored through an educational grant by the National Institute for Occupational Safety and Health (NIOSH), address the barriers to adoption and other factors influencing behavioral intention to adopt new safety technologies in the construction industry through educational and marketing strategies. These interventions were generally designed, so that they could be adapted to other construction disciplines in the future, but primarily focus on the drywall finishing trade. These interventions are in response to the specific safety and health needs in the construction industry as outlined by the NIOSH National Occupational Research Agenda (NORA), National Construction Agenda (2008). The two goals that these interventions will specifically support are the intermediate goals 5.2 and 5.3: to "Increase awareness about silica hazards" and "Increase the availability of engineering and work practice options for preventing and reducing silica exposures."

There are important gaps in the existing knowledge regarding the implementation of dust-reducing PtD solutions in the drywall finishing industry. Aside from the work of Young-Corbett and Kleiner (2008) relating to the perceived barriers to adoption of drywall dust controls, based on a literature review, there have been no interventions found to increase the intention to use dust-reducing PtD solutions. This research developed, implemented and evaluated three interventions to address the gaps in existing knowledge to determine if an intervention strategy is an effective way to increase the intention to use PtD solution methods in the drywall finishing industry.

1.4 Research Goals

The goals of this research were to design, implement and evaluate strategic interventions to improve adoption readiness and related constructs, with the ultimate goal of increasing usage of dust control technologies within the drywall finishing industry. This research has incorporated a review of literature that focused in the following areas: intervention design and implementation, the Health Belief Model, Diffusion of Innovation models, the Technology Acceptance Model including trust in technology and trust in organization, and the health effects of drywall dust on worker health. The literature review was not meant to be exhaustive but rather was intended to determine representative articles presenting theory-based intervention studies that have been used for health promotion and diffusion of new technologies. The literature review also attempted to determine appropriate intervention strategies that are applicable and effective for these types of intervention. The literature review plan with selected references is outlined in Figure 1.

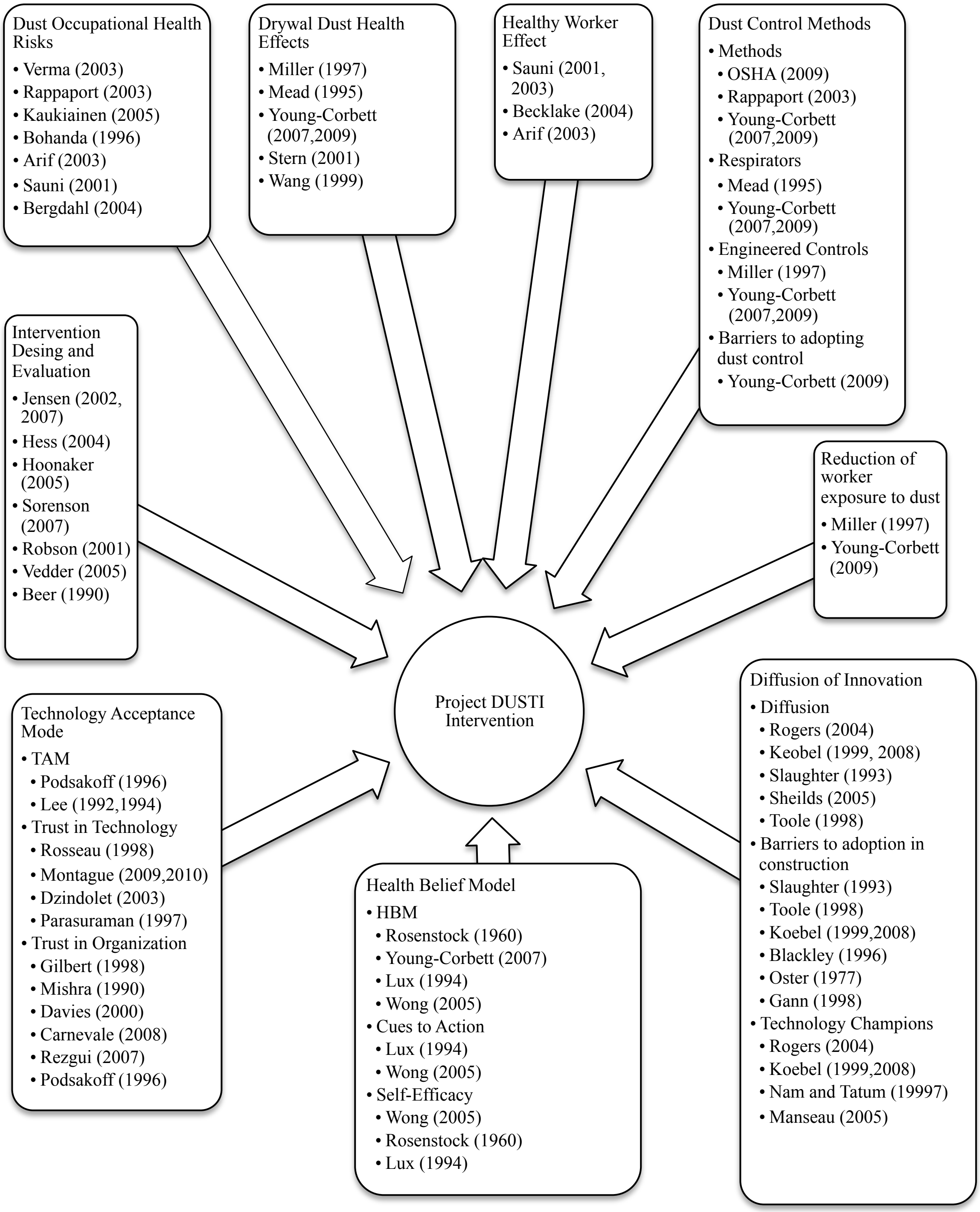


Figure 1 Expanded Literature Review Plan

1.4.1 Design Interventions to Improve Dust-Control Technology Usage

Research involving interventions involves implementing planned and applied activities designed to produce prescribed outcomes by applying scientific methods to evaluate the impact of safety and health interventions (Schulte 1996). Interventions aimed at changing behavior intentions to use PtD solutions are designed with goals to ultimately reduce occupational hazards or to control the route of the hazards away from the worker. Researchers have used interventions promoting the increased usage of PtD solutions to address various safety and health hazards (Goldenhar 1996). In the construction industry an intervention could be a new work practice, method, program or training program intended to improve safety. Interventions can be implemented at various levels of the workplace as shown in Figure 2.

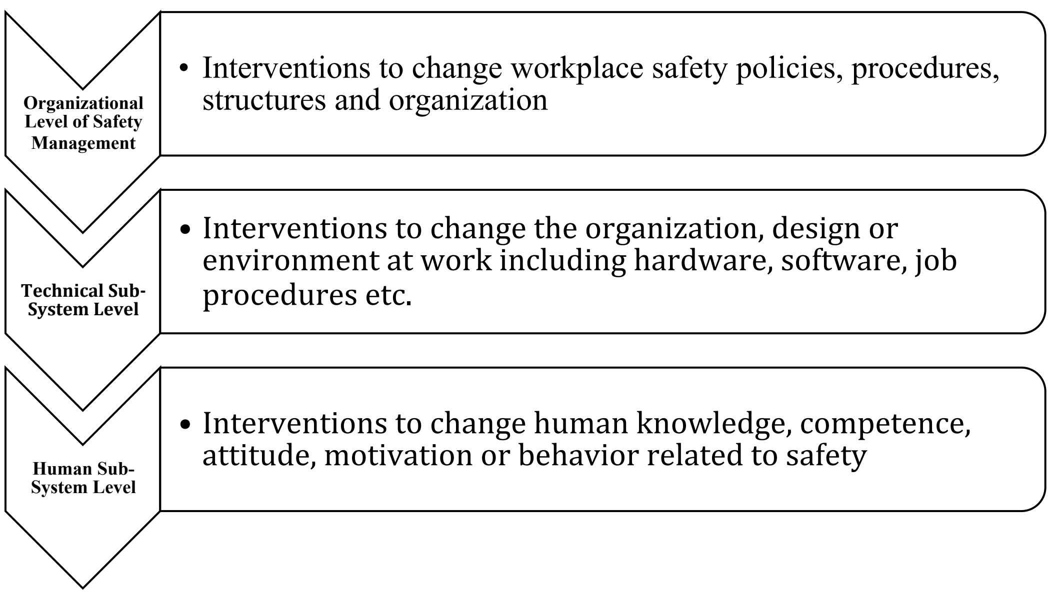


Figure 2 Levels of intervention in the workplace safety system (Adapted from Centers For Disease Control and Prevention 2001)

The DUSTI interventions addressed the three-workplace levels by promoting changes in workplace safety policies and procedures at the organizational level; changing the design and environment in the workplace at the technical sub-system; and changing human knowledge, attitudes, motivation and behavior related to safety at the worker level. Using intervention design research literature, the DUSTI interventions incorporated and adapted successful intervention strategies to design intervetnions that aimed at increasing the use of PtD solution technologies.

The designs of the interventions were guided by findings from the literature review that examined behavioral intention intervention theoretical models and research results. The design incorporated successful strategies relating to three well-established theoretical frameworks that served as measurement goals for the intervention: The Health Belief Model, the Diffusion of Innovation Model and the Technology Acceptance Model. For five decades, the Health Belief Model (HBM) has been one of the most widely used frameworks in the science of health behavior. It has been used to explain adoption and maintenance of behavior change (Rosenstock 1960). The HBM is a theoretical model developed for understanding why individuals do or do not engage in health related behaviors (Lux 1994). The HBM construct was used to increase the knowledge about health risks and benefits of using or not using drywall dust control technologies. The Diffusion of Innovation Model relies on communication of information about the characteristics of innovations to potential adopters and is designed to address factors in adoption readiness (Koebel 2008). The Diffusion of Innovation Model was used because of the understanding it provides in relation to the factors that influence the adoption of new technologies in the construction industry. There is little evidence regarding prospective strategies to promote diffusion of safety and health innovations in the construction industry. Diffusion strategies are needed to promote the successful adoption of dust control innovations. The Technology Acceptance Model (TAM) was developed to explain the factors that impact a decision to adopt a technology (Szajna 1996). The TAM uses the constructs of perceived ease of use, perceived usefulness, along with trust in technology and trust in organization to understand adoption of technology decisions. This interdisciplinary approach provides a stronger foundation for conducting behavioral intentions to adopt intervention research (Goldenhar 1996).

1.4.2 Implement Interventions

A review of literature relating to the best methods for implementing safety and health interventions was conducted and incorporated in the implementation strategy for the interventions. The interventions targeted three populations in the drywall finishing trade. Workers, small companies, and large companies were targeted due to findings that adoption barriers differ among these three groups within the construction industry (Koebel 1999). Workers were chosen to be a target population because they perform the work and need to be aware of any health risk they may be exposed to while working around drywall dust. Previous research by Koebel (1999) has documented the complexity of diffusion of innovation in construction (Koebel 1999, 2008). Different factors can influence decisions to adopt and can vary across firm size. Small and large firms were targeted to address the differences between the sizes of companies. Small builders were found to be more adoptive of innovations when they had the presence of a "technology champion" while in large firms the technology adoption decisions were likely to be made by purchasing agents (Koebel 2008).

1.4.3 Evaluate Interventions

The strategy for evaluating the interventions incorporated the findings of a literature review of the three theoretical models. Key constructs of each model were identified and implemented to evaluate the intervention aim of improving adoption readiness of dust control tools and methods. The key theoretical constructs within the three models that were expected to improve post intervention are: health knowledge, perceived risk, worker self-efficacy, organizational trust, trust in the technology, adoption readiness, perceived ease of use and perceived usefulness. Previous researchers have evaluated the applicability of the constructs of these models to the problem of technology adoption and diffusion in the construction industry (Young-Corbett et al. 2009). The evaluation of intervention strategies to increase diffusion of safety innovation provides opportunity to recommend strategies for designing other safety and health interventions combining the three theoretical models in the construction industry.

An intervention model detailing the relation of the theoretical constructs that were measured for each of the participant groups is shown in Figure 3.

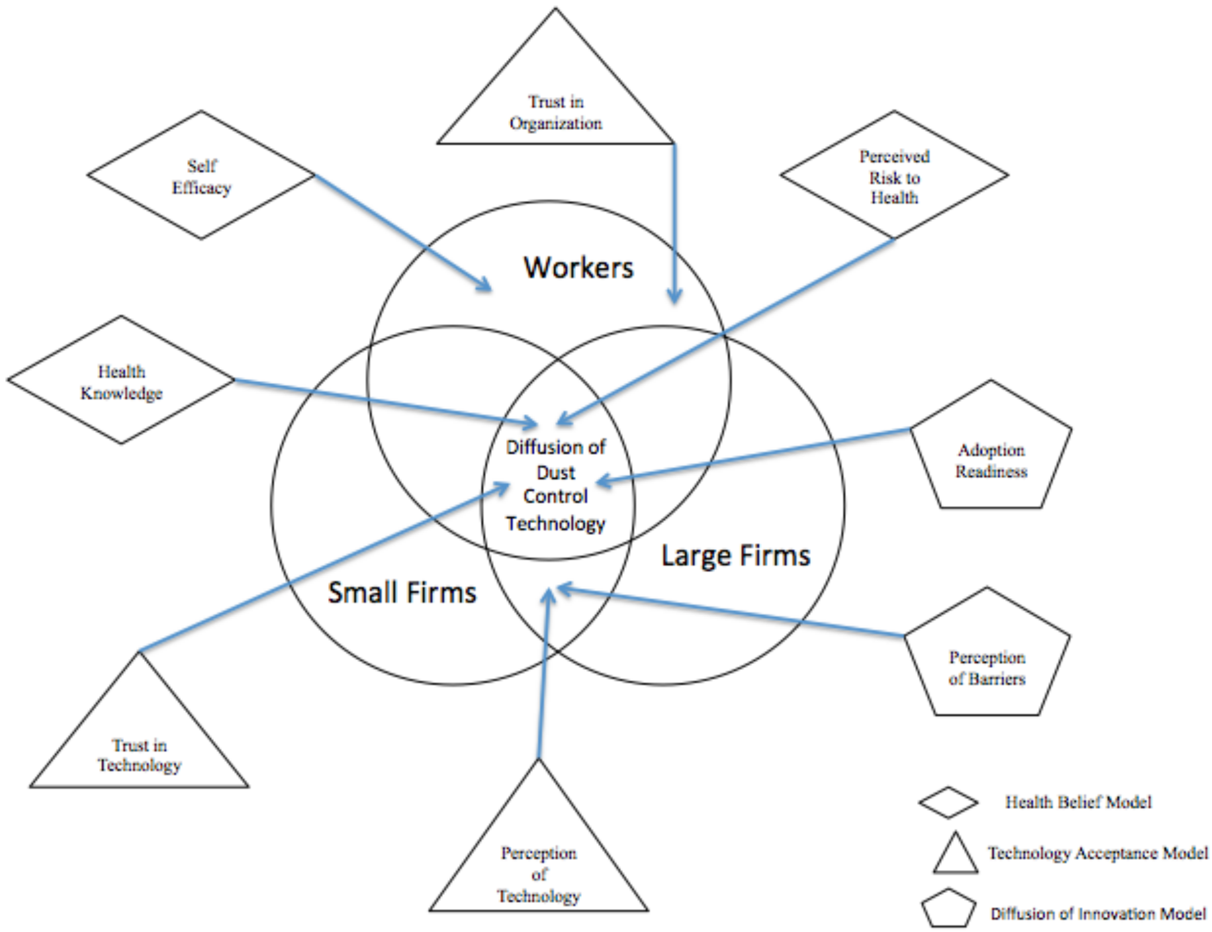


Figure 3 Project DUSTI Interventions Model

A quasi-experimental design (pretest-posttest, with control group) was conducted and the researcher internally evaluated the effectiveness of the intervention's impact on the key theoretical constructs and barriers to adoption among the participating workers, small firm owners, and large firm purchasing agents. A quasi-experimental design with control group was chosen in lieu of a true experimental design due to logistical requirements limiting the feasibility of the research due to the changing nature of construction jobsites and the limited resources of the project.

1.5 Hypotheses

The primary hypothesis in this study is that following the interventions; the treatment group participants' primary theoretical construct scores will show improvement when compared to the control group participants. The hypotheses of the specific constructs of the theoretical models that will be measured are:

For the Worker Intervention

1. Post-test scores of **health knowledge** will be greater than pre-test scores in the worker intervention group and significantly greater than in the control group.
2. Post-test scores of **self-efficacy** will be greater than pre-test scores in the worker intervention group and significantly greater than in the control group.
3. Post-test scores of **perceived risk to health** will be greater than pre-test scores in the worker intervention group and significantly greater than in the control group.
4. Post-test scores of **organizational trust** will be greater than pre-test scores in the worker intervention group and significantly greater than in the control group.
5. Post-test scores of **trust in technology** will be greater than pre-test scores in the worker intervention group and significantly greater than in the control group.
6. Post-test scores of **adoption readiness** will be greater than pre-test scores in the worker intervention group and significantly greater than in the control group.

For the Small Firm Intervention

1. Post-test scores of **health knowledge** will be greater than pre-test scores in the small-firm intervention group and significantly greater than in the control group.

2. Post-test scores of **perception risk to health** will be greater than pre-test scores in the small-firm intervention group and significantly greater than in the control group.

3. Post-test scores of **trust in technology** will be greater than pre-test scores in the small-firm intervention group and significantly greater than in the control group.

4. Post-test scores of **perceived usefulness (PU)** will be greater than pre-test scores in the small-firm intervention group and significantly greater than in the control group.

5. Post-test scores of **perceived ease of use (PEOU)** will be greater than pre-test scores in the small-firm intervention group and significantly greater than in the control group.

6. Post-test scores of **adoption readiness** will be greater than pre-test scores in the small-firm intervention group and significantly greater than in the control group.

For the Large Firm Intervention

1. Post-test scores of **health knowledge** will be greater than pre-test scores in the large-firm intervention group and significantly greater than in the control group.

2. Post-test scores of **perceived risk to health** will be greater than pre-test scores in the large-firm intervention group and significantly greater than in the control group.

3. Post-test scores of **trust in technology** will be greater than pre-test scores in the large-firm intervention group and significantly greater than in the control group.

4. Post-test scores of **perceived usefulness (PU)** will be greater than pre-test scores in the large-firm intervention group and significantly greater than in the control group.

5. Post-test scores of **perceived ease of use (PEOU)** will be greater than pre-test scores in the large-firm intervention group and significantly greater than in the control group.

6. Post-test scores of **adoption readiness** will be greater than pre-test scores in the large-firm intervention group and significantly greater than in the control group.

1.6 Summary

This chapter covered the background of the problem concerning drywall dust exposure, the rationale for the need for interventions to improve the usage of dust control technologies and the goals of the research: the design, implementation and evaluation of three intervention strategies. The proposed hypotheses for this research were also defined in this chapter. In summary, with worker safety and health being a continual concern in the construction industry, there is a need for interventions that will educate workers and business owners about the risks they encounter and the methods that have been created to control those risks. Drywall dust is of particular concern and has been found to contribute to respiratory disease. Although PtD solutions exist to lower worker exposure to dust, these controls are not widely used. This research designed, implemented and evaluated three interventions that will potentially increase the usage of PtD solutions in the drywall industry using an integrated theoretical model that was created during the research that could ultimately advance the adoption of PtD solutions within the entire construction industry.

CHAPTER 2

2 LITERATURE REVIEW

A review of the literature related to the problems drywall dust poses to workers, theoretical model backgrounds and applications for behavioral interventions, and behavioral intervention guidelines are outlined in this chapter. The study of the potential health risks to which drywall finishers are exposed is essential in understanding the need for greater use of engineered dust control methods in the drywall finishing industry. Construction is an inherently dangerous industry and worker safety and health needs to be continually addressed. Dusty occupations have shown to have adverse health effects on the workers who are involved in these industries. The health risks from working in the drywall finishing industry and theoretical models of why workers work safely and trust and adopt new technologies needs to be understood to create effective interventions that will increase worker safety and health. The theoretical models, and the constructs used in these models, which have been found by other researchers to be useful in developing interventions to deal with worker safety and health are: Diffusion of Innovation, the Health Belief Model and the Technology Acceptance Model. An overview of the literature reviewed on models and how they can influence the design of effective interventions is examined.

2.1 Particulate Occupational Health Risks

Construction workers are exposed to a variety of toxic substances including asbestos, man made mineral fibers, silica, concrete, diesel fumes, and wood dust. Research has linked construction work with cancer and other occupational diseases (Verma et al. 2003). Respirable silica dust levels have been reported to exceed occupational exposure guidelines (Rappaport et al. 2003). Airborne dust is the most prevalent chemical exposure hazard in construction. Dust not only affects the worker directly involved with the exposure-causing activity, but also other workers within the work vicinity. Many workers have expressed concerns about the presence of dust in the workplace. There is a high concern for worker health, and health and safety professionals are especially concerned about dust arising from sources such as cutting, grinding, and sweeping (Verma et al. 2003).

Workers in the construction industry are at risk of respiratory diseases such as adult-onset asthma and chronic obstructive pulmonary disease (Kaukiainen et al. 2005). Chronic airflow obstruction from work-related activities may result from the dust exposure and symptoms may include the narrowing of the large or small airways (Bohadana et al. 1996). Construction work involving mineral dusts was found to have an association with an elevated risk of asthma according to a study in Finland (Sauni et al. 2003). Occupational asthma is another concern for workers in dusty industries. Occupational asthma is defined as variable airflow limitations due to conditions in the workplace where limitations are not experienced away from the workplace (Arif et al. 2003). Workplace exposures are also known to aggravate asthma in workers where the disease was pre-existing (Chan-Yeung 1995). In a study examining the mortality rates of construction workers, Bergdahl (2004) found that there was an increased mortality rate from chronic obstructive pulmonary disease (COPD) among construction workers exposed to inorganic dusts as opposed to unexposed construction workers. The report also found that the reduction of workplace exposures to dust, gases, and fumes would prevent one out of ten deaths due to COPD.

Respiratory disease affects the quality of life of construction workers. In a study of Finnish construction workers, asthmatic construction workers evaluated their work ability and general health as significantly worse than the control group. The asthmatics in this study responded that they had more limitations in their work and everyday life (Sauni et al. 2001). The main asthma-inducting working conditions identified in Sauni's study were the presence of dust, cold air, and physical exertion with drywall dust implicated as a concern.

2.2 Drywall Dust Health Effects

Workers in the construction industry are exposed to high levels of dust that have been linked to occupational illnesses and respiratory disease (Bohadana et al. 1996). A major health concern is the risk of respiratory disease among construction workers in general and particularly among those who work in the drywall finishing and plastering trades. Workers in these trades suffer from disproportionately high rates of respiratory disease and disability (Wang 1999). Illnesses such as occupational asthma have also been linked to conditions that are encountered in dust-related industries (Arif et al. 2003). Exposure to dust in the construction industry has become a major concern. The Occupational Safety and Health Administration is particularly concerned about the silica dust exposure of construction workers. Exposure to silica has been shown to cause silicosis, a serious and sometimes fatal lung disease, and unprotected workers who are exposed to silica dust are in danger of developing the disease (OSHA 2009).

Drywall sanding operations have been associated with worker over-exposure to dust containing particulate health hazards. Some of the particulates that are in some drywall dust compounds include silica, talc, mica, and calcite (Miller et al. 1997). In a study of mortality patterns for male construction workers in North Carolina (Wang 1999) a study found that there was a significant cancer risk for painters, plasterers, paperhangers, and drywall workers. This group had significantly elevated proportionate mortality ratios (PMRs) for malignant neoplasm of the Pharynx (PMR=178), trachea and bronchus (PMR =118) and of pneumoconiosis/other respiratory disease. Specifically, drywall finishers had a statistically elevated risk of death from cancer of the pharynx (PMR 133), lung (PMR =110), and respiratory tuberculosis (PMR 675). Even when dust does not contain silica, workers still may be at risk for other respiratory problems when performing dusty jobs. Excessive exposure to dust can contribute to tissue damage in ears, eyes, and the respiratory tract (OSHA 2009).

When performing drywall-sanding operations, substantial amounts of airborne dust are generated. Drywall sanding operations have been studied and have been found to be associated with worker over-exposure to dust that contains known particulate health hazards that can affect the respiratory functions of the body. NIOSH performed an evaluation of worker exposures to drywall dust and possible health effects during finishing operations during renovation activities (Miller et al. 1997). The NIOSH study focuses on the components that make up drywall joint compounds, dust-exposure levels workers are exposed to, and symptoms exhibited by workers as a result of dust-exposure. The study found that drywall finishers during sanding operations are exposed to as much as 10 times the permissible exposure limit (PEL) of 15mg/m^3 for total dust. The PEL for respirable dust was also exceeded. The study also found that respiratory symptoms were found to be common among drywall finishers and showed a tendency to improve when the workers were away from the workplace. Drywall joint-compounds were examined to determine the constituents and were found to have calcite, quartz (silica, talc, mica, gypsum, clays (aatpulgite and kaolinite), and perlite, with the most prevalent being calcite and mica. Mica has been associated with pneumoconiosis (Verma et al. 2003). To avoid potentially hazardous concentrations of harmful dusts, workers should implement effective dust control measures during drywall sanding and finishing work (OSHA 2009).

Drywall sanding operations have been associated with over-exposure of employees to dust concentrations containing known health hazards. Results of personal breathing zone (PBZ) monitoring performed by NIOSH revealed that concentrations of total and respirable dusts exceeded the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) of 15 milligrams per cubic meter of air for total dust and 5 milligrams per cubic meter of air for respirable dust (Miller et al. 1997). Construction workers involved in the sanding and finishing of drywall joint compound are often exposed to high concentrations of dusts and in some cases respirable silica. Drywall dust exposure has been associated with varying degrees of eye, nose, throat and respiratory tract irritation. Over time, breathing the dust from drywall joint compounds can cause persistent throat and airway irritation, coughing, phlegm production, and breathing difficulties similar to asthma (Mead et al. 2000). The respiratory problems that are common among drywall finishers tend to improve when the workers are away from the workplace (Young-Corbett and Nussbaum 2009b).

When silica is present in drywall dust compounds, workers may also face an increased risk of silicosis and lung cancer (Mead et al. 2000). Depending on the brand of joint compound, airborne silica exposure may be a concern (Mead et al. 1995). Some of the highest silica exposures to dust concentrations are found in construction (Stern et al. 2001). Workers in the drywall finishing trade suffer from disproportionately high rates of respiratory disease and breathing problems (Young-Corbett and Nussbaum 2009b). In a study of mortality patterns for male construction workers in North Carolina, Wang et al. found significant cancer risks for painters, plasterers and wall hangers (Wang 1999). Drywall dust contains particulates such as silica, talc, and mica (Miller et al. 1997). Studies have shown that the silica exposure rates are grossly unacceptable in the United States construction industry (Rappaport et al. 2003). Workers in the construction industries should be educated about future risks for respiratory disease and cancer (Stern et al. 2001). Silica poses a significant threat and should be combated by substitution of materials, dust suppression methods, ventilation, re-design of equipment, and short term use of respiratory protection (Rappaport et al. 2003).

2.3 Dust Control Methods

A NIOSH study found that the some of the highest exposures to drywall dust concentrations occur when employees are sanding joint compound (OSHA 2009). While PtD solutions and administrative controls are needed to reduce airborne dust levels, the focus should in part be on the individual sites, activities and equipment involved in drywall finishing (Rappaport et al. 2003). Methods currently available to control drywall dust include ventilated (vacuum) sanders, wet sanding, pole sanding, respiratory protection and a low-dust joint compound (Young-Corbett and Nussbaum 2009b). MSDS sheets for drywall joint compound reviewed in a NIOSH study in 2000 were shown to recommend wet sanding methods and ventilation to control dust concentrations (Mead et al. 2000). The Association of Wall and Ceiling Industries (AWCI) also recommends that finishers employ wet methods to reduce drywall dust exposure (Young-Corbett and Nussbaum 2009a). The NIOSH research agenda NORA has a goal to implement controls that have been engineered into the design of tools or products to control worker exposures as opposed to reliance on personal protective equipment (Young-Corbett and Nussbaum 2009b).

2.3.1 Respirators

A study by Young-Corbett found that the most commonly used method of dust control is respiratory protection in the form of personal respirators (Young-Corbett 2007). Respirators are not the OSHA preferred method of dust control because of the training and medical clearance required prior to the use of this personal protective device (Young-Corbett and Nussbaum 2009b). When respiratory protection is used to prevent inhalation of dust it is often used incorrectly with little thought to training, proper selection, or fit (Mead et al. 2000).

2.3.2 PtD Solutions

PtD solutions are controls that have been designed into tools, materials and/or processes that are intended to remove or reduce the dependence on personal protective equipment. The PtD movement saw its genesis in the early 1990's, with the formation of a committee within the National Safety Council (NSC) to study the feasibility of incorporating safety reduction into design procedures. The outcome of this early work was the formation, in 1995, of The Institute for Safety through Design, with membership from industry, academe, organized labor, and other interested parties (Manuele 2008). Seminars, workshops, and symposia were held throughout the late 1990's and early 2000's. In 2006, the Australian government issued a guideline on the Principles for Safe Design for Work, and in 2007 a special edition of Safety Science was published on "Safety by Design". Also in 2007, the OSHA Construction Alliance Roundtable Design for Construction Safety Group developed a short course entitled, "Design for Construction Safety" and the Institute of Mechanical Engineers held a workshop entitled, "Risk Education for Engineers" (Manuele 2008). One of the goals of the latter was to advance the understanding of the importance of educating undergraduate engineers in risk assessment.

In 2008, the National Institute for Occupational Safety and Health (NIOSH) launched a national PtD initiative; calling on all major industrial sectors to emphasize hazard mitigation at the design stage of tools, facilities, and work processes (Schulte 2008). NIOSH partnered with the American Industrial Hygiene Association (AIHA), the American Society of Safety Engineers (ASSE), the Center to Protect Workers' Rights, Kaiser Permanente, Liberty Mutual, the National Safety Council (NSC), the Occupational Safety and Health Administration (OSHA), ORC Worldwide, and the Regenstrief Center for Healthcare Engineering, in the development of a National Initiative on Prevention hrough Design, launched in a 2007 workshop and published in a special edition of the Journal of Safety Research in 2008 (Howard 2008).

One conclusion of the 2007 workshop was that there are two major gaps to be addressed, in order to advance the implementation of PtD in industry. The first is that design professionals such as engineers, industrial designers, and architects, need to consider health and safety implications of end-use of their designs. The second is that business decision makers, including those who purchase products and services, will need to establish a demand for such PtD designs. The PtD Initiative aims to focus "both on the supply of innovative design solutions and on creating a demand among business decisions makers who will value and request them" (Schulte 2008).

Based on research experiments done by NIOSH in 1995, it was found that PtD solutions are commercially available which can reduce worker exposures to drywall dust, and that these controls are not widely used and workers continue to be at risk of over-exposure to harmful dust. These PtD solutions are currently being used occasionally to protect the project environment from dust as opposed to protecting the worker from overexposure to inhalable dust (Mead et al. 1995).

Despite the advances in dust-control engineered solutions, worker exposure is still a problem in the drywall finishing trade. Dust controls that have been proven effective include the use of vacuum sanders, wet sponge sanding methods, pole sanding, and using low dust joint compound (Young-Corbett and Nussbaum 2009a). Vacuum sanders collect dust at the point of generation with a collection hood near the sanding surface. Dust is collected at the point of generation and directed into a collection canister. Wet sanding is a method where the joint compound is allowed to dry and then re-wetted with a sponge prior to sanding. The wetting of the compound reduces the amount of airborne dust generated. In pole sanding, the sanding object is attached to a pole and the worker holds the other end of the pole to perform the work. This reduces the amount of dust a worker is exposed to due to removing the worker from the point of dust generation. Sanding poles originally were designed to enable workers to reach greater heights without having to leave the ground. NIOSH studies have found that pole sanding is beneficial to worker health in that it can reduce the dust exposure of employees (Miller et al. 1997). Low dust joint compound is a relatively new control that was introduced by the 3M Company in 2006. This joint compound has been chemically formulated with dust-reducing additives such as oil, surfactants, wax, or petroleum derivatives that reduce the amount of dust generated (Young-Corbett and Nussbaum 2009b).

PtD solutions for reducing exposure to workers have been found effective at reducing the levels of airborne dust. A NIOSH Hazard Control Study found that vacuum sanding systems reduce drywall dust levels by 80-97% (Mead et al. 2000). This study included the evaluation of five commercial vacuum sanders and found that four of the five reduced dust concentration levels by more than 90%. A recent study of the effectiveness of drywall dust control technologies conducted by Young-Corbett (2009) found that vacuum sanders, pole sanding and wet sanding methods produced significantly less dust concentrations in both respirable levels and thoracic levels of dust than conventional block sanding methods. The results of Young-Corbett's study showing dust concentration percentage reduction of each of these methods are summarized in Table 1 (Young-Corbett and Nussbaum 2009a). These studies show that the engineered methods of dust control significantly reduce the amount of airborne dust that is generated in drywall finishing operations and these methods should be used to protect worker health.

Table 1 Dust-Control Method Dust Concentration Reduction Results

Control Method	Respirable Dust Level Reduction	Thoracic Dust Level Reduction
Vacuum Sanding	88%	85%
Pole Sanding	58%	50%
Wet Sanding	60%	47%

2.3.3 Barriers to Adopting Dust Control Technology

The use of PtD control methods in the drywall industry faces barriers to adoption that are perceived with many products in construction. In a previous study by Young-Corbett and Nussbaum (2009), it was found that perceived diminished quality of drywall finishes and productivity reduction are the primary barriers to wet sanding methods. The studies by Young-Corbett and Nussbaum (2009) and Young-Corbett and Kleiner (2008) were the only major studies found addressing the topic barriers to adoption of engineered drywall dust control methods. Barriers found for the use of vacuum sanders dealt with usability and environmental factors. Environmental factors include the aspects of construction jobsites that make maneuverability difficult as well as the size of workspace along with reliable access electrical power. Other barriers found for the use of vacuum sanders are cost of tools, mobility limitations, difficulty to learn, clogging of vacuums, and it could take longer to do the job. The relatively new introduction of low dust drywall compound, cost, and availability of the product have been listed as barriers to the adoption of this control method (Young-Corbett and Nussbaum 2009b). Usage of dust control measures have been implemented by companies in situations relating to customer satisfaction in an effort to control dust in particular construction settings such as schools, hospitals, or buildings with sensitive electronic equipment. It was found that customer satisfaction in these areas was the primary reason for adoption and the protection of workers from over-exposure to dust was not the driving force for adoption of dust control technology (Young-Corbett and Nussbaum 2009b).

As a result of Dr. Young-Corbett's and Kleiner's work, a Systems Analysis Tool (SAT) was created to determine the decision making factors that companies and workers use when determining when to use dust control technologies and what barriers prevented the use of such controls. A Problem Factor Tree (PFT) was constructed to assess problems in the use of dust-control technology usage in sanding operations. A PFT is a tool often used in work system assessments that can be used to diagrammatically assess problems and causal factors. This tool incorporated information from the major subsystems of organization, technology and personnel in the drywall finishing industry as well as external environmental factors and user interfaces (Young-Corbett and Kleiner 2008).

The problem identified in the Young-Corbett and Kleiner study was that drywall dust control technologies were not being used frequently. The main areas addressed in the PFT in Young-Corbett and Kleiner's (2008) study shows main problem elements, constraints, and barriers to adoption of dust control technologies which contribute to the sub-problem elements including: tendency to choose non-dust control tools and methods, reliance on personal protective equipment as a means of control, failure to use personal protective equipment when provided, failure of workers and managers to assess the health risks associated with drywall dust and failure of these groups to realize the benefits that would be gained from using dust control technologies (Young-Corbett and Kleiner 2008). The PTF from the Young-Corbett and Kleiner study is shown in Figure 4.

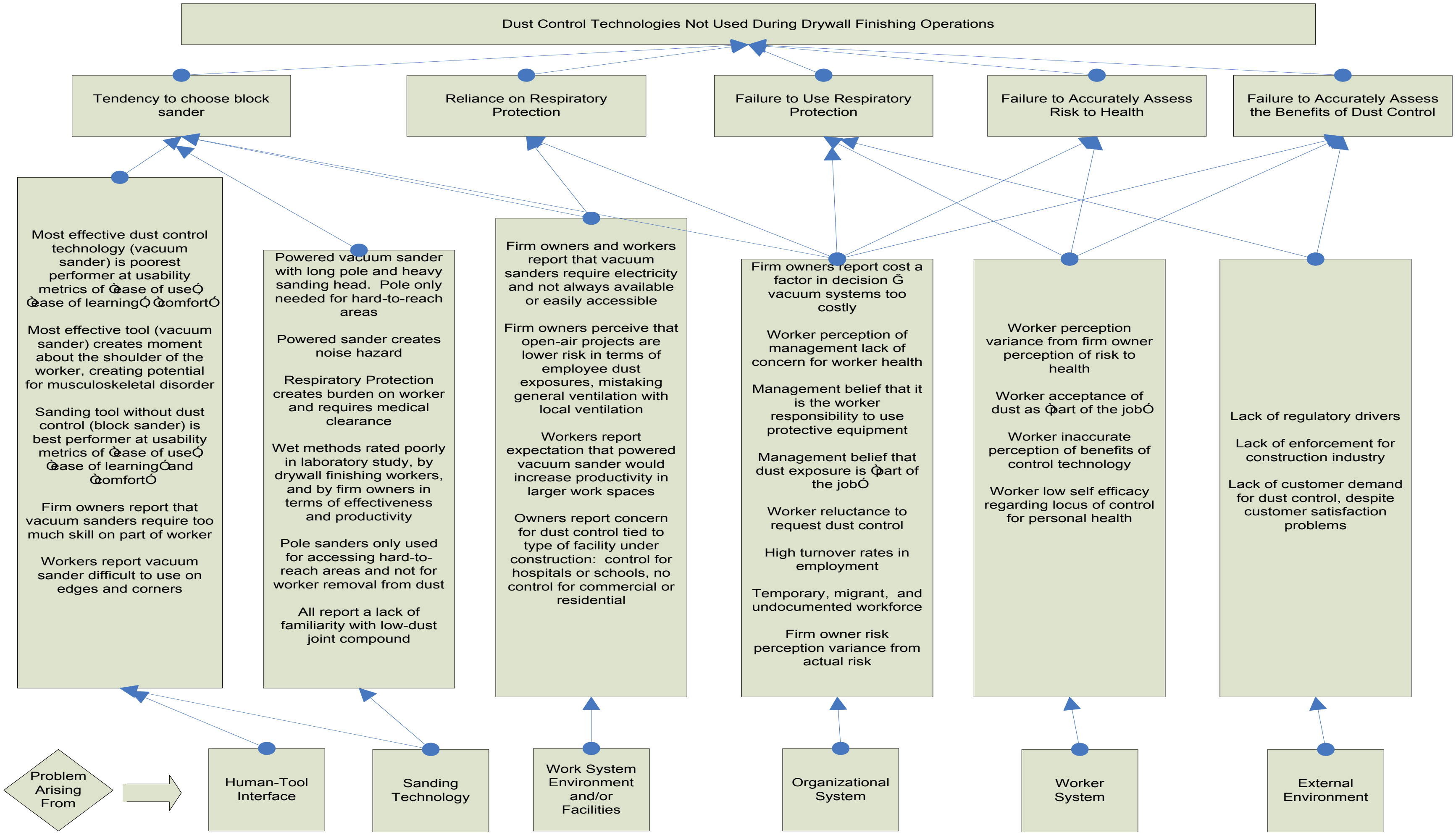


Figure 4 Problem Factor Tree (Used with Permission from Dr. Young-Corbett)

2.4 Reduction of Worker Dust Exposure

The reduction of worker exposure to harmful dust is a concern of the National Institute of Occupational Safety and Health (NIOSH). Dust controls are needed to reduce specific safety and health needs in the construction industry as outline by the NIOSH National Occupational Research Agenda (NORA), National Construction Agenda (2008). A goal that drywall dust control usage will specifically support is the intermediate goal 5.3: to "Increase the availability of engineering and work practice options for preventing and reducing silica exposures." (NORA 2008). Drywall dust controls meet this goal by reducing the exposure of employees to dust concentrations that could potentially contain silica. Objectives need to be set that develop evaluation criteria. Young-Corbett created an Objectives/Activities tree (OAT) shown in Figure 5 to accomplish the major needs that would work toward compliance with the NIOSH goals.

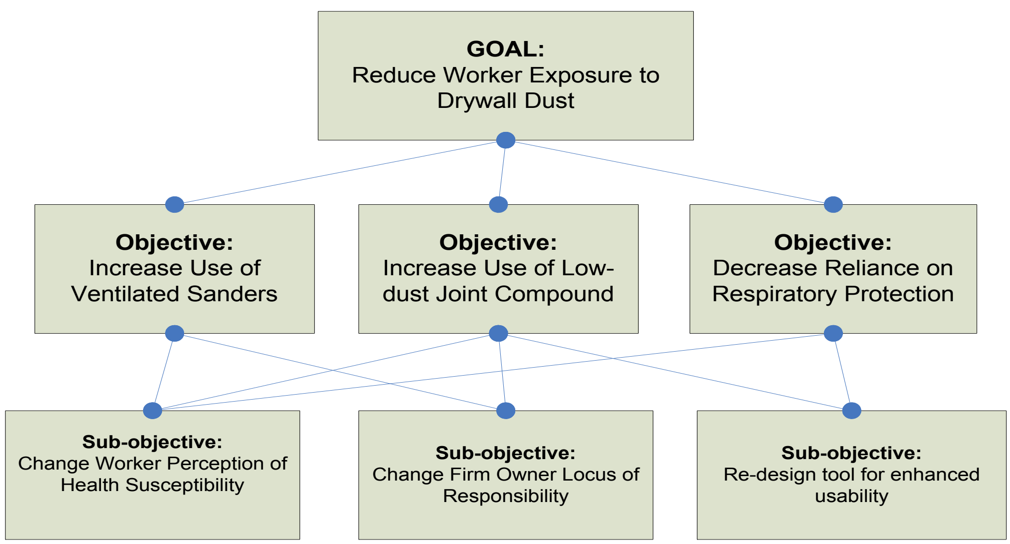


Figure 5 Objectives/Activities Tree (Used with Permission from Dr. Young-Corbett)

The major goal is to reduce worker exposure to dust in drywall sanding operations. The objectives would be to increase the usage of ventilated (vacuum) sanders, increase usage of low-dust drywall joint compound and to decrease the reliance that workers and drywall companies place on personal protective equipment such as respirators to protect workers from dust inhalation. Sub-objectives that would need to be addressed to increase usage of dust control methods include: tool design changes, education to change perceptions of health risks from drywall dust and a change in firm owner perception of responsibility to protect workers' health. Authors point out the need for research to develop and design an intervention that would target the key barriers to adoption with a goal to improve dust control technology usage throughout the construction industry (Young-Corbett and Kleiner 2008).

2.5 Diffusion of Innovation

Diffusion of innovation is the process through which an innovation, whether an idea or product, is communicated over a period of time in a social system and involves some degree of uncertainty (Rogers 2003). Innovation is defined as a significant improvement in a product, process or system that is actually used and which is new to those who will be developing or using it (Manseau and Shields 2005). One of the necessary components of an innovation is the ability of the innovation to improve some aspect of the adopter's performance of a work task (Toole 1998). Two important factors that are involved in the diffusion of innovation are the discovery of the innovation and the diffusion of it (Ball 1999). Diffusion involves communication about the innovation to the target adopters (Koebel 1999). Four main elements compose the general diffusion model as outlined in Rodgers 5th Edition of Diffusion of Innovations (2003) include: the innovation, communication channels, time, and a social system.

An **innovation** could be any idea, product, process or object that is perceived as new to an individual or group (Rogers 2003). Innovation can take many forms and can be incremental, in which small changes occur based on current experience, radical, where a breakthrough in science or technology provides a new change, or modular, where there is a change in concept within a component of a larger system (Blayse 2004). For a product, process or idea to be considered an innovation, it does not need to be something new pertaining to the time when it was created, but rather the newness of the innovation can be measured if it is new to the individual or adopting unit. The newness of an innovation is often gauged on a person's knowledge, or decision to adopt (Rogers 2003). The characteristics of innovation that are the most responsible for influencing adoption are:

a. <u>Relative advantage</u>- Relative advantage is perception that the innovation is better than the idea, product or process that already is in use by the potential adopter. If a potential adopter can readily see the benefits of using an innovation there is greater likelihood for adoption. The greater degree the adopter perceives the advantage, the more likely they are to adopt.

b. <u>Compatability</u>- Compatability is the degree to which an innovation is perceived as being consistent with the needs of the potential adopters. Adopters are looking for products they can incorporate into their systems without much effort and without having to change values.

c. <u>Complexity</u>- Complexity is the degree to which the potential adopter views the innovation in terms of how difficult the innovation is to understand or the ease of use of the innovation. If an innovation is easy to understand and use then the likelihood of adoption increases.

d. Triability- Triability of an innovation is the opportunity given to use an innovation on a trial basis before wholly committing to adoption.

e. Observability- Observability is the visible results of the innovation in practice. If observers can readily see the results of an innovation, the likelihood of adoption increases. (Rogers 2003)

Any of these five characteristics could aid in innovation adoption and if aspects of these elements are not met, the missing pieces could represent barriers to adoption of innovation.

Communication channels are the second main element of diffusion. Diffusion of innovations is facilitated by tapping into many sources of communication and information (Toole 1998). Diffusion is the information exchange through which an innovation is communicated to others. The process of communication through diffusion includes the innovation, an individual or group that has experience using the innovation or a knowledge of the innovation, an individual or group who does not yet know about the innovation or has not experienced it, and a way for these two parties to communicate with each other (Rogers 2003). Many methods of communication are available for use in the diffusion process including the use of mass media, inter-organizational networks, educational institutes, research institutions, and professional associations (Sexton 2004). Different kinds of communication channels have differing effects on the diffusion process and rate of adoption. Mass media provides an efficient channel for communication while interpersonal interactions remain the most important channel for providing information about innovations and influencing the adoption process (Lin 1975; Rogers 2003).

Time is a third element of diffusion of innovations. Time is a variable that is used to measure the rate of diffusion of an innovation and is one of the strengths of the diffusion of innovation model. Time is involved in diffusion in three major functions. The first is in measuring the time that passes from the time knowledge of an innovation is introduced to an individual or group and the time they adopt or reject the innovation. The second function time is the time in which an innovation is adopted by an individual or group in relation to the introduction of the innovation into society. For example a person can adopt in the early introduction stages of an innovation or can wait and become a late adopter after seeing others adopt the innovation and use it successfully. A common element of the Diffusion of Innovation model is the graph of Everett Rogers for Technology Adoption Lifecycle that shows the distribution of adoption in relation to time shown in Figure 6. The third function of time in the innovation process is the rate of adoption showing the number of members in a system that adopt the innovation in a given time period (Rogers 2003).

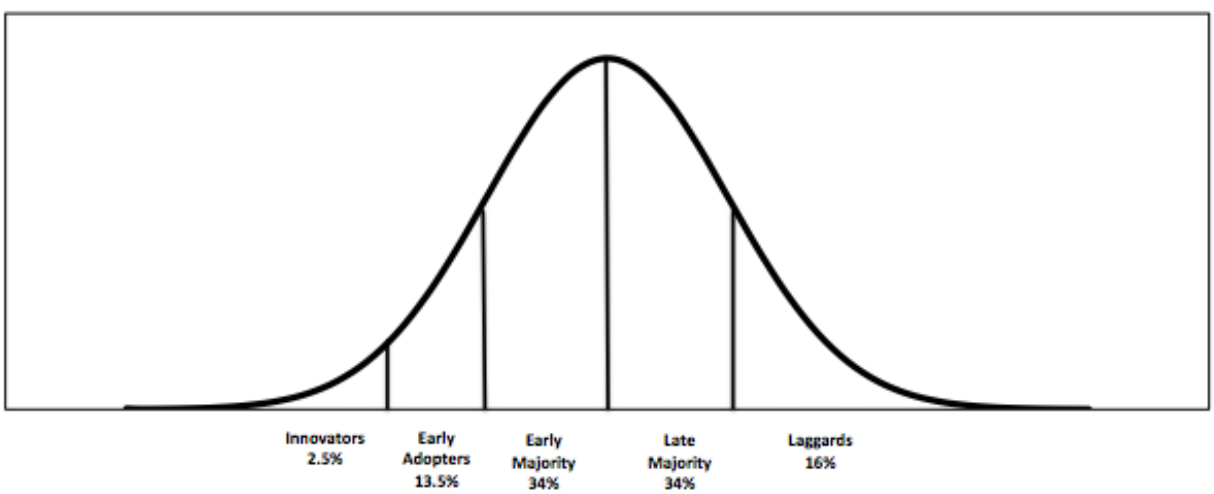


Figure 6 Bell Shaped Graph Depicting Levels of Adopters (Adapted from Rodgers 2003)

Social systems are the fourth element of diffusion of innovations. Social systems could be individuals, groups or members of organizations. The social system affects the diffusion of an innovation depending on the social system structure, processes, roles of members, types of innovation decisions and the consequences of adoption (Rogers 2003). The social system has normal patterns of behavior that may serve as a barrier to adoption for innovation. The normal patterns or processes in the social structure let an individual now what is expected. The roles of individual members of a social system also have an influence on diffusion of innovation. Innovative individuals known as opinion leaders or change agents are able to influence other individuals attitudes and behaviors (Rogers 2003). These opinion leaders also often referred to in innovation discussions as champions can come from formal leaders or informal leaders in a social system (Howell and Higgins 1990; Markham 2001). Social systems can also influence the adoption of innovation by deciding to adopt innovations by collective or authoritative decisions. Decisions to adopt innovations in a social system may be optional decisions that are left up to an individual, or collective decisions, which the decision to adopt or reject innovations is based on the consensus of the group. Social systems might also affect the adoption of innovations through the use of authority innovation decisions in which the decision for adoption lies with a few individuals who possess power. The fastest rate of adoption comes from authoritative decisions (Rogers 2003).

2.5.1 Diffusion in Construction

Innovation in construction offers potential for significant company, social and industry benefits (Slaughter 1998). The construction industry has been viewed as an industry that is resistant to technology and slow to adopt new innovations (Koebel 1999). Innovation occurs in construction more than what is recognized by those outside the construction industry. A lot of the innovations done in construction are done by people working on site as opposed to large manufacturers (Slaughter 1993). The importance of innovation in the construction industry is recognized as a means to improve the quality of life, productivity and safety (Arditi et al. 1997). The amount of information presented to the potential adopter can greatly influence the decision to adopt. Innovations can be categorized into high uncertainty and low uncertainty innovations. High uncertainty innovations are those in which potential adopters are missing substantial information relating to, for example, long-term performance, total installed cost, safety, and acceptance by customers. Low uncertainty innovations are those for which potential adopters are missing relatively little information pertaining to these criteria (Toole 1998).

2.5.2 Barriers to Adoption in the Construction Industry

Much of the research on innovation in the construction industry has focused on the barriers in the industry (Slaughter 1993). Adoption of innovations in construction has been defined as when a firm uses a technological innovation in at least 25% of the cases in which it has an opportunity to use it (Slaughter 1993). Frequent downturns in the construction market may deter firms from adopting innovations (Blackley and Shepard 1996). Regulatory bodies in construction can also have an impact on the successfulness of innovations. The development of new products or processes in construction is not always welcomed by all parties (Oster 1977). Building codes and construction regulations often serve as constraints or drivers of innovations (Manseau and Shields 2005). Stringent standards for product performance, safety and environmental impacts can create pressure for firms to innovate, improve quality, and upgrade technologies (Gann et al. 1998). Unions may resist innovations that are viewed as labor saving or eliminating products or processes (Blackley and Shepard 1996).

Cost, risks, uncertainty and control over limited aspects of the way that construction work is performed and the products that are chosen makes diffusion of innovation in the construction industry difficult (Manseau and Shields 2005). Barriers that affect the implementation of innovations also include forms of contracts, the cost of research, lack of information about the innovation or being unaware that one exists and not realizing the potential cost savings of adoption (Ling 2003). Many of those in the construction industry are looking for proof that products and processes will provide an advantage over existing methods and products. A study by Toole found that builders want to see someone else use the product and be successful before they are willing to try it for themselves (Toole 1998). Builders are frequently unwilling to adopt innovations because of the risks that fall on the builder without capturing the benefits (Manseau and Shields 2005).

One significant barrier to adoption for safety and health practices and methods in the construction industry is that there is a lack of belief among the users that a hazard actually exist or they lack the confidence that they are able to control the hazard (Kramer et al. 2009). The lack of understanding that hazards exist or that controls are available can influence the decisions of managers. Managers tend to devote more attention to items that are failing than items that are meeting their targets (Mitropoulos and Tatum 1999). If a manger doesn't perceive there is a problem then they are unlikely to adopt innovations.

2.5.3 Using Diffusion Theory to Understand the Adoption-Use of New Technologies in Construction

The use of the diffusion model can help in understanding the adoption use of new technologies in construction. Using the diffusion model as a guide and focusing on the four elements of the diffusion model, researchers can determine the most effective ways to increase diffusion of innovation in the construction industry. A review of the four elements of the model as it pertains to innovation diffusion in construction companies and particularly the introduction of dust-control technology during drywall sanding operations will be used as an example study to help understand the barriers that exist to adoption use of new safety technologies in construction. Drywall sanding dust-control is a modular type of innovation in that it changes the way the sanding work is performed, but does not alter any of the other components that make up the drywall finishing process (Slaughter 1998).

2.5.3.1 Innovation

Technologies exists that effectively control the amount of dust drywall workers are exposed to (Mead et al. 2000). These innovations have not been widely adopted in the drywall industry (Young-Corbett and Nussbaum 2009b). The four elements of the diffusion model can be used to examine the understanding of adoption usage. The first element of diffusion is the innovation (Rogers 2003). Of the diffusion characteristics enumerated above, the five characteristics of an innovation are important determinants in the decision to adopt technologies in *construction* are as follows.

1. <u>Relative Advantage</u>- The use of drywall dust-control technologies must provide the potential adopter with the perception that the use of the technology is better that the current method of drywall sanding. This relative advantage could be described as having a greater advantage in terms of cost, production or safety. An innovation must allow the adopter to execute actions that increase the organization's performance (Toole 1998). Construction firms tend to innovate when there is a clear potential for increased profits (Utterback 1974).

2. <u>Compatability-</u> The use of dust-control technologies needs to be presented to the adopter as consistent with the desired outcomes that current sanding methods produce.

The innovation must be able to produce the same results as conventional methods. Some innovations can disrupt the working system which could result in delays or reduced quality creating additional costs (Toole 1998). Technologies which construction companies tend to adopt are those that can contribute to the business quickly with visible results (Sexton 2004).

3. Complexity- The dust-control innovation needs to be easy for the user to understand and the tools need to be easy to use to increase the likelihood of adoption. New technologies acceptance is helped by the availability of properly trained and skilled people (Arditi et al. 1997).

4. Triability- Letting drywall companies have hands-on experience using the tool prior to purchasing the tool will allow for a risk free trial and improve self-efficacy in the use of the innovation and will increase the likelihood of adoption. Builders responses to innovations are considerably different when presented the opportunity to view and touch the product (Toole 1998). A high degree of user involvement is needed in the construction industry innovation process (Manseau and Shields 2005).

5. Observability- The innovation needs to be presented in a way that the results of using the innovation are observable to others. Drywall dust reduction benefits multiple trades on site and the use of dust-control technologies will be visible to others who will encourage adoption. Innovators have their eye on advantageous innovations and ones that are easy to implement (Manseau and Shields 2005).

2.5.3.2 Communication

Communication channels can be used in the construction industry to increase adoption of innovations. Construction safety innovations including drywall dust-control innovations face obstacles due to the limited knowledge of the innovation and the benefits it may provide (Nooteboom 1994) Potential adopters of innovations in construction are missing a tremendous amount of information (Toole 1998). In the diffusion model, communication is distributed in different ways. Information concerning the benefits of the usage of dust-controlling drywall sanding tools could be achieved through training and re-training courses, as well as training manuals or distributed informational materials (Gherardi 2000). Diffusion of innovation can not be achieved unless others transfer knowledge and diffuse information about innovations to others (Peansupap 2005). Knowledge and competence are key elements that influence the personal safety performance of construction workers (Langford 2000).

2.5.3.3 Time

Time is used in the diffusion model to understand the rate of adoption of innovations. The time an innovation is introduced to the time it is adopted can be the result of how ready to adopt the firms may be (Rogers 2003). Construction innovations tend to face obstacles that delay the diffusion of innovation due to liability, regulatory codes and the lack of information (Manseau and Shields 2005). When presented with innovations, people may expect that something better will come along shortly so they wait and watch the experience of others before adopting which is a retarding factor in the time element of diffusion (Ball 1999). The relative newness of dust-control tools may have an effect on the adoption rate among drywall companies. As time goes on and information increases diffusion is expected to increase.

2.5.3.4 Social System

Diffusion of innovation in construction firms requires addressing the social system of the industry. The norms of a social system are the established patterns of behavior for the members of the system. Norms set the standard and relate to individuals what behavior is expected (Rogers

2003). Introducing changes into a construction social system can create ripple effects that can be difficult to anticipate (Manseau and Shields 2005). The culture of a company can play an important role in the adoption of innovations within a social system and innovations should try to be compatible with the normal behaviors that are in place. Structural barriers such as building codes, and construction safety and health regulations can constrain or drive innovations. Safety and environmental factors can apply pressures for firms to adopt innovations or upgrade technology (Manseau and Shields 2005). The use of safety and health information dissemination and the enforcement of regulations is an effective way to increase dust-control innovation adoption among drywall companies as well as other innovations in the construction industry that increase worker safety and health. The use of regulations creates an administrative innovation decision where the decision is made by those with authority and takes away the optional innovation decision of the individual (Rogers 2003).

Another import aspect of the social system element of diffusion of innovation that can be used to help in the adoption is the use of technology champions to influence other individuals' attitudes towards adoption. Opinion leaders and change agents often referred to as technology champions (Chakrabarti 1974; Rogers 2003; Howell et al. 2005; Thompson 2006). Interventions have often used champions to provide education, champion a product, or to give support for the innovation. Reviews of interventions using champions have been found to be moderately successful (Thompson 2006). The use of champions could be beneficial in the diffusion of dust-control technology usage by using persuasive people to increase the recognition of the innovation and share experiences. Champions provide a transfer of knowledge at an interpersonal level that plays an important part in adoption (Koebel 2008)

2.5.4 Technology Champions

Frequently, the term "technology, or innovation, champion" is used to label an individual who is a leader in the innovation process (Nam and Tatum 1997). There are many terms in diffusion research for an individual who acts as a champion, champions are also called opinion leaders, facilitators, linkage agents or change agents (Rogers 2003; Thompson 2006). Research has found that about 70% of construction firms have technology champions who keep others in the company aware of new products and processes. The role of champions varies between small and large firms (Koebel 2008). Champions are individuals who influence innovation in their organizations or areas of influence (Lin 1975). The role of a technology champion is to drive innovation and be able to absorb the risk of adopting innovations. A technology champion can be delegated only if the person has slack resources and enough power to implement innovations (Ling 2003).

Decisions in organizations are typically made by people of influence and the people with the most power and resources (Mitropoulos and Tatum 1999). Champions need to have past experience and resources as in time or money (Nam and Tatum 1997). Champions act as gatekeepers of knowledge who help transfer knowledge and diffuse innovations to others (Lin 1975). Champions aren't usually assigned and can be formal leaders with titles and positions or informal leaders who others look to for information (Howell and Higgins 1990). Technology champions feel that using interpersonal relationships is a key to influencing innovation and understand that diffusion is a social process (Thompson 2006). Studies of product innovation success have shown that champions are influential in overcoming barriers to adoption within organizations. Champions who promote innovation can influence the organization to learn about new niches and to develop new processes by fostering communication within firms and stimulating managers to make decisions about innovation (Howell et al. 2005).

Based on a review of literature, many identifying factors are exhibited by technology champions. Champions are highly enthusiastic people who are willing to make special efforts and take risks to implement innovations, and are individuals who have slack resources (Nam and Tatum 1997). A champion is someone who is open to new ideas (Kramer et al. 2009). A champion needs to have a technical competence and understanding of how the innovation works, a knowledge of the company so they can identify relevant ideas, a knowledge of the market, a personal drive to push the idea ahead and get decisions made, and a champion needs to get along with different people and communicate well (Chakrabarti 1974). Champions are persistent even in the face of obstacles. They exhibit self confidence in their own ideas and are highly motivated to influence their followers (Howell and Higgins 1990). Champions are persuasive and willing to take calculated risks and adopt products as their own to promote them. Personal ownership of an idea is a critical quality of a champion (Thompson 2006). Technology champions are indispensable sponsors, protectors, and promoters of innovations who are able to negotiate and balance the opportunities of new approaches with the risks of departing from the tried and tested (Manseau and Shields 2005). A champion is an individual who recognizes a new technology as having a significant potential, adopts the project as their own, commits to the project, and seeks to generate support from other people in the organization. A champion can arise from any level of an organization, they get resources to keep the innovation alive, they support projects when there is potential to benefit the champion's own department and are just as likely to promote innovation that are failures as they are to promote successful innovations.

Identifying a champion can be difficult but similar qualities exist in the various definitions of champions. People who are enthusiastic, committed people who are willing to take risks to implement innovations should be sought out as champions. A person may view themselves as a champion but a good way to identify a champion is through peers and senior managers (Howell et al. 2005; Thompson 2006). These qualities can be used as good indicators to identify existing champions for new technologies in the drywall finishing industry as well as promoting new champions in the intervention process.

In terms of firm owners acting as champions for safety innovations, there is a chance that the champion qualities they exhibited for tool technology could falsely identify them as a champion for a safety technology innovation. Management commitment is a strong indicator of the success of any safety intervention. If manager is not a true champion for a safety innovation, then the likelihood of the intervention having an impact on worker safety is diminished because workers can see that safety is not important to the management's goals (Marsh et al. 1998). There is a natural tendency for a champion to want to select out the desirable parts of an innovation to adopt and to reject the rest. This is often caused by a lack of efficacy of certain elements of an innovation, personal preferences of champions or strong organizational norms (Bresnen 2001). An unbalanced pursuit of purpose shows how in business situations driven by profit and production, destructive behavior can actually be incentivized. Decision making of champions can be motivated by market approval, government regulations, and safety threats that are ethically inadequate since some organizations never take the time to look at the overall purposes of their chosen practices (Goodpaster 2000). The problem with falsely identifying a innovation champion for a safety innovation is that the champion might champion the wrong behavior and the intervention may lose its original meaning and the impact might be lessened (Bresnen 2001).

2.5.5 Diffusion of Innovation Interventions

The matrix below provides a sample of interventions that have used the Diffusion of Innovations Model and outlines the pros and cons of the model strategies.

Table 2 Diffusion of Innovation Intervention Summary

Intervention Description	Constructs examined	Pros	Cons
Introducing Hydraulic Drop Down Aluminum Ladder Racks to Mechanical Contractors to Prevent Musculoskeletal Disorders (Kramer et al. 2009).	What are the barriers to adopting ergonomic innovations, Relative advantage, Complexity, the characteristics of adopting companies	This intervention enhanced triability by providing the contractors with the ladder racks overcoming a barrier to adoption. Technology champion contractors were sought out through other contractors and manufacturers. Educational and hands-on training was given. Compatability was addressed since it automated the same function workers already performed.	The influence of technology champions is difficult to measure. The intervention was given to few companies limiting its effectiveness
The Intention of Utility Companies to Adopt Energy Conservation Interventions (Vollink 2002)	Relative advantage, compatability, complexity, triability, adoption readiness (intention to adopt)	The intervention looked at multiple variables and showed that not all innovation characteristics need to be addressed at the same time to influence intent to adopt. A control group was used. The innovation was new and had not been implemented among participants. Decision makers were used that had the ability to implement the innovation. The innovation was evaluated and found to be cost effective if implemented	Triability was difficult to measure since this was only an intervention that addressed the intentions to use. Observability was not measured because the observability of innovation results was not relevant at the utility company level but only at the end user level. The intervention only measured intentions to adopt.
STOP AIDS intervention to promote safe sex practices among gay men in San Francisco. 7000 individuals were trained (Rogers 2004)	Opinion Leaders, relative advantage, communication	Small groups were formed with opinion leaders providing education to participants. Advantages of safe sex were related and commitment was gained for accepting the healthy behavior and participants committed to spread the information	The intervention focused mainly on intentions to adopt behavior. Measurements of effectiveness are difficult to relate to the Diffusion of Innovation Model

A review of multiple interventions that have used the Diffusion of Innovation Model as a guide for enhancing the adoption of innovations has provided insight into the direction that was taken to create intervention designs for the DUSTI project. The literature review found that there are advantages and disadvantages of using the DOI model in interventions.

The literature suggests some advantages of using the Diffusion of Innovation Model to influence adoption of innovations The DOI model stresses the importance of different customer tendencies. The model focuses on convincing the innovators and early adopters first to increase the diffusion success (Gerrits 2005). The DOI model is generalized and can be used in many fields to increase innovation adoption with useful results. The model displays regularities across a range of various fields of studies (Rogers 2004). The model uses social networks to spread information and increase innovation adoption. Various elements are used to enhance the likelihood of adoption. Increasing perceived relative advantage of innovations, relating the compatability of the innovation with the current product or process, allowing potential adopters to try the product on a limited basis or allowing them to observe others using the innovation and decreasing the perceived complexity can all reduce perceived barriers and increase adoption readiness (Rogers 2003).

The literature also suggests some disadvantages of of using the DOI Model to influence adoption of innovations. Adopters often fall into different stages of adoption. Someone who can be seen as an innovator for one type of innovation could be viewed as a laggard for another type of intervention. A person might be an adopter for an innovation that increases productivity but a laggard for an innovation that increases safety. The DOI model is not predictive. It does not predict how well an innovation will diffuse before it has gone through its adoption curve (Gerrits 2005). Regulatory bodies might inhibit diffusion of innovations. An example of this is building codes that inhibit the use of new innovations (Oster 1977). Customers adapt innovations to their own needs and uses, which may not always correlate with the intended use of the innovation. An example relating to these interventions is the misuse of dust-control sanders by modifying the sander to be more productive while taking out the safety feature (Gerrits 2005). The decision to adopt varies according to the ability and freedom of the potential users. Some decisions can be made by an individual while other decisions are made on behalf of the individual (Koebel 1999). Outside influences on the DOI process including existing conditions, characteristics of the innovation, and communication channels can have a negative effect on the innovation process (Dooley 1999). An adopter's uncertainty about an innovation can lead them to copy the adoption practices of those around them which could lead to multiple adopters adopting inefficient innovations (Abrahamson 1991).

2.5.6 Diffusion of Innovation Summary

The Diffusion of Innovation Model has been used for decades to explain adoption of innovation in agriculture, construction, technology, health care banking and various other fields as a literature review by Rogers found more than 5,000 studies relating the innovation-diffusion have been conducted over the last 50 years (Hannan and McDowell 1984; Abrahamson 1991; Blackley and Shepard 1996; Oldenburg 1999; Rogers 2003, 2004; Koebel 2008). Using the four elements of the diffusion model, the innovation, communication, time and social systems as a guide can influence the adoption of new innovations in construction and particularly the use of dust-control technologies used in drywall sanding operations. The elements discussed herein were considered and were incorporated into the design of the interventions for drywall workers and firm owners to increase the diffusion of dust-control innovations and could be used to design other interventions to increase diffusion of innovation in the construction industry. The diffusion of innovation model concepts were used in conjunction with the Health Belief Model and Technology Acceptance Model.

2.6 The Health Belief Model

The Health Belief Model (HBM) was developed to explain the decision processes related to actions people take to prevent injury or illness (Rosenstock 1960). For decades the HBM has been one of the most widely used theoretical constructs used in studying health behaviors. It has been used to explain both adoption and adherence of health behaviors and the continued following of health behaviors (Young-Corbett 2007). This model focuses on perceptions, beliefs and other personal characteristics that influence whether a person feels at risk for a certain health problem and whether they position themselves to change certain health behaviors, health practices and/or to utilize health care services (Lux 1994). Individuals who value the perceived benefits of behavioral changes will attempt to change as long as they believe their current behavior poses a threat to their lifestyle and if they feel they are capable of adopting the new behavior (Rosenstock 1988).

The main theoretical constructs that make up the HBM are: perceived susceptibility, perceived severity, perceived barriers, and perceived benefits (Rosenstock 1960; Rosenstock 1988; Elder 1999). These constructs are the major determining factors that cause people to adopt or continue practices that are meant to protect a person's safety and health. The first is the degree to which a person feels he or she is susceptible to a certain health problem or disease. The second is the severity the person believes that contracting the disease or health problem would have serious consequences to them. The third is perceived barriers to adopting a particular health practice. The fourth factor is the perceived benefits of a health action (Rosenstock 1960). Perceived threats and perceived benefits are strong motivators for a person's health practices.

Perceived threat refers to a person's belief about the seriousness of a disease and his/her susceptibility to that disease. Perceived benefits refer to the amount an individual views health behaviors as being beneficial and effective (Wong and Tang 2005). Perceived susceptibility and perceived severity have been found to motivate people to act while any perceived barriers potentially stand in the way of realizing any perceived benefits. People often weigh their decisions based on the relation of barriers and benefits to adopting health behaviors. Some of the factors that are commonly weighed are cost, convenience, pain and embarrassment (Lux 1994). An adapted graphical model depicting the HBM is shown in Figure 7.

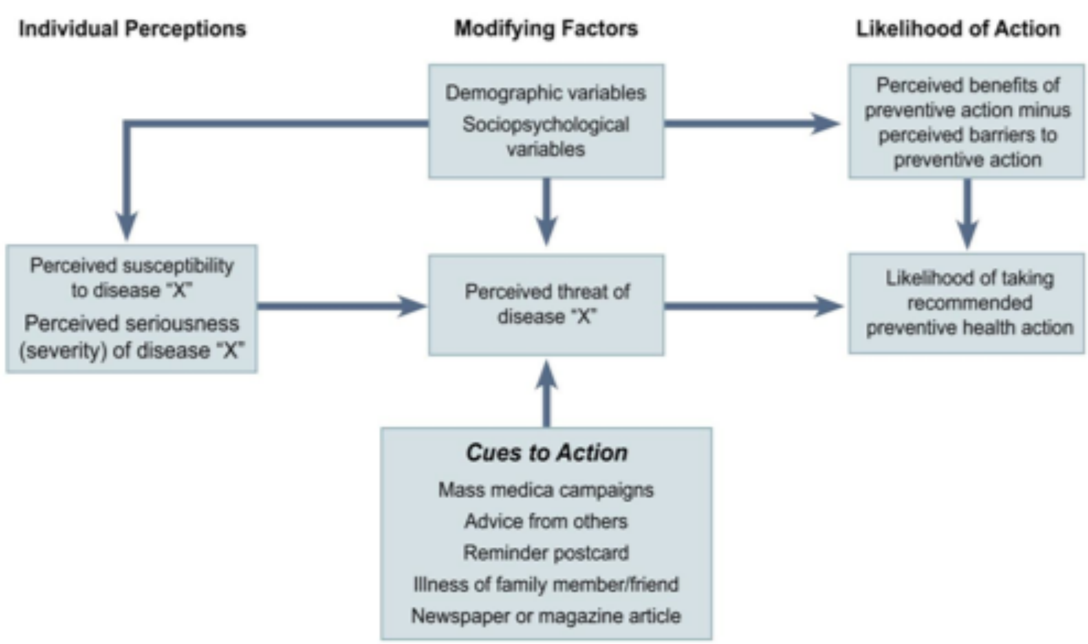


Figure 7 The Health Belief Model (Adapted from Rosenstock, 1960)

Additions to the HBM, found in the literature review, have been made to the Rosenstock version of the HBM that that have been found to influence people's perceptions. In a review of HBM literature, Young-Corbett (2007) found many additions to the original HBM that have guided HBM intervention research. Demographic variables such as age, gender, ethnicity and occupation as well as socio-psychological variables such as socio-economic status and personality should be considered in HBM studies. Perceived efficacy variables such as an individual's self-assessment of his/her ability to adopt the desired behavior should be considered. Cues to action, which act as external influences promoting desired behavior, have been found to influence HBM studies. Health motivation, whether an individual is driven to adhere to a given health goal should also be considered. The perception of the risk one encounters by not undertaking the health promoting behavior should be examined by looking at perceived threats to health. These variables and influences have served to strengthen the effectiveness of HBM studies over time.

The HBM constructs including modifying factors are summarized in Table 3.

Table 3 Health Belief Model Constructs

Health Belief Model Constructs
HBM Constructs: (Becker et al. 1977) • Health Knowledge (an awareness of the health risk) • Perceived Susceptibility (an individual's perception of their risk of experiencing negative health effects) • Perceived Severity (an individual's perception of the seriousness of a health risk) • Perceived Barriers (an individual's perception of factors that would discourage adoption) • Perceived Benefits (an individual's perception of the positive factors that would result from adopting a health behavior) • Self-Efficacy (an individual's perceived or actual ability to successfully adopt a health behavior) • Cues to Action (external influences that act as motivation to adopt appropriate behavior)
Modifying Factors (Elder 1999) • Demographic variables-such as age, gender, occupation • Socio-psychological variables- such as social economic status and individual personality • Health Motivation- whether a person is driven to adopt a health practice to achieve a goal

The original constructs of the HBM aim to increase health knowledge of intervention participants. The important additions that have been used in previous health interventions that were used to in addition to the aim of increasing health knowledge to create these interventions include, cues to action and self-efficacy.

Cues to Action

One important motivator that could cause a person to adopt a health behavior is a stimulus known as a “cue to action”. A cue to action serves as a trigger to the person to adhere to the appropriate behavior (Elder 1999). Cues to action could be any activity, media message, policy or trigger that catches the attention of a person and makes them dwell, however briefly, on the negative aspects of their behavior or acts as a reminder of the benefits of positive behaviors (Conrad et al. 1996). Individuals must recognize there is a problem before they are likely to change (Lux 1994). Cues to action are the most effective when introduced to their social networks including peers, family members and work associates. The HBM has found that knowledge of health risks alone doesn’t motivate action. Cues to action serve as a good motivator for people to reinforce the threats or benefits of safe work practices (Wong and Tang 2005). Cues to action can influence whether a person will be motivated to make behavioral changes. Cues to action can come in many forms such as internal cues such as symptoms or bodily states, or external cues such as health communications from others, advice from others, illnesses in other family members or co-workers or items such as a sticker on a calendar (Becker et al. 1977; Elder 1999).

Self-Efficacy

Self-efficacy refers to a person's beliefs in their own ability to perform certain behaviors (Wong and Tang 2005). Self-efficacy plays an important part in the HBM due to the user needing to feel comfortable that they are able to perform actions and protect themselves from health risks while realizing the desired health benefits (Rosenstock 1988). A certain set of beliefs including one's ability to properly control the risk is required before any action to protect one's health is taken (Rosenstock 1960). A person needs to have a certain level of trust in him or herself and also a level of trust in the existing environment and the control to be adopted (Lux 1994). Self-efficacy empowers a person to make correct choices allows them to gain control over personal, social, and administrative forces in order to take action to achieve the desired health behavior (Israel 1994). Any given behavior change is most likely to occur if the person has a desire to perform the behavior and if they have the necessary skills to perform the required behavior and there is no environmental restraints that prohibit them from performing the required behavior (Fishbein 2003).

Where actions are required to prevent health risks and maintain health, self-efficacy enhancement may be required (Rosenstock 1988). Skill training may be required to help people enhance self-efficacy before adopting a certain behavior. Performance accomplishments where the person has the ability to successfully try the skill or behavior and master the skill has been found to be the most effective method of obtaining self-efficacy (Rosenstock 1988). Vicarious experiences, that can be gained through observing others successfully or unsuccessfully practicing the skill or behavior, are another effective way to enhance self-efficacy and is the way through which much of a person's learning is gained in their life. Verbal persuasion is also used in health education while it is provides a lower level of self-efficacy than performance accomplishments or vicarious experiences gained by watching others (Rosenstock 1988).

Interventions Using the HBM

In conducting a review of literature, many previous interventions have been designed and implemented using the HBM with the constructs of the HBM used as design guides and measurements for determining the effectiveness of interventions designed to increase certain health behaviors. A review of several HBM interventions is outlined using the type of intervention, the HBM constructs used, the target population of the interventions, the health behavior in question and the effectiveness of the intervention strategy. Those who design behavioral health change interventions are challenged with a number of decisions during the design process. Decisions need to be made on the messages for the intervention, the goals and desired outcomes, the target populations, and the strategies that need to be implemented (Fishbein 2003). The following interventions differ in many of the aspects of design, implementation, and the health behaviors and actions they are aiming to change but the use of principles of the HBM are commonly used to guide the design. Interventions types are can be classified as "didactic" meaning sessions defined as primarily lectures or presentations with little interaction or discussion, "interactive" meaning techniques using participation, hands-on training, discussion groups or problem solving techniques, or "mixed" meaning using a combination of didactic and interactive methods (Davis 1999). Examinations of five interventions that are representative of examples of interventions using the HBM have been summarized in Table 4.

Table 4 Summary of Health Belief Model Intervention Examples

Intervention Type	HBM Constructs	Target Population	Health behavior of interest	Effectiveness of Intervention Strategy
Mother's health motives	Health knowledge, perceived susceptibility, perceived severity, perceived benefits, perceived barriers	Mothers of obese Children	Dietary adherence and health beliefs	High fear intervention showed results of higher weight loss
Cancer, Tuberculosis and Heart Disease	Health Knowledge, perceived susceptibility perceived severity, self-efficacy of taking action, perceived benefits	General Population	People's knowledge and health beliefs about cancer, tuberculosis and heart disease	Educational materials increased perceived susceptibility, self-efficacy, and perceived benefits of accepting health behaviors. Doctor visits, exercise, and diet changes were reported following intervention
Lead Safety among Painting Contractors	Health Knowledge, Self-efficacy, perceived benefits of healthy behaviors	Painting Contractors and their employees	Implementation of safe practices when working with and around lead paint including: Washing hands before eating, wearing respiratory protection, performing daily face seal checks on equipment, wearing work clothes home, eating and drinking in work areas.	Improvements in employee safe practice behaviors were shown to improve post intervention. Not all areas of interest met the target improvement rates that the intervention had set as goals.
Tailored dietary messages	Self-efficacy, Perceived susceptibility	Adult patients visiting family practice medical offices	Change in diet to reduce fat levels	The tailored message showed a significant decrease in total fat as compared with the non-tailored group showing the effectiveness of a tailored message to individuals readiness to change their behaviors
Sexually transmitted disease prevention	Health knowledge, perceived susceptibility, perception of benefits, Perceived Ease of Use, self efficacy	Minority Women	Safe Sex practices	The effectiveness of the intervention was measured by the decreased rates of sexually transmitted diseases among high-risk minority women. There was a significant decrease in the amount of women in the intervention attributed to the use of behavior change theories and promotion of self-efficacy.

HBM interventions address a variety of health behaviors and issues. Other intervention examples not discussed in detail but discovered through the literature review include interventions to reduce smoking, interventions to increase breast cancer screening, increased nutrition at worksites, increase in colorectal cancer screenings, increased diabetes awareness and prevention, increased vaccination participation and various other health related concerns (Bastani 1995; Conrad et al. 1996; Vernon 1997; Aoun et al. 2002; Abood 2003; Dempsey 2006). Worksite health promotion programs have been used to protect employee health and to encourage employees to practice safe behaviors (Conrad et al. 1996; Rychetnik 2002). Health and safety interventions require a variety of channels to deliver messages, products and services to target populations. Consideration needs to be given to what channels the target audience will come into contact with on a regular basis as well as attention to the nature of the message that will be delivered (Craig Lefebvre 1988).

The HBM has been used as a model for behavioral interventions for decades and has shown to be applicable to various situations. Worksites remain an important domain for reaching adult populations with health information. Results from worksite health promotion activities have yielded promising yet modest health behavioral changes while evidence suggests that employees who participate in workplace health promotion interventions achieve positive health outcomes (Linnan 2001). Helping workers to become aware of the risks they are exposed to by increasing health knowledge, perceived susceptibility, perceived severity and helping them to break down any perceived barriers by teaching self-efficacy and allowing them to realize the benefits of healthy behaviors can easily be adapted to work site situations and hazards. Workplace interventions can adapt the HBM by using the work environment to teach self-efficacy and items and people in the workplace serve as cues-to-action triggers to enforce the objectives of the intervention (Conrad et al. 1996)

The literature suggests some advantages of using the HBM to influence health related behaviors. The HBM is a widely used model that has been shown to enhance the adoption of healthy behaviors and practices in many fields. The HBM has been used successfully to increase health knowledge about the risks of certain behaviors which has shown to reflect on the constructs of perceived severity and perceived susceptibility, which can predict compliance with health behaviors (Becker et al. 1977). The HBM can increase self-efficacy, which allows for participants to gain confidence to overcome barriers that might exist. Performance accomplishments have been found to be influential in enhancing efficacy and reducing the perceived difficulty of adopting healthy behaviors (Rosenstock 1988). The HBM utilizes various channels of communication to trigger participants to practice healthy behaviors. Cues to action provide a trigger or stimulus for the behavior. Cues can come from many forms of communication including internal cues such as symptoms or external cues such as family members, peers, or media such as television, radio or printed channels (Elder 1999)

The literature suggests there are also disadvantages to using the HBM to influence health related behaviors. The beliefs and actions of people are subject to change over time and depending on their situation and interactions with others (Rosenstock 1960; Finfgeld 2003). Direct attempts to change a person's beliefs are not always effective and efforts should be focused on removing environmental factors that could be seen as barriers to change (Strecher and Rosenstock 1997). The constructs of the HBM have often been thought of as independent components rather than directly or indirectly interdependent on each other and have often been misused in HBM studies (Strecher et al. 1997; Finfgeld 2003). Most HBM research has incorporated only selected components of the model that results in the model as a whole failing to be tested (Janz 1984). The HBM is limited in that factors other than health beliefs also influence health behavioral practices. These factors may include cultural factors, previous experiences, socioeconomic status and external pressures from organizations or peer groups (Elder 1999).

2.7 Technology Acceptance

The Technology Acceptance Model (TAM) was developed by Davis (1989) to explain the factors that influence the decisions to accept or use new technology (Venkatesh 2000b). The TAM was originally designed to understand and predict user intentions to accept new computer technologies but has been used to understand technology acceptance in various fields of study including medical technology, information systems, and information technology (Chau 1996; Hu 1999; Venkatesh 2000c; Brown 2002; Yi et al. 2006). The TAM has been used to show that perspective adopter's behavioral intentions to use a technology correlate to the actual usage of the technology (Chau 1996). If potential users do not fully accept the new technology they can obstruct the new system and cause it to be underutilized (Brown 2002). The TAM is comprised of two main constructs which are perceived usefulness (PU) and perceived ease of use (PEOU) (Davis 1989). PU is defined as the degree a person believes that using the a new technology will increase their effectiveness or performance while PEOU is defined by the potential adopter's view of how much effort will be required to adopt the new technology (Davis 1989; Venkatesh 2000b). These two constructs of the TAM have been shown to be strong determinants of predicting adopter's intentions to accept technology (Venkatesh 2000b).

PU has been found to have a strong influence on people's perceptions of new technology (Chau 1996). Davis (1989) further described perceived usefulness by showing six ways potential adopters judge the usefulness of a technology which include: (1) does the technology allow the adopter to do their job more quickly? (2) Does using the technology improve the user's job performance? (3) Does using the technology increase productivity? (4) Does using the technology increase the effectiveness of the user's job? (5) Does using the technology make it easier for the user to do their job? (6) Does the user find the technology useful? PU can have short term implications to a user such as improving job performance or it can also have long term implications to a user such as improving the user's status in the company over time or improving the user's health (Chau 1996). People form usefulness judgments by comparing what the new technology capable of doing and what they need to get done to fulfill the requirements of their job. There are similarities between PU construct of the TAM and the relative advantage construct in Rogers diffusion of innovation model (Chau 1996; Rogers 2003). A focus on PU and relative advantage will help in the design of effective interventions that promote acceptance of new technology (Venkatesh 2000b)

PEOU can also have a strong influence on potentially increasing acceptance of new technology. The perception that a technology is easy to use will have a direct effect on its acceptance since technology viewed as being easy to use is more likely to be accepted (Davis 1989). PEOU also has an indirect effect on acceptance in its correlation to PU. If a technology is viewed as easy to use, then the perceived level of usefulness has also been found to increase (Hu 1999; Brown 2002). PEOU has been shown to have a smaller but still significant effect on user intentions to accept technology. This effect decreases over time due to the user gaining self-efficacy with the system with increased usage (Chau 1996). PEOU has been found similar to the construct of complexity from the diffusion of innovation model in showing that the adoption of technology is determined by its perceived attributes (Yi et al. 2006). The construct of self-efficacy has also been compared to ease of use in that a persons' perception of efficacy with a technology can influence their view on the ease of use the technology offers (Venkatesh 2000c; Yi et al. 2006). The influence of PEOU is greater in organizational settings where adoption is mandatory while in voluntary settings PU is the stronger determinant of behavior intention to use technology (Brown 2002).

A matrix is given in (Table 5) evaluating a sample of interventions that have used the Diffusion of Innovations Model in which pros and cons of the Model strategies are highlighted.

Table 5 Technology Acceptance Model Interventions

Intervention Description	Constructs Examined	Pros	Cons
Introduction of a new computer management system for floor supervisors in manufacturing firms (Venkatesh 2000b).	Perceived Usefulness, Perceived Ease of Use, behavioral intention to use	The decision to use the technology was voluntary. The subjects received training including one day of on-the-job training with the technology. Validated measurement instruments were used as effective measurement tools. It only measured intentions to use and not self reported usage that avoided the common method variance limitation of measuring both on a single questionnaire	Several of the constructs were measured with only two items. The sample sizes were small and the intervention was an observational design and nothing was done in effort to enhance user intentions to accept the technology. Intentions were self-reported.
An intervention to increase physician's decisions to accept telemedicine technology in health care (Hu 1999).	Perceived Usefulness, Perceived Ease of Use, behavioral intention to use	Most measurement items were obtained directly from literature. Validity and reliability steps were taken. Results showed that the PU construct had an affect on behavioral intention to use	No training was provided and no efforts were made to enhance user intentions to use. The participation in the study was voluntary and may have only included physicians who are interested in or had used the technology.
An intervention introducing a new interactive online help desk system (Venkatesh 2000a).	Perceived Usefulness, Perceived Ease of Use, behavioral intention to use, perceived voluntariness	Measured user reactions to the new system. User reactions were tracked over time as users became more experienced using the system. Validated instruments from prior research were used in measuring the constructs. The acceptance of the technology was voluntary. Computer self-efficacy scores acted as a control. Training was conducted by a group of 3 individuals with no knowledge of the research.	The training did not focus on increasing the intentions of users to accept the technology but rather focused on teaching self-efficacy in effort to enhance perceived ease of use through the gaining of experience using the technology.

Over the past 20 years the TAM has become a well-established model for predicting user acceptance (Venkatesh 2000b). A review of multiple interventions that have used the Technology Acceptance Model as a guide for enhancing the adoption of innovations has provided insight into the direction that was taken to create the intervention designs for the DUSTI project. A general summary of the pros and cons of the Technology Acceptance Model interventions studied are listed below.

The literature suggests there are advantages to using the TAM to influence adoption of innovations. The TAM construct of perceived usefulness has shown to be a strong determinant of usage intentions (Venkatesh 2000b). The TAM has been found to be influential in determining the acceptance of technology and has strong theoretical basis and empirical support (Hu 1999). TAM has been used generally to predict intentions to adopt technology in a wide variety of fields and has a large inventory of validated measurements that make it operationally appealing (Hu 1999). Training interventions using the TAM can positively influence PEOU (Venkatesh 2002).

The literature also suggests there are disadvantages to using the TAM to influence the adoption of innovations. The TAM fails to incorporate social influences and voluntariness. Social influences affect acceptance of technology in that if a person feels favorable or unfavorable towards a technology, they still may choose to adopt or not adopt depending on if they feel someone they consider important feels they should. Voluntariness affects acceptance due to the adopter's perception that acceptance is non-mandatory. If a user feels the usage of technology is mandatory this may affect their intentions to use. Compliance-based interventions mandating the use of technology have less effect than the use of social influences to affect an adopter's perception of usefulness (Venkatesh 2000b). The effect of perceived ease of use diminishes over time and becomes insignificant in predicting intention to use (Hu 1999). The

TAM evaluates behavioral intentions to use and not actual usage of technology (Chau 1996). The TAM can yield different results when technology acceptance is mandatory instead of voluntary (Brown 2002). The TAM assumes that there are no barriers preventing an individual from adopting if the user chooses to adopt. Perceived user resources should be included in the model (Mathieson 2001).

2.8 Trust in Technology

In order for changes in work procedures and practices in relation to technology acceptance to take place, trust must be a fundamental part of the organizational culture if the change is to be sustainable and adopted effectively (Podsakoff et al. 1996). Trust is related to a person's dispositions, decisions, behaviors and social networks. Trust is not a behavior or a choice, but rather a condition that can cause results that leads to action (Rousseau 1998). Trust has a direct influence on a behavioral intentions to use a technology and has a positive effect on the PU and PEOU constructs of the TAM (Wu and Chen 2005).Trust in technology is defined as an individual's willingness to be vulnerable to a technology based on that individual's expectation that the technology will exhibit the elements of predictability, reliability and utility (Lippert 2005). Trust in technology research has been conducted in various fields including ecommerce, online marketplaces, information systems, medical technology and food science (Eiser 2002; Misiolek 2002; Yee 2005; Li et al. 2008; Montague et al. 2009). In a study on trust in medical technology conducted by Montague (2009), participants described trust in technology in three different categories. These categories include:

1. Actions that a person performs when they trust a technology. Examples include: using a technology, consenting to use, purchasing, and trusting it with important information or safety.
2. Feelings about the technology. Examples include: having faith, believing in the technology, and feeling comfortable.

3. Actions that the technology performs leads to trust or distrust. Examples include: being accurate, being reliable, being understandable, being easy to use and matching assumptions (Montague et al. 2009).

Trust in Technology includes two constructs, perceived risks and perceived benefits which have an indirect impact on the acceptance of technology (Siegrist 2000). Potential users are less likely to experiment with a new technology if they perceive it as being too risky (Li et al. 2008). Trust in technology, which can lead to acceptance of new technology, is based on the perception of risk which is influenced by the information potential users receive about the technology (Eiser 2002). Recent research indicates that increasing trust helps potential users overcome perceptions of risk and uncertainty in the use of new technology (Li et al. 2008). Trust in technology is built when the perceived benefits can be seen and the tangible results of the technology are apparent to users (Yi et al. 2006).

Predictability, reliability and utility are important elements of building trust in technology through their ability to address the constructs of perceived risk and perceived benefits. Predictability refers to the expectation that the technology will perform the desired function in a manner that is expected by the users (Lippert 2005). The users of a technology determine predictability by seeing the technology do what it is designed to do and as the technology exhibits the desired predictability then trust in the technology will build over time (Lee and Moray 1992). Reliability refers to user's confidence that the technology will perform the desired function in situations that involve some degree of risk where if the technology does not perform, the user is placed in a position of vulnerability (Lippert 2005). Most definitions of trust include multidimensional aspects and tend to include reliability as a factor of trust (Dzindolet et al. 2003). Attitudes towards new innovations are often shaped by the reliability and accuracy of the innovation (Parasuraman and Riley 1997). Utility is the perceived usefulness of a technology. If a technology is perceived as useful then trust in that technology is increased (Lippert 2005). If a user considers a technology useful, and perceive that it will improve their performance, then they are more likely to trust in that technology (Johnson 2007).

The level of risk in adopting new technology affects trust and could be a factor in determining whether to use or not use new technologies (Parasuraman and Riley 1997). The design of new innovations should allow the operators to trust in the innovation that the desired quality and function will be achieved and should give the operator self-confidence in their ability to properly use the tool and receive the benefits (Lee and Moray 1994). An important aspect of trust in technology is the user understanding how the technology works. The more someone understands how something works, the more likely they are to put their trust in it (Dzindolet et al. 2003). Better operator knowledge of how a technology works will result in more appropriate use of technology (Parasuraman and Riley 1997).

The decision to perform a job manually versus to use technology to perform the task depends on the operator's level of trust in the piece of equipment. If an operator lacks trust in a piece of equipment then barriers are formed which limit the potential for increased adoption and use of the technology (Lee and Moray 1994). To promote the appropriate use of technology, operators of new technology should be made aware of any biases they may bring to the use of the technology. Human operators are likely to dislike or even mistrust the innovation. As experience is gained, trust improves as the technology demonstrates reliability and accuracy (Parasuraman and Riley 1997). Trust can positively influence a user's decision to adopt by providing information, credibility and reliability (Yee 2005).

2.9 Technology Adoption

Once trust is gained in a technology and the user has exhibited an intention to use the technology, the user looks for accurate and reliable information to remove any uncertainty before and after adoption (Yee 2005). The TAM of Davis (1989) is used to analyze why users choose to accept or reject new technologies. Technology adoption is the actual usage of the new technology (Ammenwerth 2006). The benefits from technology are dependent on the level the technology is utilized. Technology adoption decisions require information with the most significant factors for adoption include: the benefits of implementing the technology, organizational culture, availability of the technology and self-efficacy in using the technology (Fink 1998). Once the potential adopter gathers and evaluates the information and decides to adopt the new technology, the adoption can happen all at once or incrementally (Mitropoulos and Tatum 1999). Adoption of new technology includes three critical decisions which are: whether or not to adopt the new technology, the degree of which the new technology will be implemented and utilized, and the speed which the new technology will replace the old technology (Astebro 2004).

The decision to adopt can be difficult due to possible uncertainties of the new technologies and the view that old investments in previous technologies will have been wasted (Srinivasan 2002). Knowledge about the technology and the opinion of others are often considered in the decision to adopt or reject a new technology (Fink 1998). Decisions to adopt are based on maximizing benefits and reducing risks that could help a person or organization to gain a competitive advantage (Mitropoulos and Tatum 1999). The investment of time can be a determining factor of decisions to adopt. The amount of workload a potential adopter has might inhibit the decision to adopt due to not wanting to invest the time into learning how to use a new technology when the old one gets the job done. The risk of adopting the new technology or the risks that are present by not using the technology weigh into the decision of whether or not to adopt (Parasuraman and Riley 1997). If a potential adopter is able to personally experience the benefits of the new technology or are consistently satisfied with the technology and can see that potential PU and PEOU barriers have been overcome, the decision to adopt is strengthened (Lippert 2005).

The degree or depth of which new technologies will be implemented and utilized is a critical decision for potential adopters of new technologies. Depth of adoption doesn't necessarily mean the amount of technology purchased, but rather the degree to which the technology is being utilized to receive the desired benefits of the technology (Astebro 2004). Technology adoption at the organizational level does not always mean greater depth of adoption since all users in the organization may not always fully adopt the new technology or use it correctly (Misiolek 2002). Adoption of new technology depends on the attributes of the users and the technology itself. The user's attributes of self-efficacy (their perceived capacity to interact with the technology), motivation to use the technology and attitude towards the technology can possibly affect the depth of adoption (Walker 2002). The usability, performance and function of the technology also possibly affect the depth of adoption (Ammenwerth 2006). The cost of new technology can also increase or decrease the depth of adoption of the technology (Srinivasan 2002).

The speed that a technology can be implemented is another decision in the technology adoption process (Astebro 2004). Adoption of new technologies usually occurs in phases in effort to limit the risk of adopters (Fink 1998). Institutional pressures can often drive the speed of adoption in the form of stakeholders and competition. Stakeholder pressures can come from internal stakeholders such as management or employees or external stakeholders such as customers, investors, insurance companies, the general public, media, or government interactions. Competitive pressures force firms to adopt technologies in order to gain a competitive advantage or simply to continue to compete with other organizations (Srinivasan 2002).

2.10 Trust in Automation

When new automated technology is introduced to the workplace, instant acceptance is generally limited to a few cases. Many users may dislike the new technology and may be hesitant to trust the technology (Parasuraman and Riley 1997). The decision to perform a job manually or using automation depends on the operator's level of trust in the technology (Lee and Moray 1992). The more a user understands how an automated technology works, the more likely the user will trust in the technology (Dzindolet et al. 2003). Trust in automation is a principal factor for acceptance and usage of the technology (Madhavan et al. 2006). Trust in automation is an expectation that the automated technology will function in a consistent manner in the future in a manner that is predictable and reliable (Lippert 2005).

Automation is used when the operator's trust in the technology exceeds the operator's self confidence in performing the task manually and not used when the opposite is true (Lee and Moray 1994). Reliability, accuracy and availability are required for user trust in automation (Riegelsberger et al. 2005). If the automation is perceived to have errors, the level of trust in the automation is decreased and the level of self-confidence in manual operations is increased due to the attitudes toward the automation being formed by the reliability and accuracy of the automation (Parasuraman and Riley 1997; Madhavan et al. 2006). Trust in automation is important to achieve the benefits of technology. Potential problems exist when the user places too much trust too much in automation or don't trust automation enough. People become over reliant on automation when high levels of trust exist and lose out on potential benefits of the automation when levels of trust are low (Dzindolet et al. 2003). When mandatory acceptance and use of an automated system is implemented, operators who do no have trust in the automation can result to creative ways of disabling the automation and getting the job done other ways (Parasuraman and Riley 1997). Mistrust of automation can lead to failures and can undermine the potential benefits that the automation could provide. Trust in automation is dependent on the characteristics of the operator, the automation, and the way they interact (Lee and See 2004).

2.11 Trust in Organization

Many American workers are suspicious of management (Gilbert and Tang 1998). Forty-three percent of all American workers can be described as cynical and mistrusting of their organization and other employees. Organizational trust is the belief an employee has in an organization that the employer will be straightforward and follow through with commitments made. Organizational trust refers to employee faith in company leaders, goals and that the company will do what is best for the employee (Gilbert and Tang 1998). Trust is composed of predictability, dependability and faith. In the cases where employees do not trust their organization, workers tend to spend time protecting their self interests and hold back from the organization. Trust needs to begin at the top and filter down throughout the organization (Mishra and Morrissey 1990). Building organizational trust is not easily wrought from the top down in an organization. Organizational trust needs to be built by taking into account the needs, fears, and motivations of all staff levels (Davies et al. 2000). One important factor of trust in organization is communication. Without trust, resistances to change and conduct are more prevalent (Carnevale 2008).

As people generally tend to trust other people more than companies, managers can build employee trust by communicating information that is reliable and by standing by the promises the company makes and exceeding employee expectations (Rezgui 2007). Leaders who gain the trust of employees can increase employee's role clarity, attitudes, satisfaction and organizational commitment and trust. Employees who view themselves as having a high degree of ability and experience are more likely to place a higher degree of trust in the organization than those who do not view themselves as having the ability and experience in the company (Podsakoff et al. 1996).

Decreased human relations and organizational performance, low employee morale, and reduced quality of work are results of organizational mistrust (Gilbert and Tang 1998). Better communication, sharing in decision making and sharing of information with employees helps to build organizational trust (Gilbert and Tang 1998). If the culture of an organization had led to mistrust, then it may be possible to create, change and manage the culture of the company in order to change the level of organizational trust (Davies et al. 2000). The lack of trust has been found to have a more negative effect than the presence of trust is positive in its influence (Mishra and Morrissey 1990).

2.12 Overview of Trust and Acceptance of Technology

Trust in technology, trust in automation, technology acceptance and technology adoption literature reviewed revealed that each of these areas of studies are aimed toward the increased usage of technology. These constructs are often used in connection with each other and sometimes are combined to explain adoption of technology. There are similarities these four constructs share that help them to build upon each other and strengthen the depth of adoption as well as differences that make them unique areas of study in which increased focus can be placed in order to gain greater understanding of each construct. Trust is needed in each of these constructs and increased trust leads to increased adoption.

Literature suggests there are similarities between the constructs of trust in technology and trust in automation. Trust in technology is similar to trust in automation in that in order for trust to be increased, the technology or automation has to be perceived as accurate, reliable and useful (Lippert 2005; Riegelsberger et al. 2005). When a user trusts the technology that provides automation, then the automation will be utilized. Both constructs are necessary elements of acceptance and usage of technology (Lee and Moray 1992; Podsakoff et al. 1996). Having faith in, believing in and feeling comfortable with the technology are elements that also exist in both trust in technology and trust in automation (Lee and Moray 1992; Montague et al. 2009). Perceived risks must be overcome and perceived benefits of the technology must be tangible for trust to be increased in both constructs (Siegrist 2000; Riegelsberger et al. 2005). Both trust in technology and trust in automation are dependant on the user's understanding of the technology (Dzindolet et al. 2003; Yee 2005).

The literature also suggests there are differences between these two constructs. Trust in technology is a part of trust in automation. Decisions to use automation are dependant on the level of trust in the technology (Lee and Moray 1992). Trust in technology might exist, but an important factor in trust in automation that differs from trust in technology is that if the user has greater trust in their abilities than they do the technology, then the usage of the technology is not realized (Lee and Moray 1994).

Trust in Technology compared to Technology Acceptance

There is evidence of similarities between the trust in technology and technology acceptance constructs. Both constructs are based on information about the technology (Chau

1996; Dzindolet et al. 2003). Perceived Usefulness (PU) elements of technology acceptance are similar to the predictability, reliability, and utility elements of trust in technology. When these elements are perceived, trust and acceptance increase (Davis 1989; Lippert 2005). When trust exists, acceptances increases (Yee 2005).

Perceived Ease of Use (PEOU) increases trust and acceptance (Davis 1989; Hu 1999).

Trust and acceptance both influence the decision to adopt (Venkatesh 2002; Yee 2005).

The literature also suggests differences between these two constructs. Trust in technology is a part of technology acceptance. Technology acceptance is used to predict user intentions to adopt while trust in technology influences acceptance of technology (Podsakoff et al. 1996). Trust in technology has a positive effect on the PU and PEOU constructs of technology acceptance (Wu and Chen 2005).

Trust in Technology compared to Technology Adoption

The literature suggests there is evidence of similarities between the constructs of trust in technology and technology adoption. Both constructs are based on information about the technology (Fink 1998; Dzindolet et al. 2003). Both constructs are strengthened by personal experience using the technology (Parasuraman and Riley 1997; Lippert 2005).

Usability of the technology affects both trust in technology and technology adoption (Lippert 2005; Ammenwerth 2006). When trust exists, adoption increases (Yee 2005).

Perceived risks and benefits are elements of both constructs (Fink 1998; Siegrist 2000).

Trust and acceptance both influence the decision to adopt (Podsakoff et al. 1996; Venkatesh 2000b)

The literature also suggests differences between the constructs of trust in technology and technology adoption Trust in technology is a part of technology adoption. Trust in technology is used with technology acceptance to predict user intentions to adopt while technology adoption is the actual usage of the technology (Yee 2005). The degree of usage of the technology relates to the level of trust and acceptance of the technology (Misiolek 2002). User beliefs about technology influences trust and affect the rate of adoption (Lee and Moray 1992). Adoption can be pressured from internal or external stakeholders (Srinivasan 2002). Adoption can be forced upon a user even when trust in the technology does not exist (Misiolek 2002).

Trust in Automation compared to Technology Acceptance:

There is evidence that suggests there are similarities between the constructs of trust in automation and technology acceptance. Both trust in automation and technology acceptance are dependant on the user's understanding of the technology (Chau 1996; Dzindolet et al. 2003). Trust in technology affects both trust in automation and technology acceptance with the level of trust in technology influencing the level trust in automation and the level of acceptance (Lee and Moray 1992; Podsakoff et al. 1996). The level of trust in automation is determined by the reliability and accuracy that is similar to the PU construct of acceptance (Davis 1989; Riegelsberger et al. 2005).

The literature also suggests differences between the constructs of trust in automation and technology acceptance. Trust in automation is often considered a factor for technology acceptance (Madhavan et al. 2006). Creative disablement may occur with trust in automation where parts of the automation are not accepted and bypasses if although some elements are accepted (Parasuraman and Riley 1997).

Technology Acceptance compared to Technology Adoption:

There is evidence that suggests similarities exist between the constructs of technology acceptance and technology adoption. Technology acceptance and technology adoption are dependant on the user's understanding of the technology (Chau 1996; Fink 1998). Both acceptance and adoption are based on the level of trust in the technology (Podsakoff et al. 1996; Yee 2005). Both constructs look at what competitive advantage can be gained by using the technology (Davis 1989; Fink 1998).

The literature also suggests differences between these two constructs. Technology acceptance is used as a predictor of user intentions to use while technology adoption is the actual usage of the technology (Chau 1996; Ammenwerth 2006). A technology might be accepted but the adoption may not correlate to the depth of adoption due to cost of implementation, risks of failure, and pressure from stakeholders (Fink 1998; Srinivasan 2002). Technology adoption includes the decisions to adopt, the degree with which to adopt and the speed of adoption. Technology acceptance intentions are based more on perceived usefulness and perceived ease of use (Davis 1989; Astebro 2004).

Enhancing user acceptance of dust-control technology leading to adoption is the end goal of these interventions. To enhance adoption, trust in the technology needs to be enhanced and that trust needs to be calibrated. Trust in technology, which can lead to acceptance of new technology, is based on the perception of risk which is influenced by the information potential users receive about the technology (Eiser 2002). Calibration is a term used to describe the process by which users of a technology learn to adjust their behavior and decisions based upon the capabilities and performances of the technology (McBride and Morgan 2010). Failure to calibrate trust in a technologies capabilities properly can lead to misuse or disuse of the technology (Fallon 2010).

Enhancing trust in technology

Trust is a subjective concept that is affected by individual and situational differences The development of trust in technology is based on user's view that the technology will benefit the user (Wang 2005). Guidelines used in various interventions (air traffic control, medical, computers, CAD, information systems) introducing new technologies have been used for enhancing trust and include: education, user experiences, ability (skills, and competence), integrity (credibility and dependability) and reducing risk (Steinauer 1997; Eiser 2002; Yee 2005; Shea 2008). The barriers of trust enhancement include the lack information and training, fear brought on by uncertainty and resistance to changes (McBride and Morgan 2010). The guidelines with their strengths and weaknesses are discussed below including how they can be implemented into interventions for increasing trust in dust-control technology.

Educational information that is designed to enhance a user's knowledge about the technology can increase trust by removing uncertainty about the technology and is an important first step in building trust (Yee 2005; Shea 2008). Information is important for the initial formation of trust and provides a strong base for which trust in technology can be built upon. Educational information's weakness is that information alone may not build enough trust in the technology to lead to adoption. Information only provides a starting point that can help remove uncertainties. The effect of information provided by others on user trust diminishes over time and the user will form their own trust in the technology through experience (Venkatesh 2000c). Educational materials were used to inform drywall workers and employers about the dangers of drywall dust and how dust-control technologies work and the benefits of using the technology.

User experiences with a technology build trust as the user becomes more familiar with the technology, trust will be enhanced (Steinauer 1997). Experiences are used to develop the level of faith that a user places in the technology. Trust is enhanced over time by having positive experiences with the technology (McBride and Morgan 2010). The weakness of user experience as a guideline for trust enhancement is that not all users have experience using the technology and if they have bad experiences then they trust will be diminished. These interventions provided new users the opportunity to gain experience with the dust-control technology, which was aimed at increasing their level of trust in the technology. The more experience they have with the technology, the more likely they are to trust the technology (Corbitt et al. 2003).

Demonstrating ability can increase trust in a technology. As ability, which also can be defined as the skill or confidence a user has in the technology, of the user increases, their confidence using the technology will be enhanced (Shea 2008). Ability is similar to the construct of self-efficacy as outlined in the HBM. The technology must have the functionality to complete the desired task and the user must be adequately trained in the use of the technology (Ammenwerth 2006). While users may be willing to try a new technology, they may become frustrated and trust may decrease if they lack the skill and self-efficacy to reap the benefits of using the technology. Skill training is needed to help users avoid mistakes that could diminish trust. (Shea 2008). A weakness that could occur as a result of demonstrating ability is the training that the person receives needs to be reliable. Educators must not only be able to perform the skill but must be able to instruct others how to do it as well (Shea 2008). Hands-on skill training using the dust-control technology was used in the design of these interventions, allowing the user's to gain skills and confidence using the technology the proper way.

Demonstrating integrity includes providing information about the technology that gives it credibility and reliability, and allows for the user to check the results (traceability) has been used as a trust enhancement method (Yee 2005; Shea 2008). Endorsements (from major firms, government or other respected organizations) and formal testing or certifications can be used to enhance credibility and reliability that help establish trust in technology (McBride and Morgan 2010). If a user is able to check the results of a using a technology against their expectations, trust can be enhanced (McBride and Morgan 2010). A weakness of demonstrating integrity could be that not all people value the recommendations of others the same and if they don't see perceived value, then trust will not be enhanced. These interventions used endorsements from NIOSH in the form of published reports on the effects of drywall dust and the beneficial use of dust-control technologies to help establish credibility. Results from dust-control studies conducted at Virginia Tech University (Young-Corbett, 2007) were used to show the reliability and effectiveness of dust-control technologies. Traceability was utilized by allowing the users to visibly see the lower levels of dust generated either in on-site demonstrations or web-based video-trainings depending on the intervention type.

Reducing Risk is a way to enhance trust in technology (McBride and Morgan 2010). Perceived risk influences a person's trust and ultimately their acceptance of a technology where lower levels of perceived risk lead to greater trust in technology (Eiser 2002). One way that has been used to enhance trust is to inform the potential users of the risks of using or not using a technology and also how those risks can be minimized (Johnston et al. 2003). The weakness of using risk as an enhancement of trust is that people have different perceptions of risk and are willing to accept different levels of risk. The risk of not using dust-control technologies could vary depending on the situation and user. These interventions attempted to inform the participants of the risks of not using dust-control technologies in effort to enhance trust in the technology.

Enhancing Trust Calibration

Even when trust has been formed in a technology, the benefits of using the technology will still require an educated user who understands the risks and benefits the new technology offers (Wang 2005). Maximizing trust in a technology can sometimes be a poor design goal. If too much or not enough trust is placed in a technology, potential risks arise and that could affect the level of user trust (Parasuraman and Riley 1997). A level of trust is needed that allows for trust to be calibrated properly so the user is able to gain the benefits for using the technology (McBride and Morgan 2010). Proper calibration prevents the misuse and disuse of a technology that could lead to decreased trust, errors, inefficiencies and even rejection of technology (Lee and See 2004; Fallon 2010). Methods used for calibrating trust are training and user experience (Fallon 2010; McBride and Morgan 2010).

Training that helps the operator understand the capabilities of the technology can enhance calibration of trust by allowing the operator to know when to adopt and apply the technology (Fallon 2010). Training is important in the calibration of trust but may not be adequate enough to prompt usage of technology (McBride and Morgan 2010). Information alone may not enhance the appropriate calibration of trust. The information needs to be presented in a way that the user can understand and incorporate into the experience of using the technology (Lee and See 2004). The weakness of training is that alone it may not adequately calibrate the appropriate level of trust in a technology. These interventions incorporated training on the technology and focus on calibrating the user's trust in the dust-control technology by providing and understanding of how the system works and when to use the system.

User Experience using the technology helps the operator to calibrate their trust in the technology**.** Experiences help the operator to determine the level of faith they can put in the technology at different times to realize the benefits of the technology. If an error occurs then the level of trust changes and must be regained (McBride and Morgan 2010). Using experiences to calibrate trust can be a weakness because if positive experiences are expected, misuse of the technology occur and if negative experiences occur it could result in disuse or abandonment of the technology (Lee and See 2004).

Enhancing Technology Adoption

The decision to adopt technology is often difficult due to uncertainties about the technology and the effect it will have and that old investments in previous technology may be viewed as lost (Srinivasan 2002). A properly calibrated trust in technology can enhance adoption of technology. Adopters are different from each other in how they view potential technologies for adoption although they can compare the experiences of others with their own experiences to form decisions whether to adopt or not (Malhotra 1999). Training is a critical component of technology adoption (Leonard 2004). Methods that interventions should focus on to increase technology adoption include training on: perceived risk and benefits, external pressures to adopt, CEO support and user participation (Fink 1998).

Perceived Risks and Benefits training gives the decision maker the support they need to overcome adoption obstacles. The positives and negatives of the technology must clearly be communicated and the purpose of the technology should be made clear so trust can be developed (Leonard 2004). Adoption of technology can be increased by showing that the technology is functional enough to complete the desired task since users who personally can see the technology as useful have a greater affinity for adoption (Malhotra 1999; Ammenwerth 2006). Training of perceived benefits should also include focusing on how the technology can maximize the benefits by creating a competitive advantage for the user and that the probability of success will be high (Mitropoulos and Tatum 1999). The weakness of focusing on the perceived risk and benefit is that people view these items differently and it doesn't take into account the ability of the user to use the technology that is a barrier to adoption. Typically researchers have focused on adoption from a perceived risk and benefit standpoint using the TAM constructs of PU and PEOU which can overlook individual differences of users (Venkatesh 2000a). These interventions incorporated education on the risks and benefits of using dust-control technology in efforts to increase acceptance of the technology that can lead to increased adoption.

External Pressures to adopt can enhance technology adoption. External pressures that have used to enhance adoption include stakeholders such as the general public, customers, investors, insurance companies, and government regulation (Srinivasan 2002). Outside forces can serve as motivation for firms to adopt new technology. The weakness of using external pressures is that if the pressure to adopt technology doesn't lead the users to believe that the technology is trustworthy, then the decision to use the technology will not happen (Wang 2005). These interventions incorporated how external stakeholders namely customers, government regulators and insurance companies support the adoption of dust-control technology.

CEO Support plays a significant role in the adoption of technology in small firms. The management of a company needs information about the technology in order to have the motivation and courage to adopt new technology (Fink 1998). The weakness of using CEO support to enhance adoption can be that the CEO doesn't have enough information about the technology to make an informed decision or doesn't trust the technology. These interventions focused on informing the owners of small companies about dust-control technology benefits and strengths since managerial attitudes toward technology affect adoption decisions (Mitropoulos and Tatum 1999). Drywall-sanders were also given to the small firm intervention participants in effort to provide the owners a risk free trial of the technology that can enhance adoption.

User Participation is used as a technology adoption enhancer since adoption often depends on the attributes (self-efficacy, motivation, and attitudes) of the user (Walker 2002; Ammenwerth 2006). User involvement, user training and motivation by management have been used in interventions to encourage user participation to enhance adoption of technology. The weakness of user participation is that the user must be motivated, have the required knowledge and ability to complete the required task (Ammenwerth 2006). These interventions encouraged user participation in training sessions through hands-on training with the tools to enhance self-efficacy, increase motivation and attitudes towards the use of dust-control technologies.

2.13 Health Promotion Intervention Strategies

Some of the common strategies found through the review of health promotion intervention literature using the three theoretical models will be used to create the interventions for dust-control technology usage and could enhance intentions to use dust-control technology. The most common and effective methods are educational materials, self-efficacy training and social system influences.

Educational training materials- Educational materials should be administered through short lectures and handouts that can increase awareness of the effects of drywall dust and provide information that is important to increase the health knowledge of workers and employers. Educational training will provide participants with information pertaining to the following constructs that can influence perceptions of ease of use and usability of technology which then directly influence the intention to use new technology: Perceived Susceptibility (HBM), Perceived Severity (HBM), Perceived Risks (HBM, TAM), Relative Advantage (DOI), Reliability (DOI), Compatability (DOI) an Complexity (DOI). These materials can include information that supports the severity of the problem that might cause a fear motivation in some participants, which in turn might motivate them to improve unsafe behaviors. Using training methods known to be effective with adult audiences which include minimizing lecture time and combining them with graphics and visuals can enhance the effectiveness of construction safety interventions (Materna 2002).

Self-Efficacy Training- Teaching workers and employers how to use the engineered methods for dust control can be an important factor for breaking down any barriers that might exist for using the tool and increasing the skill of workers. This training can be done through hands-on demonstrations at the worksite enabling the participants to ask questions and gain familiarity with the tools and methods. This hands-on training incorporates the elements of all three models used in the design of the intervention by increasing self-efficacy (HBM), increasing trust by demonstrating the ease of use and perceived usefulness of the tools (TAM) and by allowing participants to overcome perceived barriers through triability and observability (DOI). Since performance accomplishments are the most effective source of efficacy, the intervention should include worker experience with the tools (Rosenstock 1988).

Social System Influences- Introducing changes into a construction social system can create ripple effects that can be difficult to anticipate (Manseau and Shields 2005). The culture of a company can play an important role in the adoption of innovations within a social system and innovations should try to be compatible with the normal behaviors that are in place. Structural barriers such as building codes, and construction safety and health regulations can constrain or drive innovations and can influence actual usage of technology. Safety and environmental factors can apply pressures for firms to change intentions to adopt innovations or upgrade technology (Manseau and Shields 2005). Another import aspect of the social system element outlined in the DOI that can be used to help increase intent to adopt is the use of technology champions to influence other individuals' attitudes towards adoption. Opinion leaders and change agents often referred to as technology champions (Chakrabarti 1974; Rogers 2003; Howell et al. 2005; Thompson 2006). Interventions have often used a champion to provide education, champion a product, or to give support for the innovation. Reviews of interventions using champions have been found to be moderately successful (Thompson 2006). The use of champions could be beneficial in the diffusion of dust-control technology usage by using persuasive people to increase the recognition of the innovation and share experiences. Champions provide a transfer of knowledge at an interpersonal level that plays an important part in adoption (Koebel 2008)

2.14 Construction Safety Interventions

The intensity of work, time pressures, frequent changes of work locations and the trades' pattern for working in small firms are some of the factors that make it difficult to introduce safe work practices in the construction industry(Jensen and Kofoed 2002). Breaking down the barriers to change requires education and instruction by people who know the trade and can effectively communicate with construction workers (Jensen and Kofoed 2002). For a new tool or work method to be accepted it must be easy to use, easy to understand and must fit into the culture of the trade. If these conditions are not met, the desired benefits may never be realized because the innovations were not given a fair chance due to the time pressures of construction work (Hess et al. 2004). The construction industry is a priority for research and interventions because of its high number of work related fatal and non-fatal injuries (Hoonakker et al. 2005). Tailored interventions have been shown to be effective in promoting health behavioral change in construction workers (Sorensen et al. 2007). A safety intervention is an attempt to change how things are done in construction companies in order to improve safety. Within the workplace it could be a new program, practice, or tool intended to protect the health and safety of employees (Robson et al. 2001).

Currently the main motivator for interventions in the construction industry is the concern for increased worker safety and health due to the injury and illness statistics published by OSHA and NIOSH. Construction work is unique in that it changes work conditions and workplaces. Most safety and health related issues in construction arise from the specific working conditions in the industry. To reduce the injury and health risks to workers, interventions educating workers about new PtD solutions and safety designs should be administered. Design for health means the elimination or reduction of worker exposure to potentially damaging physical agents that could be noise, vibration and dust (Vedder and Carey 2005). Better educated workers are more aware of the hazards that exist in the work environment. Appropriate training and education on health and safety is now widely recognized as a crucial factor in reducing and preventing injuries (Brunette 2005). Construction interventions should incorporate a theoretical basis for the design of the intervention, valid measurement instruments, and appropriate use of statistical analysis (Becker 2004). Most interventions in the area of construction safety and health have not been theory driven which limits the understanding of what interventions work and the variables and methods that are important to implement in their design. Theory driven interventions provide a conceptual framework for refining and improving existing hazard control measures as well as aiding researchers design studies that are repeatable and generalizable (Goldenhar 1996). Examples of workplace interventions that have used educational training sessions to improve worker behaviors include: agricultural workers use of hearing protection, skin cancer prevention for farm workers, ergonomic interventions dealing with musculoskeletal disorders in floor layers and concrete workers, and lead paint worker interventions (Goldenhar 1994; Parrott et al. 1996; Kirkhorn 2002; Materna 2002).

The ultimate success of construction safety interventions depends not only on the efficacy of the implemented change in safe work practices, but also on the willingness of workers and employers to continue to utilize the practices in the field. The proposed change in work practice must appear reasonable to those who are asked to use it and it needs to be consistent (Hess et al. 2004). Change requires more from employees so they need help and support from management to be able to implement consistent changes (Beer 1990). Workers in the construction industry typically have received their training from experiences and values that have been passed down from earlier generations that are accepted as normal practices. Resistance to change is encountered because workers perceive that new innovations or work practices will at least for some period of time decrease their work intensity and output which correlates to their income. If changes in methods or new tools do not increase productivity or cannot be shown to be economically beneficial, it is difficult to motivate workers and employers to make changes (Jensen and Kofoed 2002).

2.15 Summary

The health and safety of workers in the construction industry is a constant concern. Workers in dusty occupations should take precautions to protect themselves from the risk of disease or disability that have been shown to exist. Workers who stay in the drywall industry should use dust control methods that have been developed to reduce their exposure to potentially harmful dusts. Diffusion of innovation in the construction industry can be used to help understand barriers to adoption and the use of technology champions can increase the use of new safety technologies. The Health Belief Model can be used to understand worker perceptions of health risks and self-efficacy. The Technology Acceptance Model can be used to understand trust in technology and trust in organization that can help to overcome barriers to adopting new dust control technologies. The literature review has provided background to aid in developing and evaluating three interventions to address the gaps in existing knowledge and to determine if an intervention strategy is an effective way to increase the use of PtD solutions in the drywall finishing industry.

CHAPTER 3

3 METHODS

This research focused on designing, implementing and evaluating three interventions to increase construction worker/manager intention to use PtD drywall dust-control tools and methods. These intervention strategies targeted three categories of respondents involved in the drywall finishing industry including a workers intervention strategy, a small firm strategy and a large firm strategy. The intent of these interventions was primarily aimed at increasing awareness of and trust in dust-control technology tools and methods in the drywall industry and increasing intentions to use the technology while addressing barriers to adoption. Technology adoption or usage rates were not measured in this study. Due to the varying depths of adoption that can occur in different organizations (Misiolek 2002) and the different stages of adoption readiness of these organizations (Rogers 2003), this study only focused on the behavior, attitudes and intentions of these organizations in relation to adopting new technologies. These interventions addressed the key barriers to adoption that have been found to exist among the participants in the drywall finishing industry (Young-Corbett and Nussbaum 2009b). The methodology utilizing the Health Belief Model (HBM), Diffusion of Innovation Model (DOI), and Technology Acceptance Model (TAM) as a guide for designing, implementing and evaluating the interventions are set forth. A detailed description of the survey instrument design is also included in this chapter.

3.1 Methods Overview

The theoretical models HBM, DOI and TAM have all been used to increase the intention to adopt new technologies in relation to improving health through interventions and served as a guide for the design of the intervention materials. The intervention designs were based on constructs of the three theoretical models and varied based on the participant group. A PtD adoption readiness integrated model detailing the relationships of key constructs of the three models was created and served as a guide in developing intervention materials. A quasi-experimental design, consisting of a pretest-posttest with a control group, was employed for each intervention. Successful interventions measured by the increase in intentions to use PtD solution dust-control tools will help to further the field of occupational safety by building a body of intervention practices based on scientific evidence, that can be applied in the workplace (Robson et al. 2001). The following research plan describes the design, implementation and evaluation of three interventions to address the gaps in existing knowledge.

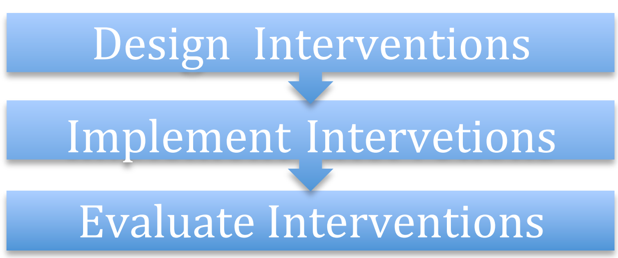


Figure 8 Intervention Research Outline

3.2 Intervention Designs

The design of the interventions targeted three participant groups who received different interventions that addressed key constructs of the three theoretical models. Workers, small firms and large firms received interventions aimed at educating them about drywall dust health risks and the benefits of using PtD solutions when finishing drywall. Findings from a review of literature served as the basis of design for the three interventions. Methods from intervention literature on the three theoretical models were evaluated in the literature review and the constructs that were incorporated into the drywall dust intervention designs are outlined in table 6.

Table 6 Intervention Target Constructs

Intervention Theoretical Target Constructs		
Worker Intervention	Small Firm Intervention	Large Firm Intervention
Perceived Risk to Health (HBM) Health Knowledge (HBM) Trust in Organization (TAM) Trust in Technology (TAM) Adoption Readiness/Intent to Adopt (DOI, TAM) Self-Efficacy (HBM)	Perceived Risk to Health (HBM) Health Knowledge (HBM) Perceived Usefulness (TAM, DOI) Perceived Ease of Use (DOI, TAM) Trust in Technology (TAM) Adoption Readiness/ Intent to Adopt (DOI, TAM)	Perceived Risk to Health (HBM) Health Knowledge (HBM) Perceived Usefulness (TAM, DOI) Perceived Ease of Use (DOI, TAM) Trust in Technology (TAM) Adoption Readiness/ Intent to Adopt (DOI, TAM)

The worker intervention was aimed at improving the following constructs: perceived risk of drywall dust to personal health, health knowledge about the effects of drywall dust, trust in organization, trust in technology, adoption readiness and self efficacy. The small and large firm interventions were aimed at improving the following constructs among manager/owners of small and large drywall companies: perceived risk to worker health resulting from dust exposure, health knowledge about the constituents contained in drywall dust and specific effects associated with drywall dust exposure, perceived ease of use, perceived usefulness, trust in technology, and adoption readiness of firms.

Little research has attempted to integrate the HBM, DOI and the TAM and to define the relationships between their key constructs in explaining or predicting behavioral intentions to accept and adopt new technology. This project attempted to integrate these models and their similar and complimenting constructs to affect user intentions to accept dust-control technology in the drywall finishing industry through the design, implementation and evaluation of these interventions using these three models as a guide. By taking an integrative approach, researchers can develop an understanding of what factors influence user adoption intentions of technology that has been developed for preventing worker injury and illness. Based on the review of literature, the relation of the constructs that will be used as a basis for design is shown in PtD adoption readiness model below (Figure 9).

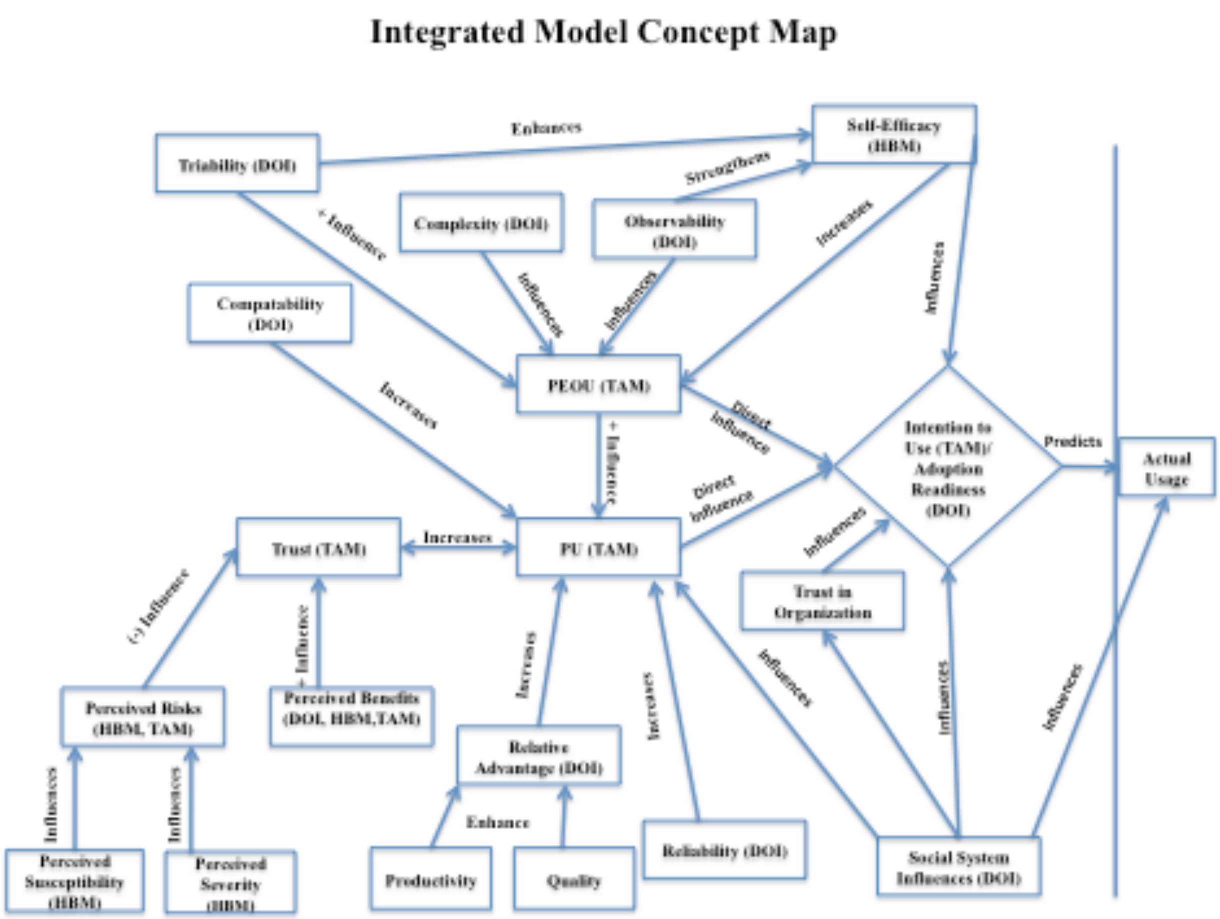


Figure 9 PtD Adoption Readiness Model

There are multiple intervention strategies that, when combined, might have proved to be effective for the project DUSTI interventions. Construction projects pose a complex work environment that is challenged with changing of conditions, and a changing workforce with most construction companies being small (less than 10 employees) companies (Harrington 2009). Considering the transient work population in the very busy, production-oriented construction industry, some of the strategies found through a review of health promotion literature that were used to create the interventions for dust-control technology usage that could produce an effective interventions are educational materials, self efficacy training and social system influences.

3.2.1 Integrated Model Key Constructs

HBM- The HBM components that were incorporated into the Project DUSTI intervention designs were the constructs of health knowledge, self-efficacy, perceived susceptibility, perceived severity, perceived risks, perceived benefits, and cues to action. All of these constructs have been used in previous successful interventions using the HBM. While all of the constructs were used in the design and implementation of the interventions, not all constructs were measured in the interventions. Perceived barriers and benefits act as a decision tool for participants and when participants view the benefits of adopting a health behavior as greater than the risk barriers, then the decision to adopt the behavior is increased. Information relating the benefits of dust-control technology was incorporated in the educational training to help increase the perceived benefits and reduce perceptions of barriers of technology usage for participants. Cues to action were used as a stimulus to remind the participants of what the healthy behavior is although their effectiveness was not individually measured. Self-efficacy was incorporated into the worker and small firm interventions through hands-on training with the workers and small firm owners since the intention to adopt healthy behaviors is more likely to occur if a person has the skills required to adopt the behavior (Fishbein 2003). Health knowledge, perceived risk (which includes perceived severity and perceived susceptibility), and self-efficacy constructs were the target constructs from the HBM that the design of the interventions addressed.

TAM- The TAM constructs that were used in the design of the DUSTI interventions were Perceived Usefulness (PU), Perceived Ease of Use (PEOU) and Trust. These constructs have been found to positively influence the intention to accept technology (Davis 1989; Chau 1996; Venkatesh 2000c; Venkatesh 2000a). The DUSTI interventions focused on training to increase trust in technology and included information on how the technology will benefit the user in the short term and the long term (Chau 1996). The training focused on presenting the PU of the vacuum sanders and how they can benefit the drywall sanding work and the workers using the sanders. Hands-on training with the vacuum sander was incorporated to enhance PEOU by increasing familiarity and efficacy with the tool. This research project incorporated the TAM and makes a contribution to construction safety technology acceptance and adoption research by advancing the understanding of safety technology user acceptance attitudes. User acceptance in this study was viewed from the potential adopter's intent to use rather than actual usage due to the diffusion of dust-control technologies still being in the early stages and the availability for workers to use vacuum sanders is not universal among subjects. Advancing the issue of construction innovation acceptance can fill a research void and meet a need for increased adoption of safety in the workplace.

The training materials created in these interventions were aimed at increasing user and owner perceptions of perceived usefulness of dust-control technologies by showing how the tools and methods can perform drywall sanding effectively while reducing the amount of dust they are exposed to. Through an educational training session and hands-on demonstration, the participants were able to see the technology in use and build their trust in the technology. Informative training on how the sanding tools are designed aimed to increase user awareness and understanding which can help reduce the "creative disablement" of the tools that has been found to be taking place with the sanders. Hands-on demonstrations were used during worker trainings to demonstrate the ease of use of drywall dust-control technologies. The hands-on training that involves the participants and gives them experience using the technology can increase their understanding of how the technology works resulting in more appropriate usage (Dzindolet et al. 2003)

The training materials were also aimed at increasing user trust in dust-control technologies by informing the participants about the perceived risks and perceived benefits of using the technology. The perception of risk is influenced by the information received (Eiser 2002). Risks that arise from using the new technology as well as risks that are present by not using the technologies were included in the intervention designs. Users have been found to show greater trust in technology if they believe there are significant risks for not using the systems (Li et al. 2008). The design of the interventions allowed training that can increase trust in the dust-control technologies by providing the operators with information about the technology of how and why it works along with hands-on training that can build the operator's self-confidence in their ability to properly utilize the tool and receive the benefits (Lee and Moray 1992; Lee and Moray 1994). Information in the training should include information about the predictability, reliability and utility of the technologies (Lippert 2005; Li et al. 2008). These interventions attempted to increase trust in technology by providing credible, reliable information that addressed barriers to adoption in effort to remove uncertainty. Increased trust has been found to positively influence decisions to adopt technology (Lippert 2005; Yee 2005). User training to enable the potential adopters and increase self-efficacy with the tools in a relaxed environment with motivational messages was used to increase trust and promote usage of dust-control technology (Venkatesh 2002).

Factors that were used to increase trust that could lead to adoption that were incorporated into the training were similarity and trial periods. Similarity was incorporated by showing how the new technology is similar to the previous methods through training sessions (Bahmanziari 2003). Trial periods were used as an opportunity was given to use the technology prior to investment which limits the risk of failure and increases the likelihood of adoption (Li et al. 2008) This was accomplished through the distribution of a drywall vacuum sander at no cost to small firm owner intervention participants as part of the intervention to increase familiarity and efficacy with the tools.

DOI- DOI was incorporated since the DUSTI interventions were aimed at introducing a safety innovation to prevent future potential illness among drywall workers. The health rewards that adopting individuals will gain may be delayed in time and are not visible and the consequence of not adopting the innovation on their health may never occur. Preventative innovations have been perceived as having low relative advantage as compared to other innovations that are designed to create a profit (Rogers 2002). Perceived relative advantage has been found to be the most important predictor of the rate of diffusion causing preventative innovations to be slowly adopted. Increasing the rate of preventative innovation adoption can be helped by increasing the perceived relative advantage (Rogers 2003).

The interventions focused on the perceived relative advantage of using the machine in regards to production capability, ease of use and safety. They then incorporated educational materials on the health risks to increase the effectiveness of an intervention approach that focused on approaches that are concerned with worker safety, satisfaction, and motivation (Bresnen 2001). If safety prevention is the only perceived relative advantage then the innovation will be unlikely to be adopted (Rogers 2002). The encouragement of a champion in the intervention population acted as part of the intervention designs to help diffuse information through social networks. In this project, champions were utilized by identifying, through peer identification or self-identification, champions to act as opinion leaders who exhibit the qualities of champions as discussed in the literature review. These champions received training and education that encouraged them to be information gatekeepers who received the dust-control sanders for use within their company and they were encouraged to get others to use the technology.

3.2.2 Worker Intervention Design

The design of the Worker intervention (Table 7) was guided by the constructs that were measured and how these constructs have been used to enhance the intentions to use new technologies to prevent health risks, increase safety, and provide advantages for the users.

Table 7 Worker Intervention Design Constructs

Intervention Theoretical Target Constructs		
Worker Intervention	Small Firm Intervention	Large Firm Intervention
Perceived Risk to Health (HBM) **Health Knowledge (HBM)** **Trust in Organization (TAM)** **Trust in Technology (TAM)** **Adoption Readiness/Intent to Adopt (DOI, TAM)** **Self-Efficacy (HBM)**	Perceived Risk to Health (HBM) Health Knowledge (HBM) Perceived Usefulness (TAM, DOI) Perceived Ease of Use (DOI, TAM) Trust in Technology (TAM) Adoption Readiness/ Intent to Adopt (DOI, TAM)	Perceived Risk to Health (HBM) Health Knowledge (HBM) Perceived Usefulness (TAM, DOI) Perceived Ease of Use (DOI, TAM) Trust in Technology (TAM) Adoption Readiness/ Intent to Adopt (DOI, TAM)

The worker intervention consisted of a combination of didactic (informational) training and interactive training. The intervention focused on two components: training and cues to action. The intervention was aimed at improving the following constructs in relation to worker safety and health: perceived risk of drywall dust to personal health, health knowledge about the effects of drywall dust, trust in organization, trust in technology, adoption readiness and self-efficacy.

A training presentation program was developed that included information about the material composition of drywall dust, the health problems dust could potentially cause, the usefulness and relative advantage of using vacuum sanders which was aimed at influencing worker's perceived views of the usefulness of the tools. The information was assembled from previous studies regarding worker exposure and health outcomes, disease trends in the drywall finishing industry, available engineered technologies and methods for dust-control. Along with health and technology information, workers received a hands-on training with the vacuum sander aimed to enhance worker self-efficacy and trust in technology. The workers and small firms received handouts at the end of the training (Appendix B) that provided basis for the materials covered. This hands-on training attempted to educate the workers on how the system works and to give them experience with its effectiveness. Triability is an element of the DOI that relates to the construct of perceived ease of use from the TAM and enhances the self-efficacy construct of the HBM which all influence a potential adopter's decision to adopt. Workers are prone to sometimes disuse or misuse technology if not properly trained or have not used certain methods that may reduce the trust in the technology. The more someone understands how a technology works, the more likely they are to trust the technology (Dzindolet et al. 2003).

Two "cues to action" were developed as part of the intervention strategy. Cues to action are prompts that remind people to take action to practice certain behaviors that will protect their health. Incorporating cues to action into the worker intervention helped to provide a stimulus to participants and serve as a reminder to practice safe behavior. Cues to action can be realized in a variety of forms but should be elicited from potential cues that the participant is exposed to on a regular basis. Cues that could be used are visible cues such as hard had stickers, t-shirts, posters, or could come from non-visible sources such as experiences with family or other workers (Elder 1999). For this intervention, cues that workers can see regularly were used so the behavior could be reinforced often. The first cue to action was t-shirts the workers were given and could wear regularly to remind them and their co-workers of the hazards associated with drywall dust exposure and the importance of using dust-control technology to protect them from over-exposure to dust. The second cue to action was hart hat stickers aimed at reminding workers to use dust control technologies. These cues (Appendix E) attempted to serve as a motivation to employees to implement dust control methods to improve their health and quality of life. Drywall sanders who use PtD solutions will be less likely to require respiratory protection, they will be less irritated by airborne drywall dust and should be more comfortable, more alert and more productive (Mead et al. 1995).

3.2.3 Small Firm Intervention Design

The design of the Small Firm intervention (Table 8) was guided by the constructs that were measured and how these constructs have been used to enhance the intentions to use new technologies to prevent health risks, increase safety, and provide advantages for the users.

Table 8 Small Firm Intervention Design Constructs

Intervention Theoretical Target Constructs		
Worker Intervention	**Small Firm Intervention**	Large Firm Intervention
Perceived Risk to Health (HBM) Health Knowledge (HBM) Trust in Organization (TAM) Trust in Technology (TAM) Adoption Readiness/Intent to Adopt (DOI, TAM) Self-Efficacy (HBM)	**Perceived Risk to Health (HBM) Health Knowledge (HBM) Perceived Usefulness (TAM, DOI) Perceived Ease of Use (DOI, TAM) Trust in Technology (TAM) Adoption Readiness/ Intent to Adopt (DOI, TAM)**	Perceived Risk to Health (HBM) Health Knowledge (HBM) Perceived Usefulness (TAM, DOI) Perceived Ease of Use (DOI, TAM) Trust in Technology (TAM) Adoption Readiness/ Intent to Adopt (DOI, TAM)

The small firm intervention was aimed at improving the following constructs among manager/owners of small drywall companies: perceived risk to worker health resulting from dust exposure, health knowledge about the constituents contained in drywall dust and specific effects associated with drywall dust exposure, trust in technology, perceived usefulness, perceived ease of use, and adoption readiness of firms. Small firm owners were targeted because decisions to use new innovations is not usually up to the individual workers but are made by the managers of the company (Koebel 1999). The intervention consisted of a mixed informational and interactive training session with the owners of small drywall firms that included information about the material composition of drywall compound, the constituents that are present during drywall sanding operations, effects of illness related to drywall dust exposure, previous studies relating to worker exposure and health outcomes, disease trends in the drywall finishing industry, regulatory issues, and engineered dust control technologies and their impact on productivity and customer satisfaction. The workers and small firms received handouts at the end of the training (Appendix B) that provided basis for the materials covered. The training also included a hands-on demonstration of drywall finishing using vacuum sanders that allowed participants to gain familiarity with the dust-control technology. Small firm intervention participants received a vacuum sander to use in their company. Providing the sanders at no cost to the owners allowed them and their workers to try the technology at no investment risk and provided triability, a key element that can influence the diffusion of new innovations. As owners and workers were able to use the sander free of charge, it allowed them the opportunity to gain familiarity with the tool, increase their self efficacy, increase trust in the technology, and overcome potential barriers to adoption which can all be influential in the decision to adopt new technology.

The aim of the training session was to create a "technology champion" within the small firms. Technology champions are indispensible players in the diffusion of innovation process. These champions sponsor, protect and promote new products and methods and have the authority to negotiate and balance the opportunities and risks of using new technologies against the previous products or methods (Manseau and Shields 2005). Technology champions are highly enthusiastic and committed individuals who are willing to make special efforts and take risks to lead innovation processes in a company. Previous work by Keobel has shown that technology champions within companies can significantly improve the adoption of new technologies and work methods (Koebel 2008). Technology champions are willing to take risks associated with innovation. In a previous diffusion of innovation study, about 70% of construction firms surveyed were found to have a technology champion within their company who kept them aware of innovative product and processes (Koebel 2008). As a person finds out about a new product or process and takes a risk and begins to use it, they share their personal and subjective experiences with others which gradually give meaning to the innovation and help people to adopt the new ideas (Rogers 2004). The identification of a champion in small firms was used to help promote the use of vacuum sanders. Champions were identified through either through self-reporting or through peer identification.

3.2.4 Large Firm Intervention Design

The design of the Large Firm intervention (Table 9) was guided by the constructs that were measured and how these constructs have been used to enhance the intentions to use new technologies to prevent health risks, increase safety, and provide advantages for the users.

Table 9 Large Firm Intervention Design Constructs

Intervention Theoretical Target Constructs		
Worker Intervention	Small Firm Intervention	**Large Firm Intervention**
Perceived Risk to Health (HBM) Health Knowledge (HBM) Trust in Organization (TAM) Trust in Technology (TAM) Adoption Readiness/Intent to Adopt (DOI, TAM) Self-Efficacy (HBM)	Perceived Risk to Health (HBM) Health Knowledge (HBM) Perceived Usefulness (TAM, DOI) Perceived Ease of Use (DOI, TAM) Trust in Technology (TAM) Adoption Readiness/ Intent to Adopt (DOI, TAM)	**Perceived Risk to Health (HBM)** **Health Knowledge (HBM)** **Perceived Usefulness (TAM, DOI)** **Perceived Ease of Use (DOI, TAM)** **Trust in Technology (TAM)** **Adoption Readiness/ Intent to Adopt (DOI, TAM)**

The intervention for large firms was aimed at improving constructs that were identified as barriers to adoption of dust control tools and methods in previous studies by Young-Corbett (Young-Corbett and Nussbaum 2009b). The specific constructs that were targeted were: perceived risk to worker health resulting from dust exposure, health knowledge about the constituents contained in drywall dust and specific effects associated with drywall dust exposure, trust in technology, perceived usefulness, perceived ease of use, and adoption readiness of firms.

Purchasing departments play a large role in the adoption of new products and methods in large companies and are responsible for the decisions made and innovative risks taken (Koebel 2008). Purchasing agents must be convinced of a product's benefits and that manufacturers will support their products. Understanding products and processes and the potential benefits that could be realized through the use of new innovations could help purchasing agents make informed decisions about adopting safety and health innovations.

A web site was developed as part of the large firm intervention. The web site was structured to provide information on about drywall worker health and safety in regards to dust control as well as demonstrate the successful use of vacuum sanders. The information on the web site contained findings from previous studies on drywall dust and the health effects it has on workers as well as regulatory drivers such as OSHA regulations and network effects such as insurance premiums that could influence the decision makers' decision to adopt. Included on the site were video clips showing the performance of the vacuum sander compared to the use of conventional sanding methods. The video demonstrated the time difference between the two methods in effort to demonstrate the productivity gains and health benefits that can be realized by using the vacuum sander. Screen shots from the website can be found in Appendix C.

Prior to the development of the web site, information about quality and productivity was generated through a work analysis study performed by graduate students at Virginia Tech. This work-study incorporated students trained drywall finishers who performed identical sanding tasks with a pole hand sander and again with a vacuum sander. The sanding sessions were recorded and analysis was performed to obtain data about the task cycle times and efficiency. Sanding area square footage completed in a given amount of time was measured to determine productivity of the workers. The results of the sanding sessions were evaluated for quality by professional drywall finishers. The results of these sanding sessions were included on the web site.

3.3 Intervention Implementation

Participants in this quasi-experimental design included recruited workers and owners of small firms from a convenience population of Virginia and North Carolina. These participants were recruited based on the recommendation of drywall supply companies in Virginia and North

Carolina. Large firms were recruited from the national trade organizations for drywall finishing including the Finishing Contractors Association and the Association of Wall and Ceiling Industries as well as from recommendations from general contractors around the country. The definition of a large firm for this study was any company that employs more than 100 workers. Recruitment of workers and small firms was performed through the contact of drywall distributors in Virginia and North Carolina. The research plan calls for 40 participants in each of the 3 respondent groups. Of the 40 in each group, 20 will receive the intervention and 20 will serve as a control group by not receiving the intervention. It was determined that a minimum of 17 control and intervention participant respondents for each round should be obtained according to statistical software sample size power calculations. The research plan called for 40 participants in each group to allow for some attrition of participants over the 3 month period due to the transient nature of construction workers. Participants were recruited as volunteer participants as such they could have elected to drop out of the study at any time (Goldenhar 1996). All participants in the small firm and employee groups were compensated in the amount of fifteen dollars an hour for their participation. The Large firm participants were compensated with a $25 Home Depot Gift Card for each round of participation.

The intervention implementation began with a member of the research team gaining consent from the participants and explaining that the participant's identity will remain anonymous followed by a pre-test for all participants administered by a member of the research team. Once the interventions were administered, the participants were then given the posttest. Following the interventions and initial control surveys, attempts were made to contact all participants again three months following the intervention and were given the same posttest. When measuring changes in employee knowledge and attitudes after a training session, measurements should be taken prior to the intervention, immediately after the intervention and around three months following the intervention to see if the intervention has a lasting effect on the participants (Feldman et al. 2004). Due to the rapidly changing workforce in the construction industry where workers frequently have no long-term relationships with given employers, a three-month interval between the intervention and posttest should aid in providing a greater response rate for the study (Brunette 2005). This was found to be relevant in this study during the posttest where even in the 3 months following initial contact, workers were no longer working with the same employers and some small firms had gone out of business.

The basic structure of the interventions were based on health promotion interventions that were given to minority women to prevent sexually transmitted diseases and research done in Georgia relating to how skin cancer information is being distributed to agricultural workers (Parrott et al. 1996; Shain et al. 1999). The structure consisted of teaching the participants to recognize the risk, committing them to change and enhancing self-efficacy skills. This structure incorporated the constructs of the HBM, TAM and Diffusion of Innovation Models in the educational training sessions of the implementation stage of the interventions.

The Project DUSTI research plan was designed by Dr. Young Corbett and is outlined in Table 10.

Table 10 DUSTI Research Implementation Plan

DUSTI Research Plan					
Workers		Small Firms		Large Firms	
Treatment (n=20)	Control (n=20)	Treatment (n=20)	Control (n=20)	Treatment (n=20)	Control (n=20)
Pre-test: Questionnaire: HBM Constructs Health Knowledge Trust-in-Technology Adoption Readiness	**Pre-test:** Questionnaire: HBM Constructs Health Knowledge Trust-in-Technology Adoption Readiness	**Pre-test:** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness	**Pre-test:** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness	**Pre-test:** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness	**Pre-test:** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness
Intervention: Training: Health Information Dust Risks Dust Health Effects Dust Controls Hands-on Cues to Action: T-shirts Hard Hat stickers	**None**	**Intervention:** Technology Champion: Demonstration of Technology Training: Productivity Safety Customer Satisfaction Health Information Regulatory Information	**None**	**Intervention:** Information: Productivity Quality Study Health Information Regulatory Information	**None**
Post-test 1 Questionnaire: HBM Constructs Health Knowledge Trust-in-Technology Adoption Readiness		**Post-test 1** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness		**Post-test 1** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness	
3 month period **Post-test 2** Questionnaire: HBM Constructs Health Knowledge Trust-in-Technology Adoption Readiness	3 month period **Post-test** Questionnaire: HBM Constructs Health Knowledge Trust-in-Technology Adoption Readiness	3 month period **Post-test 2** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness	3 month period **Post-test** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness	3 month period **Post-test 2** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness	3 month period **Post-test** Questionnaire: Perception of Risk Health Knowledge Perceptions of Technology Barriers Adoption Readiness

3.3.1 Worker intervention Implementation

The Worker intervention began with a member of the research team contacting drywall companies based on the recommendations of local drywall suppliers. The researchers obtained consent from the drywall companies to contact their workers who were then recruited as volunteer participants who acted as control participants or receive the intervention. Participants were compensated in the amount of fifteen dollars an hour. Consenting employers were encouraged to participate in the employer interventions. The participants were randomly assigned as either control group or intervention group participants and given a pretest as a basis for evaluation of the intervention. The control participants contact information was taken and attempts were made to contact participants again after 3 months to take the posttest. Intervention participants were given the intervention immediately following the pretest and then attempts were made to contact participants to administer a posttest after 3 months.

The interventions were held at the jobsites where the employees are working so that practical hands on experience could be demonstrated in the training and disruption of employer operations could be minimized. The training was worker centered with hands on training that attempted to motivate employees to remain active in improving their safe working conditions (Becker 2004). An authorized OSHA outreach trainer with experience in teaching construction safety topics administered the training sessions in this intervention. Interactive small group training was be used as this method has been strongly associated with achieving desired changes in work practices (Goldenhar 2001). The implementation involved increasing worker knowledge about working around drywall dust and how to control the hazard, attempting to decrease negative perceptions about the control methods and allowing them to practice using the tools to gain self-efficacy (Parrott et al. 1996). The intervention included a short educational training focusing on content about the potential health effects of drywall dust based on past studies found in the literature review, information about the OSHA regulations for exposure to drywall dust, and information about the use and effectiveness of the various PtD options available for controlling dust exposure. The trainer then showed how to properly use the vacuum sander and highlighted the safety features of the tool. Employees were then given the opportunity to practice with the sanders to apply what they learned in the training on their projects. All workers received a certificate of training to acknowledge they have received health and safety training from an OSHA authorized trainer. This certificate was aimed to enhance the credibility of the training and provided employers added training documentation OSHA regulations require employers to keep. As part of the worker intervention materials, T-shirts and hardhat stickers were also given to the workers to serve as cues to action reminding the workers of the training received and the actions they need to take to protect their health.

3.3.2 Small Firm Intervention Implementation

The Small Firm intervention began with a member of the research team contacting drywall companies based on the recommendations of local drywall suppliers. The researchers obtained consent from the drywall companies recruited as volunteer participants who received the intervention. Participants were compensated in the amount of fifteen dollars an hour. Consenting employers were encouraged to allow employee participation in the worker interventions. The participants were assigned as either control group or intervention group participants and given a pretest as a basis for evaluation of the intervention. The control participants contact information was taken and attempts were made to contact participants again in three months to receive the posttest. Intervention participants were given the intervention immediately following the pretest and then received the posttest immediately following the intervention. Those participants with whom successful contact was made again after 3 months were given a final posttest.

The small firm interventions were held on the jobsite where the employees were working so that practical hands on experience could be demonstrated in the training and disruption of employer operations could be minimized. An authorized OSHA outreach trainer with experience in teaching construction safety topics administered the training sessions in this intervention. Interactive training was used as this method has been strongly associated with achieving desired changes in work practices (Goldenhar 2001). The implementation aimed to increase employer knowledge about working around drywall dust and how to control the hazard, decrease negative perceptions about the control methods and allowed them to see the tools in action to enhance trust in the technology. All employers received a certificate of training to acknowledge they have received health and safety training from an OSHA authorized trainer. The certificate aimed to enhance the credibility of the training and provided employers added training documentation that OSHA regulations require employers to keep. As part of the small-firm intervention, small firm owners were given a drywall sander free of charge for use within their company. This allowed the owners to use the tool free of investment risk and give them the ability to champion the technology in their firm by implementing the use on their projects among their workers.

3.3.3 Large Firm Intervention Implementation

The Large Firm intervention began with contacting members of the national drywall trade organizations including Finishing Contractors Association (FCA) and Association of the Wall and Ceiling Industries (AWCI) and large drywall contracts referred by general contractors around the nation. Members of the research team made telephone contact with key purchasing decision makers in the large companies. In the telephone contact, consent to participate was obtained along with the participant's contact information followed by a pretest that was administered through online media to all participants. Control group participants were emailed a $25 Home Depot gift card as compensation for their participation. Following the telephone contact, a follow-up email was sent to the purchasing decision maker, which contained a link to the intervention web site. Participants were asked to login using future contact information, take the pretest and then view the website content and then take a posttest after viewing the website. For the group that received the intervention, a short informational website session provided information about the availability and benefits of vacuum sanders and other dust control technologies. Information was also provided on health risks associated with drywall dust as well as evidence of work quality and productivity. Three months following the submission of the initial posttest, reminder emails were sent to participants with a link to the second posttest. Participants in the large firm intervention were compensated in the form of $25 Home Depot gift cards.

3.4 Intervention Evaluation

The main goal of occupational health and safety intervention research studies is to determine if the intervention either enhanced or did not enhance worker safety and health (Robson et al. 2001). These interventions were evaluated using the results from a quasi-experimental design consisting of a pre-test/ posttest with-in subjects design with control groups that do not receive the intervention. Quasi-experimental designs allow for a means of compromise between the practical workplace restrictions and the rigor required for demonstrating intervention effectiveness. Quasi-experimental designs are structured similar to experimental designs but the participants and control group are created through a non-random process (Robson et al. 2001). The analysis of scores relating to the theoretical constructs from the pretest and posttest measurement instruments was used to determine the effectiveness of the interventions. A statistically significant increase in the scores served as a measurement of the success of the interventions as it relates to the various constructs being examined. Effects of the interventions on the theoretical constructs, in Table 11 below, that were measured in each intervention were evaluated by gain scores of analysis of variance (ANOVA) on the simple differences between responses on pretests and posttests. The results of the intervention evaluations are expounded in chapter 4 of this dissertation.

Table 11 Intervention Evaluation Constructs

Intervention Theoretical Target Constructs		
Worker Intervention	Small Firm Intervention	Large Firm Intervention
Perceived Risk to Health (HBM) Health Knowledge (HBM) Trust in Organization (TAM) Trust in Technology (TAM) Adoption Readiness/Intent to Adopt (DOI, TAM) Self-Efficacy (HBM)	Perceived Risk to Health (HBM) Health Knowledge (HBM) Perceived Usefulness (TAM, DOI) Perceived Ease of Use (DOI, TAM) Trust in Technology (TAM) Adoption Readiness/ Intent to Adopt (DOI, TAM)	Perceived Risk to Health (HBM) Health Knowledge (HBM) Perceived Usefulness (TAM, DOI) Perceived Ease of Use (DOI, TAM) Trust in Technology (TAM) Adoption Readiness/ Intent to Adopt (DOI, TAM)

3.4.1 Data Collection

As part of the three organizational sub-system interventions, two questionnaires were developed as survey instruments that were designed to measure the key constructs of interest. The questionnaires consisted mainly of Likert-type scaled response options that were used to measure the respondent’s opinions and beliefs concerning the theoretical target constructs that the interventions addressed. A worker version of the questionnaire was developed to measure the dependent variables that were examined during the worker intervention which were: health knowledge, adoption readiness, and four elements of the HBM (perceived susceptibility to health problems relating from drywall dust, perceived severity of health effects from drywall dust exposure, perceived benefits of dust control, and perceived barriers to dust control). The questionnaire developed for the worker intervention was used as the pre-test and as both post-tests; the first being administered immediately after the intervention and the second was administered three months following the intervention. Effects of the intervention on the dependent variables for worker intervention were evaluated by gain scores of analysis of variance (ANOVA) on the simple differences between post-and pre-tests.

A second questionnaire was developed that was used to measure the dependent variables for small firm owners and large firm purchasing agents which are: health knowledge, adoption readiness, perceived impacts on productivity, perceived impacts on quality and four HBM constructs (perceived worker susceptibility to health effects resulting from dust exposure, perceived severity of health effects from dust exposure, benefits of dust controls, and barriers to dust control). The questionnaire developed for the employer interventions was used as the pre-test and as both posttests, the first being administered immediately after the intervention and the second to be administered a three months following the intervention. Effects of the interventions on the dependent variables for small and large firm interventions were evaluated by gain scores of analysis of variance (ANOVA) on the simple differences between post-and pre-tests. Along with the Likert-scale response questions, open-ended questions were asked to small and large firms to determine any network effects that may be affecting organizational adoption of engineered dust-control technology. Open-ended questions can be used to help elucidate the steps between the intervention and the final outcome (Robson et al. 2001).

3.4.2 Survey Instrument Design

While examples of validated instruments were found for the three theoretical frameworks (Moore 1991; Lux 1994; Koebel 2008; Montague 2010) that are the basis for the constructs examined in this study, after a review of literature, there was no comprehensive instrument found that would be suitable to measure all of the dependent variables being explored in the interventions. Accordingly a measurement instrument had to be created that could functionally obtain the data needed for evaluation of the effectiveness of the interventions on the dependent variables. In creating these instruments, items from validated instruments were adapted from the HBM, Diffusion of Innovation and Technology Acceptance Models to address the theoretical constructs (Moore 1991; Lux 1994; Koebel 2008; Montague 2010). One factor considered in the instrument design was to allow for the questionnaires developed for this study to be generally applicable. This would allow for other safety and health interventions to use the developed questionnaires with only minor adjustments. The purpose of the instrument is to serve as a pre-test/post-test for the intervention that will gauge the effectiveness of the interventions that measured the positive change in scores of those who receive the interventions versus the control group. The quasi-experimental design involved a control group for each of the three groups of respondents. The control group aided in the validation on the interventions' effectiveness.

In a joint effort of the American Psychological Association, the American Education Research Association and the National Council on Measurement in Education, created the Standards for Educational and Psychological Tests where the three basic types of validity are outlined as: criterion, content and construct (Kaplan 1976). Criterion validity is exhibited when an investigator is primarily interested in some criteria which is predicted to occur that is measured during or after a test is given (Cronbach and Meehl 1955). This research assesses criterion validity with the use of a post-intervention questionnaire to measure the predicted increase in scores relating to theoretical constructs being measured. Content validity is dependent on whether the items in a measurement instrument are representing the concepts of interest (Kaplan 1976). The technical quality and the representativeness of the content upon which the items are based is included in content validity (Wolfe and Smith 2007). A measurement tool that exhibits content validity exhibits "face validity," which is the appearance that the items contained in the instrument are related to the items of interest (Kaplan 1976). Having industry experts review the content of the instrument for completeness helped assess the content validity of the measurement instrument. Construct validity is established by relating evidence that theories about the construct being measured adequately account for performance results on the measurement test (Wolfe and Smith 2007). Specifying the relations of constructs is used to assemble evidence and support for a particular measurement to have meaning (Kaplan 1976). A workgroup consisting of doctoral students was used to sort measurement items, which were not adapted from previously validated instruments, into construct categories for use as measurement tools to assess construct validity. Table 12 outlines the measures used to assess the validity of the survey instruments used in this research.

Table 12 Validity Assessment of Instrument Development

Instrument Development Efforts to Establish Validity		
Criterion Validity	Content Validity	Construct Validity
Posttest after intervention will be used to measure predicted increase in scores relates to theoretical constructs being measured	Review of instrument by construction and drywall industry experts in terms of relevance, representativeness and technical quality as it relates to the drywall industry	Work group sorted measurement items into construct categories for use as measurement tools

The first stage of the instrument development process was item creation. Items were created for the two instruments. The first instrument was the worker instrument that served as the pretest and posttest for the interventions. The second instrument was the instrument that served as the pretest and posttest for both the small firm and large firm interventions. Questions were developed for both instruments which included adapted items from validated questionnaires scales, and by creating additional items that appeared to fit the construct definitions (Moore 1991). The newly created items were then separated by members of the project work group into construct categories that differentiated the items from other construct items so that relationships between the focus construct and the other constructs could be identified. These categories were established by members of the project workgroup composed of PhD students and professors at Virginia Tech. The construct categories for the worker instrument included health belief, self-efficacy, adoption readiness, trust in organization, and trust in technology. The construct boundaries for the small and large firm instrument were health perceptions, risk, trust in technology and adoption readiness. The process for creating the pre-test/posttest instruments is outlined in Figure 10.

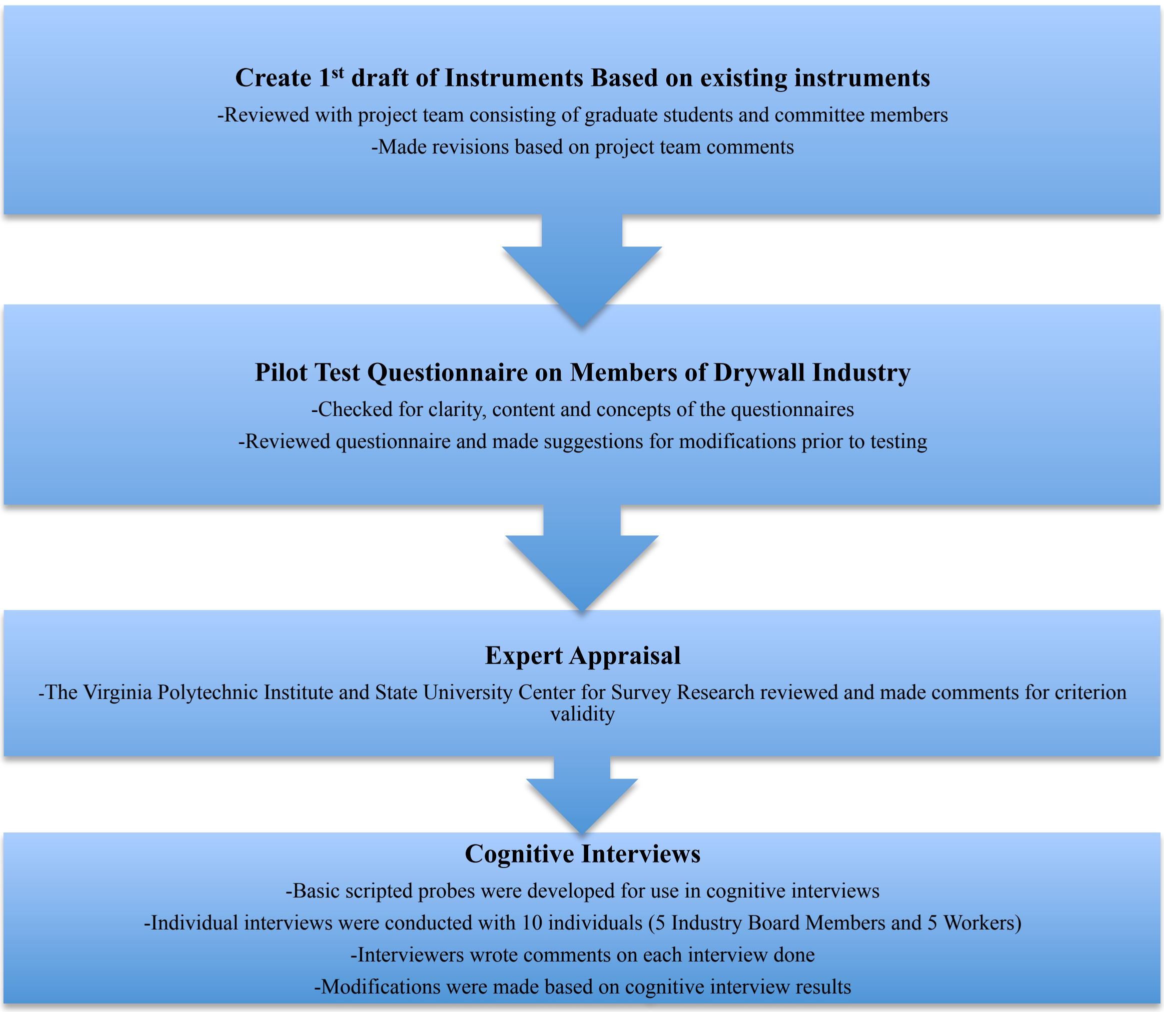


Figure 10 Survey Instrument Design Process

The procedure was to have a work group consisting of three graduate students at Virginia Tech, with experience in building construction and construction safety, and PhD committee members, with varying research backgrounds including construction, worker safety and health, the health belief model, diffusion of innovation and trust in technology, review sort and examine the items. Any items that were determined to be inappropriately worded or ambiguous were revised. A Likert scale ranging from Strongly Disagree, Somewhat Disagree, Somewhat Agree and Strongly Agree was set for each response.

Once the scales were determined, the various items were assembled into an instrument and moved to the instrument testing stage. The instruments were developed by adapting validated questions from instruments used for other studies involving the HBM, Diffusion of Innovation and Trust in Technology. HBM questions relating to health perception, self-efficacy and health belief were adapted from (Lux 1994). Diffusion of Innovation questions addressing barriers to adoption, readiness to adopt and perception of risk were adapted from (Moore 1991; Koebel 1999, 2008). Trust in Technology and Organization questions were adapted from (Davis 1989; Moore 1991; Venkatesh 2000b; Montague 2010). The instruments then went through a review by a workgroup that included the investigator, co-investigators and the project committee members who brought in expertise in drywall operations, Diffusion of Innovation, Trust in Technology and the HBM.

Once the first drafts were developed by the workgroup, a pilot study was conducted with members of the drywall finishing industry serving as Subject Matter Experts (SMEs). SMEs were recruited from the construction industry in Blacksburg, Virginia. The SMEs were asked to review the instrument items in order to ascertain the content validity of the items in terms of relevance, representativeness and technical quality as it relates to the drywall finishing industry. The verbal discussion notes from the interview were taken and kept on file with the project instrument development file and SME comments were incorporated into a second draft. The comments received from the SME review are listed in Tables 13 and 14 for the worker and employer instruments respectively. Items viewed by the SME as unclear or leading were reviewed and revised or omitted from the pool of questions. Items that were deemed to be confusing or negatively worded were revised and incorporated into future revisions.

Table 13 Worker Construct SME Review

Target Construct	Item	Decision
Health Belief	Drywall dust has bad affects on my health	Revise/Drop
Health Belief	I am not worried about being exposed to drywall dust	Keep
Health Belief	I am very healthy so working around drywall dust doesn't affect me	Keep
Health Belief	Drywall dust contains dusts such as silica that can cause cancer or other health problems	Revise/Drop
Self-Efficacy	I feel confident in my ability to properly protect myself from exposure to dust	Keep
Trust in Organization	My employer takes appropriate steps to protect me from things that could damage my health and safety	Revise
Trust in Organization	My employer requires me to use dust-reducing methods such as ventilated-sanders, wet methods, low dust compounds or wear a respirator when performing drywall finishing tasks	Revise/Drop
Trust in Organization	My employer cares as much about worker health and safety as they do getting the job done fast and making money	Revise/Drop
Trust in Organization	My employer helps me work safely and will provide means for me to use new safe technology	Revise/Drop
Trust in Technology	Ventilated (Vacuum) sanders, wet sanding methods, and low dust joint compounds are effective methods for finishing drywall	Revise/Drop
Trust in Technology	Dust reducing methods produce quality drywall finish work	Revise
Trust in Technology	Dust reducing tools and methods are easy to use	Revise
Trust in Technology	Dust reducing tools have no effect on the time it takes to complete drywall finishing	Revise
Trust in Technology	Vacuum sanders, wet methods, and low dust joint compounds are effective at lowering the amount of dust I am exposed to.	Revise/Drop
Self-Efficacy	I feel confident in my ability to use a vacuum sander to finish drywall	Keep
Self-Efficacy	I feel confident in my ability to correctly use a respirator mask when finishing drywall	Keep
Trust in Technology	I would use dust control methods and tools if my employer provided them	Revise
Trust in Technology	I would use dust control tools only if my employer made me use them	Revise/Drop
Trust in Technology	I won't work without dust control tools or methods in place	Revise/Drop
Trust in Technology	I feel confident I could produce quality drywall finishes using ventilated sanders or wet methods	Revise/Drop

Table 14 Employer Construct SME Review

Target Construct	Item	Decision
Perception of Risk	Exposure to drywall dust poses a potential health risk to workers in regards to silica exposure	Revise
Perception of Risk	My employees are potentially exposed to high levels of dust concentrations that would exceed OSHA limits	Revise/Drop
Perception of Risk	In the absence of dust control technologies such as vacuum sanders, wet sanding methods, and dust reducing joint compounds, workers are often overexposed to dust concentrations	Revise/Drop
Perception of Risk	There is a threat of future litigation resulting from exposing employees to high levels of dust in drywall finishing	Revise/Drop
Health Knowledge	Would you say drywall dust poses a great threat, somewhat of a great threat, an unknown threat, not much of a threat, or no threat to the health f workers in your firm?	Revise/Drop
Health Knowledge	My employees are susceptible to health problems from exposure to drywall dust	Keep
Health Knowledge	Drywall dust contain dusts such as silica that can cause cancer or other health problems.	Revise/Drop
Health Knowledge	In your firm employees have complained about health problems resulting from drywall dust exposure	Revise/Drop
Barriers to Adoption	Using dust control technologies increases the cost of finishing drywall	Revise
Barriers to Adoption	Using dust control technologies increases the quality of finishing drywall	Revise
Barriers to Adoption	Using dust control technologies increases the time it takes to finish drywall	Revise/Drop
Barriers to Adoption	Vacuum sanders are easy to use	Keep
Adoption Readiness	Innovations lead to increased profits	Revise
Adoption Readiness	My company feels it is risky to be among the first to try new safety technologies	Keep
Adoption Readiness	Your company will only buy from established manufacturers	Revise/Drop
Adoption Readiness	Your company generally sticks with what has worked in the past	Revise/Drop
Adoption Readiness	Your companies strategy is to be innovative and creative	Revise/Drop
Adoption Readiness	Your company is eager to adopt new technologies relating to dust control on your projects	Revise/Drop
Adoption Readiness	Your company is likely to spend time and money to implement dust control technology to reduce worker exposure to drywall dust	Revise/Drop

Following the SME review and creation of the pretest version, the survey instrument was reviewed by the Center for Survey Research at Virginia Tech for criterion validity to determine if the questions would give the evidence that is desired. Following the review, changes were incorporated and the instruments were evaluated for structural problems and content validity through cognitive interviews with drywall finish workers and members of the Construction Industry Advisory Board for the Building Construction Department of the Myers-Lawson School of Construction at Virginia Tech. Cognitive interview techniques based on (Willis 2005) using a concurrent, scripted probing method were conducted with industry board members and drywall workers recruited from Southwest Virginia.

The cognitive interviews were scheduled for 30 minutes. The interviews were held in a private conference room setting. The interviews began with an overview of the project and explanation of the purpose of the cognitive interview process in instrument design and development. Participants were informed that the interview was not a data gathering session but rather a session to evaluate the questionnaires for clarity and relevance to the industry. A rating scale was then selected as an appropriate scale to support the substantial aspect of construct validity by showing a set of items that share a fixed set of response options and the difficultly of the thresholds do not vary across items (Wolfe and Smith 2007). A five-point scale was developed to determine the clarity of each question and difficulty of answering each of the questions. The clarity scale was based on 1 being very unclear and a 5 being very clear. The difficulty of answering scale was based on a 1 being very difficult to answer and a 5 being very easy to answer. The interview participants were asked to rate and provide comments for each of the questions. Scripted probing questions were developed for use by all interviewers prior to the interviews along with allowing for spontaneous probing by the interviewer as needed (Willis 2005). Notes were taken by graduate students at Virginia Polytechnic Institute and State University and were recorded subsequent to each interview and kept on file in the instrument development file for the project. Questions receiving a mean score of less than 4.0 on a five-point scale were examined for revision while questions with a mean score of less than 3.0 were dropped from the questionnaire. The breakdown of responses from each question are shown in Tables 15 and 16.

Table 15 Worker Instrument Cognitive Interview Results

Worker Construct Cognitive Interview Results

Note-Mean Scores less than 4.0 were reviewed while means scores with less than 3.0 were dropped

NO.	**Target Construct**	**Item**	**Mean Clarity Score**	**Mean Difficulty Score**	**Decision**
1	Familiarity	**How familiar are you with vacuum sanders use for drywall finishing?**	5.00	5.00	Revise/Keep
2	Frequency of Use	**How often do you use vacuum sanders when finishing drywall?**	5.00	5.00	Revise/Keep
3	Frequency of Use	**How often do other workers in your company use vacuum sanders when finishing drywall?**	4.67	4.67	Revise/Keep
4	Adoption Readiness	**I *would like/like* to use a vacuum sander to finish drywall**	3.67	4.00	Revise/Keep
5	Frequency of Use	**How often do you use a dust mask when finishing drywall?**	5.00	5.00	Revise/Keep
6	Frequency of Use	**How often do other workers in your company use dust masks when finishing drywall?**	5.00	5.00	Revise/Keep
7	Adoption Readiness	**I would like/like to use a dust mask to finish drywall**	3.67	4.00	Revise/Keep
8	Adoption Readiness	**The decision to use or not use a vacuum sander is voluntary (as opposed to required by my supervisors or job description)**	4.33	4.33	Revise/Keep
9	Adoption Readiness	**The decision to use or not use a dust mask is voluntary (as opposed to required by my supervisors or job description)**	4.67	4.67	Revise/Keep
10	Trust in Organization	**I feel good about my employer's decision to *use/not use* vacuum sanders**	4.33	4.33	Keep
11	Trust in Organization	**My employer has me finish drywall in a safe way**	5.00	5.00	Revise/Keep
12	Trust in Organization	**My employer protects me from health risks**	5.00	5.00	Keep
13	Trust in Organization	**I trust my employer**	5.00	5.00	Keep
14	Trust in Technology	**Vacuum sanders are effective for finishing drywall**	4.00	4.00	Revise/Keep
15	Trust in Technology	**Vacuum Sanders are a safe way to finish drywall**	4.67	4.67	Revise/Keep
16	Self Efficacy	**I feel confident in my ability to use a vacuum sander to finish drywall**	4.67	4.67	Revise/Keep
17	Trust in Technology	**I feel confident that vacuum sanders are effective at lowering the amount of dust I am exposed to**	4.67	4.67	Revise/Keep
18	Adoption readiness	**Using a vacuum sander is frustrating**	4.67	4.67	Keep
19	Self Efficacy	**It's easy to get a vacuum sander to do what I want it to do**	4.67	4.67	Keep
20	Health Knowledge	**I am worried about being exposed to drywall dust**	4.67	4.67	Keep
21	Perceived Risk to Health	**I am healthy so working around drywall dust doesn't affect me**	4.67	4.67	Keep
22	Perceived Risk to Health	**Working around drywall dust puts me at risk for health problems**	5.00	5.00	Keep
23	Self Efficacy	**I feel confident in my ability to properly protect myself from exposure to dust**	5.00	5.00	Keep
24	Self Efficacy	**I feel confident in my ability to correctly use a mask when finishing drywall**	5.00	5.00	Revise/Keep
25	Health Knowledge	**A mask should be worn even when using a vacuum sander to finish drywall**	4.67	4.67	Revise/Keep

Table 16 Employer Instrument Cognitive Interview Results

Employer Construct Cognitive Interview Results
Note- Note-Mean Scores less than 4.0 were reviewed while means scores with less than 3.0 were dropped

No.	Target Construct	Item	Mean Clarity Score	Mean Difficulty Score	Decision
1	Familiarity	**How familiar are you with vacuum sanders used for drywall finishing?**	4.8	5	Keep
2	Frequency of Use	**How often do your employees use vacuum sanders when finishing drywall?**	4.8	4.6	Revise/Keep
3	Frequency of Use	**How often do the workers in your company connect the vacuum to the vacuum sanders when finishing drywall?**	3.6	3.8	Drop
4	Frequency of Use	**How often do your employees use a dust mask when finishing drywall?**	5.0	4.8	Keep
5	Perceived Risk to Health	**Exposure to drywall dust poses a potential health risk to workers**	4.2	4.2	Revise/Keep
6	Perceived Risk to Health	**Working in the drywall industry is a risk factor for certain illnesses**	3.0	3.6	Revise/Keep
7	Perceived Risk to Health	**When conventional block sanding is used, my employees are exposed to high dust concentration levels**	4.0	4.2	Keep
8	Perceived Usefulness	**When using vacuum sanders, workers are exposed to lower dust levels**	4.2	4.8	Keep
9	Health Knowledge	**My employees are susceptible to health problems from exposure to drywall dust**	4.6	4.8	Keep
10	Health Knowledge	**Components of drywall dust can cause health problems**	3.4	3.8	Review/Keep
11	Health Knowledge	**My employees should wear a dust mask when using a vacuum sander**	4.8	4.8	Keep
12	Health Knowledge	**I feel confident in my employees' ability to correctly use a dust mask when finishing drywall**	4.0	4.8	Revise/Keep
13	Perceived Ease of Use	**I feel confident in my employees' ability to correctly use a vacuum sander when finishing drywall**	3.8	3.8	Revise/Keep
14	Adoption readiness	**My company considers safety to be equally as important as production**	3.4	3.6	Review/Keep
15	Perceived Ease of Use	**Vacuum Sanders are easy to use**	5.0	5.0	Keep
16	Perceived Usefulness	**Using vacuum sanders decreases the cost of finishing drywall**	4.6	4.8	Keep
17	Perceived Usefulness	**Using vacuum sanders improves the quality of drywall finishes**	4.0	4.6	Keep
18	Adoption readiness	**Using vacuum sanders increases productivity**	4.2	4.8	Keep
19	Adoption readiness	**My company is proactive in removing workplace hazards**	4.2	4.2	Keep
20	Adoption readiness	**My company feels safety innovation leads to increased profits**	3.8	3.8	Review/Keep
21	Adoption readiness	**My company feels it is risky to be among the first to try new safety technologies**	3.6	3.6	Review/Keep
22	Adoption readiness	**My company is eager to adopt new technologies relating to dust control on our projects**	4.8	4.8	Keep
23	Perceived Usefulness	**Vacuum sanders are a worthwhile investment to reduce worker exposure to drywall dust**	4.8	4.8	Keep
24	Perceived Usefulness	**I feel confident that vacuum sanders are a worthwhile investment to reduce worker exposure to dust**	0	0	Same as 23 Drop
25	Trust in Technology	**Vacuum Sanders produce quality drywall finishes**	2.0	2.0	Drop

Information obtained in the cognitive interview sessions was incorporated in the development of the pre-proposal version of the questionnaire instruments shown in Appendix A. The questionnaire instruments used in Appendix A were taken to the AWCI convention in Las Vegas Nevada where a pilot test group of 50 drywall professionals completed the questionnaires. The project committee evaluated these responses and statistics were run to determine the correlation of each question in regards to the construct they were intended to measure. Using these results, a final review of the instrument was performed by the workgroup to discuss the findings from the instrument development process and produce the final instruments that were then sent to the Virginia Tech Institutional Review Board for approval for use in the intervention evaluations. These instruments found in Appendix D were then approved and used as the final instruments for the interventions.

3.5 Anaylsis

Results of the scaled survey items that were grouped by theoretical construct and measured for each round. Post-test data was collected three months following the intial pre-test and first intervention post-test. A gain score analysis using an independent sample t-test (one way ANOVA) of the mean gain scores for each construct was used to test for differences in control and intervention groups for the post-test immediately following the intervention to see if the intervention had any immediate effect and again for the second post-test to see if the intervention had any lasting effect. All statistical analysis were performed using JMP ® 9.0.0 (SAS Institute Inc., Cary, NC).

The open-ended survey questions for small and large firm employers were analyzed using content analysis procedures. The researcher for each open-ended response category established codes for responses. These codes were then used to assign responses by independent coders who had been trained by the researcher on the particular coding definitions and process.

3.6 Sampling Design

Using JMP 9.0.0 statistical software to conduct power calculations, it was determined that a sample size of 17 participants in both the control group and intervention group was sufficient to conduct the intervention experiments. Each group began with a minimum of 20 participants for the first round of the study. Over the three months between contacts, some participants were lost due to attrition at companies or companies going out of business. Each group did achieve at least 17 respondents for each of the three intervention groups for each round of data collection. Demographics of the sample population for employees was based on the United States Bureau of Labor Statistics labor force reports where 49% of drywall employees were listed as Hispanic(Bureau of Labor Statistics 2008). Based on this information, half of the 20 participants from both the intervention and control groups were from the Hispanic workforce. Participant surveys in English and Spanish were made available for all participants.

Employee and small firm participants were recruited from local companies in Virginia and North Carolina while Large Firm Participants were randomly selected from around the nation from members of two professional trade organizations: The Finish Contractors Association (FCA) and the Association of the Wall and Ceiling industries (AWCI). Large firms were contacted by phone and invited to participate in the web based surveys and interventions.

3.7 Intervention Evaluations

The employee survey instrument (Appendix D) was administered as the pre and post-test to all employee participants. Constructs measured were: Health Knowledge, Perception of Risk, Self Efficacy, Trust in Technology, Trust in Organization and Adoption Readiness. Questions designed to measure each construct were grouped according to construct and each construct was examined against the null hypothesis to determine if the interventions had any significant impact on the constructs. Each question response was scored as a 7 point Likert Scale question with possible answers scaled as follows: 1= strongly disagree, 2 disagree, 3 somewhat disagree, 4 neither disagree or agree, 5 somewhat agree, 6 agree, 7 strongly agree and 0 N/A. The question groupings by construct are shown in Table 17. Results were complied for each round for each construct and a independent T test was run using the JMP 9.0.0 statistical software to compare the difference in mean scores between intervention group and control group participant responses for each construct.

Table 17 Employee Construct Item Measurements

Construct	Questions measuring construct
Health Knowledge	Serious health problems can result from working around drywall dust.
	Components of drywall dust can cause health problems.
Self-Efficacy	I feel confident in my ability to use a vacuum sander.
	It is easy for me to become skillful at using a vacuum sander
Perceived Risk	I am worried about being exposed to drywall dust.
	Working around drywall dust puts me at risk for health problems.
Trust in Technology	Vacuum sanders are good tools to use when sanding drywall.
	I trust vacuum sanders.
	Using a vacuum sander improves performance in my job.
	I feel that vacuum sanders can lower the amount of dust I am exposed to.
Trust in Organization	I trust my employer to protect me from hazards.
	I believe my employer is open and up-front with me.
	I fully trust my employer.
	I believe my employer's motive's and intentions are good.
Adoption Readiness	Assuming I have access to a vacuum sander, I intend to use it.
	If I have access to a vacuum sander, I want to use it as much as possible

The Small and large firm survey instrument (Appendix D) was administered as the pre and post-test to all small and large firm participants. Constructs measured were: Health Knowledge, Perception of Risk, Trust in Technology, Perceived Usefulness, Perceived Ease of Use and Adoption Readiness. Questions designed to measure each construct were grouped according to construct and each construct was examined against the null hypothesis to determine if the interventions had any significant impact on the constructs. Each question response was scored as a 7 point Likert Scale question with possible answers scaled as follows: 1= strongly disagree, 2 disagree, 3 somewhat disagree, 4 neither disagree or agree, 5 somewhat agree, 6 agree, 7 strongly agree and 0 N/A. The question groupings by construct are shown in Table 18. Results were complied for each round for each construct and an independent T test was run using the JMP 9.0.0 statistical software to compare the difference in mean scores between intervention group and control group participant responses for each construct.

Table 18 Employer Construct Item Measurements

Construct	Questions measuring construct
Health Knowledge	Exposure to drywall dust poses a potential health risk to workers
	Components of drywall dust can cause health problems.
Perceived Risk	Working in the drywall industry is a risk factor for certain illnesses
	My employees are susceptible to major health problems from exposure to drywall dust
	Serious health problems can result from working around drywall dust
Trust in Technology	When using vacuum sanders, workers are exposed to lower dust concentration levels than conventional block sanding
	I trust vacuum sanders.
Perceived Usefulness	Using vacuum sanders increases productivity
	Vacuum sanders are a good tool to use for sanding drywall
	Vacuum sanders save my company time
	Vacuum sanders produce quality drywall finishes
Perceived Ease of Use	It is convenient to use a vacuum sander
	My employees could effectively use vacuum sanders
	It will take a long time for my employees to learn to use vacuum sanders
	Vacuum sanders are too complex
	Vacuum sanders are easy to use
Adoption Readiness	I anticipate my company will use (or continue to use) drywall sanders in our work
	My company always tries to use vacuum sanders in as many cases/occasions as possible

3.8 Chapter 3 Summary

The methods for the design, implementation and evaluation of the drywall dust PtD solutions safety and health interventions have been outlined in this chapter. The design of the interventions was based on the reviewed health promotion intervention literature discussed in chapter two and specifically incorporated the constructs of the HBM, TAM and DOI theoretical models. The implementation methods for each of the three participant groups of the interventions have been outlined. The evaluation of the interventions with a quasi-experimental design project with pre-test/post-test with control group was used to determine the effectiveness of the interventions and will serve as recommendation for use of the intervention principles in future construction safety and health interventions. The methods used to design the survey measurement tools and analyz the results have also been detailed in this chapter.

Chapter 4

4 RESULTS

The objective of the current study was to develop, implement and evaluate interventions for employees, small firms and large firms to increase intent to use dust-control technology (specifically vacuum sanders) in the drywall finishing industry. The following is a compilation of the results of the intervention evaluations based on the original hypotheses for the study.

4.1 Worker Intervention Results

The following null hypotheses were examined to determine intervention effectiveness.

- Null Hypothesis 1= Post-test gain scores of **health knowledge** for worker intervention participants will be no different than post-test scores in the worker control group for post-test 1 and post-test 2.
- Null Hypothesis 2= Post-test gain scores of **self-efficacy** for worker intervention participants will be no different than post-test scores in the worker control group for post-test 1 and post-test 2.
- Null Hypothesis 3= Post-test gain scores of **perceived risk** for worker intervention participants will be no different than post-test scores in the worker control group for post-test 1 and post-test 2.
- Null Hypothesis 4= Post-test gain scores of **trust in technology** for worker intervention participants will be no different than post-test scores in the worker control group for post-test 1 and post-test 2.

- Null Hypothesis 5= Post-test gain scores of **trust in organization** for worker intervention participants will be no different than post-test scores in the worker control group for post-test 1 and post-test 2.
- Null Hypothesis 6= Post-test gain scores of **adoption readiness** for worker intervention participants will be no different than post-test scores in the worker control group for post-test 1 and post-test 2.

A summary of the employee intervention evaluation results, based on a gain score analysis measuring each construct is shown in Table 19. Individual construct statistical results are reported in more detail in the sections that follow.

Table 19 Employee Intervention Construct Gain Score Summary

Employee Intervention Results Summary
Gain Score ANOVA

Construct Measured	Gain Score p value	Significant at .05 level	Significant at .10 level
Health Knowledge Post-Test 1	0.989		No
Health Knowledge Post-Test 2	0.826	No	No
Self-Efficacy Post-Test 1	0.100	No	No
Self-Efficacy Post-Test 2	0.050	No	Yes
Perceived Risk Post-Test 1	0.621	No	No
Perceived Risk Post-Test 2	0.612	No	No
Trust in Technology Post-Test 1	0.05	No	Yes
Trust in Technology Post-Test 2	0.21	No	No
Trust in Organization Post-Test 1	0.802	No	No
Trust in Organization Post-Test 2	0.5939	No	No
Adoption Readiness Post-Test 1	0.018	Yes	Yes
Adoption Readiness Post-Test 2	0.566	No	No

4.1.1 Employee Health Knowledge

Based on the results (Independent Sample t= .0132, df=49, p>.989) the null hypothesis is not rejected at both the .05 and .1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores from pre-test to *post-test 1* of health knowledge among intervention participants.

Table 20 Employee Health Knowledge Post-Test 1 Results

Gain Score ANOVA Pre-Test to Post-Test 1 Construct: Health Knowledge					
Difference	0.0101	t =	0.013152		
Std Err Dif	0.768	DF	49		
Upper CL Dif	1.5535	p =	0.9896		
Lower CL Dif	-1.5333	Prob > t	0.4948		
Confidence	0.95	Prob < t	0.5052		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	1.44444	0.61779	0.20295	2.6859
Intervention	33	1.45455	0.45627	0.53764	2.3714

Based on the results (Independent Sample t= -.22, df=36, p=.826) the null hypothesis is not rejected at both the .05 and .1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores from pre-test to the *second post-test* of health knowledge among intervention participants.

Table 21 Employee Health Knowledge Post-Test 2 Results

Gain Score ANOVA Pre-Test to Post-Test 2 Construct: Health Knowledge					
Difference	-0.1944	t Ratio	-0.22092		
Std Err Dif	0.8801	DF	36		
Upper CL Dif	1.5906	Prob > |t|	0.8264		
Lower CL Dif	-1.9794	Prob > t	0.5868		
Confidence	0.95	Prob < t	0.4132		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	1.44444	0.63852	0.14947	2.7394
Intervention	20	1.25	0.60575	0.02148	2.4785

4.1.2 Employee Self-Efficacy

Based on the results (Independent Sample t= 1.674, df=49, p=.1005) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores from pre-test to *post-test 1* of self-efficacy among intervention participants for the first post-test.

Table 22 Employee Self-Efficacy Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Self-Efficacy					
Difference	1.8384	t Ratio	1.673964		
Std Err Dif	1.0982	DF	49		
Upper CL Dif	4.0453	Prob > |t|	0.1005		
Lower CL Dif	-0.3686	Prob > t	0.0503		
Confidence	0.95	Prob < t	0.9497		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	-0.1111	0.88341	-1.886	1.6642
Intervention	33	1.7273	0.65244	0.416	3.0384

Based on the results (Independent Sample t= 2.027, df=36, p=.0501) the null hypothesis is not rejected at the .05 level and rejected at the 0.1 level. There is significant evidence at the 0.1 level that the intervention did have an effect on increasing gain scores from pre-test to the *second post-test* of self-efficacy among intervention participants.

Table 23 Employee Self-Efficacy Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct:Self-Efficacy					
Difference	2.0611	t Ratio	2.026713		
Std Err Dif	1.017	DF	36		
Upper CL Dif	4.1236	Prob > |t|	0.0501		
Lower CL Dif	-0.0014	Prob > t	0.0251		
Confidence	0.95	Prob < t	0.9749		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	-0.1111	0.73779	-1.607	1.3852
Intervention	20	1.95	0.69993	0.53	3.3695

4.1.3 Employee Perceived Health Risk

Based on the results (Independent Sample t= .498, df=49, p=.6207) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores from pre-test to *post-test 1* of perceived health risk among intervention participants.

Table 24 Employee Perceived Risk to Health Post-Test 1 Result

Gain Score Anova Pre-Test to Post-Test 1 Construct: Perceived Risk to Health					
Difference	0.4444	t Ratio	0.498062		
Std Err Dif	0.8923	DF	49		
Upper CL Dif	2.2377	Prob > |t|	0.6207		
Lower CL Dif	-1.3488	Prob > t	0.3103		
Confidence	0.95	Prob < t	0.6897		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	1.22222	0.7178	-0.2203	2.6647
Intervention	33	1.66667	0.53013	0.6013	2.732

Based on the results (Independent Sample t= .512, df=36, p=.6115) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores from pre-test to the *second post-test* of perceived health risk among intervention participants.

Table 25 Employee Perceived Risk to Health Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Perceived Risk to Health					
Difference	0.4278	t Ratio	0.512448		
Std Err Dif	0.8348	DF	36		
Upper CL Dif	2.1208	Prob > |t|	0.6115		
Lower CL Dif	-1.2652	Prob > t	0.3057		
Confidence	0.95	Prob < t	0.6943		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	1.22222	0.60561	-0.006	2.4505
Intervention	20	1.65	0.57453	0.4848	2.8152

4.1.4 Employee Trust in Technology

Based on the results (Independent Sample t= 2.006, df=49, p=.0504) the null hypothesis is not rejected at the .05 level and is rejected at the 0.1 level. There is significant evidence at the 0.1 level that the intervention was effective at increasing gain scores from pre-test to *post-test 1* trust in technology among intervention participants.

Table 26 Employee Trust in Technology Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Trust in Technology					
Difference	2.0505	t Ratio	2.005978		
Std Err Dif	1.0222	DF	49		
Upper CL Dif	4.1047	Prob > |t|	0.0504		
Lower CL Dif	-0.0037	Prob > t	0.0252		
Confidence	0.95	Prob < t	0.9748		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	0.55556	0.82226	-1.097	2.2079
Intervention	33	2.60606	0.60728	1.386	3.8264

Based on the results (Independent Sample t= 1.276, df=36, p=.21) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores from pre-test to the *second post-test* of trust in technology among intervention participants.

Table 27 Employee Trust in Technology Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Trust in Technology					
Difference	1.9444	t Ratio	1.276427		
Std Err Dif	1.5233	DF	36		
Upper CL Dif	5.0339	Prob > |t|	0.21		
Lower CL Dif	-1.1451	Prob > t	0.105		
Confidence	0.95	Prob < t	0.895		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	0.55556	1.1052	-1.686	2.7969
Intervention	20	2.5	1.0484	0.374	4.6263

4.1.5 Employee Trust in Organization

Based on the results (Independent Sample t= ..2527, df=49, p=.8015) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores from pre-test to *post-test 1* of trust in organization among intervention participants.

Table 28 Employee Trust in Organization Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Trust in Organization					
Difference	0.3485	t Ratio	0.252771		
Std Err Dif	1.3787	DF	49		
Upper CL Dif	3.119	Prob > |t|	0.8015		
Lower CL Dif	-2.422	Prob > t	0.4008		
Confidence	0.95	Prob < t	0.5992		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	0.5	1.109	-1.729	2.7286
Intervention	33	0.848485	0.819	-0.797	2.4944

Based on the results (Independent Sample t= -.0538, df=36, p=.5939) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores from pre-test to the *second post-test* of trust in organization among intervention participants.

Table 29 Employee Trust in Organization Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Trust in Organization					
Difference	-0.6	t Ratio	-0.53793		
Std Err Dif	1.1154	DF	36		
Upper CL Dif	1.6621	Prob > |t|	0.5939		
Lower CL Dif	-2.8621	Prob > t	0.703		
Confidence	0.95	Prob < t	0.297		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	0.5	0.80919	-1.141	2.1411
Intervention	20	-0.1	0.76766	-1.657	1.4569

4.1.6 Employee Adoption Readiness

Based on the results (Independent Sample t= 2.442, df=49, p=.0183) the null hypothesis is rejected at both the 0.05 level and the 0.1 level. There is significant evidence at the 0.5 level that the intervention was effective at increasing gain scores from pre-test to *post-test 1* Adoption Readiness among intervention participants.

Table 30 Employee Adoption Readiness Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct:Adoption Readiness					
Difference	1.26768	t Ratio	2.442005		
Std Err Dif	0.51911	DF	49		
Upper CL Dif	2.31087	Prob > |t|	0.0183		
Lower CL Dif	0.22448	Prob > t	0.0091		
Confidence	0.95	Prob < t	0.9909		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	0.27778	0.41757	-0.5614	1.1169
Intervention	33	1.54545	0.3084	0.9257	2.1652

Based on the results (Independent Sample t=.578, df=36, p=.566) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any affect on increasing gain scores of Adoption Readiness from the pre-test to the *second post-test* among intervention participants.

Table 31 Employee Adoption Readiness Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Adoption Readiness					
Difference	0.4722	t Ratio	0.578361		
Std Err Dif	0.8165	DF	36		
Upper CL Dif	2.1281	Prob > |t|	0.5666		
Lower CL Dif	-1.1837	Prob > t	0.2833		
Confidence	0.95	Prob < t	0.7167		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	0.277778	0.59234	-0.9235	1.4791
Intervention	20	0.75	0.56194	-0.3897	1.8897

4.2 Small Firm Results

The following null hypotheses were examined to determine intervention effectiveness.

- Null Hypothesis 1= Post-test gain scores of **health knowledge** for small firm intervention participants will be no different than post-test scores in the small firm control group for post-test 1 and post-test 2.
- Null Hypothesis 2= Post-test gain scores of **perceived risk** for small firm intervention participants will be no different than post-test scores in the small firm control group for post-test 1 and post-test 2.
- Null Hypothesis 3= Post-test gain scores of **trust in technology** for small firm intervention participants will be no different than post-test scores in the small firm control group for post-test 1 and post-test 2.
- Null Hypothesis 4= Post-test gain scores of **perceived usefulness (PU)** for small firm intervention participants will be no different than post-test scores in the small firm control group for post-test 1 and post-test 2.
- Null Hypothesis 5= Post-test gain scores of **perceived ease of use (PEOU)** for small firm intervention participants will be no different than post-test scores in the small firm control group for post-test 1 and post-test 2.
- Null Hypothesis 6= Post-test gain scores of **adoption readiness** for small firm intervention participants will be no different than post-test scores in the small firm control group for post-test 1 and post-test 2.

A summary of the small firm intervention evaluation based on a gain score analysis measuring each construct is shown in Table 32. Individual construct statistical results are reported in more detail in the sections that follow.

Table 32 Small Firm Intervention Results Summary

Small Firm Intervention Results Summary			
Construct Measured	**Gain Score p value**	**Significant at .05**	**Significant at 0.1**
Health Knowledge Post-Test 1	0.813	No	No
Health Knowledge Post-Test 2	0.733	No	No
Perceived Risk Post-Test 1	0.0012	Yes	Yes
Perceived Risk Post-Test 2	0.029	Yes	Yes
Trust in Technology Post-Test 1	0.038	Yes	Yes
Trust in Technology Post-Test 2	0.0462	Yes	Yes
Perceived Usefulness Post-Test 1	0.089	No	Yes
Perceived Usefulness Post-Test 2	0.063	No	Yes
Perceived Ease of Use Post-Test 1	0.578	No	No
Perceived Ease of Use Post-Test 2	0.0214	Yes	Yes
Adoption Readiness Post-Test 1	0.223	No	No
Adoption Readiness Post-Test 2	0.064	No	Yes

4.2.1 Small Firm Health Knowledge

Based on the results (Independent Sample t= .239, df=35, p=.813) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores of health knowledge from pre-test to the *first post-test* among intervention participants.

Table 33 Small Firm Health Knowledge Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Health Knowledge					
Difference	0.2176	t Ratio	0.238622		
Std Err Dif	0.9121	DF	35		
Upper CL Dif	2.0693	Prob > |t|	0.8128		
Lower CL Dif	-1.634	Prob > t	0.4064		
Confidence	0.95	Prob < t	0.5936		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	0.88235	0.67059	-0.479	2.2437
Intervention	20	1.1	0.61825	-0.1551	2.3551

Based on the results (Independent Sample t=.344, df=32, p=.733) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores of health knowledge from the pre-test to the *second post-test* among intervention participants.

Table 34 Small Firm Health Knowledge Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Health Knowledge					
Difference	0.2941	t Ratio	0.34452		
Std Err Dif	0.8537	DF	32		
Upper CL Dif	2.0331	Prob > |t|	0.7327		
Lower CL Dif	-1.4448	Prob > t	0.3664		
Confidence	0.95	Prob < t	0.6336		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	0.88235	0.60366	-0.3473	2.112
Intervention	17	1.17647	0.60366	-0.0531	2.4061

4.2.2 Small Firm Perceived Risk to Health

Based on the results (Independent Sample t= 3.51, df=35, p=.0012) the null hypothesis is rejected at both the .05 and 0.1 levels. There is significant evidence that the intervention had effect on increasing gain scores of perceived risk to health from pre-test to the *first post-test* among intervention participants.

Table 35 Small Firm Perceived Risk Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Perceived Risk					
Difference	3.37059	t Ratio	3.51323		
Std Err Dif	0.9594	DF	35		
Upper CL Dif	5.31827	Prob > |t|	0.0012		
Lower CL Dif	1.42291	Prob > t	0.0006		
Confidence	0.95	Prob < t	0.9994		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	-0.4706	0.70536	-1.903	0.9614
Intervention	20	2.9	0.65031	1.58	4.2202

Based on the results (Independent Sample t=2.28, df=32, p=.0296) the null hypothesis is rejected at both the .05 and 0.1 levels. There is significant evidence that the intervention had an effect on increasing gain scores of perceived risk from the pre-test to the *second post-test* among intervention participants.

Table 36 Small Firm Perceived Risk Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Perceived Risk					
Difference	2.47059	t Ratio	2.276933		
Std Err Dif	1.08505	DF	32		
Upper CL Dif	4.68076	Prob > |t|	0.0296		
Lower CL Dif	0.26041	Prob > t	0.0148		
Confidence	0.95	Prob < t	0.9852		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	-0.4706	0.76725	-2.033	1.0922
Intervention	17	2	0.76725	0.437	3.5628

4.2.3 Small Firm Trust in Technology

Based on the results (Independent Sample t= 2.16, df=35, p=.0379) the null hypothesis is rejected at both the .05 and 0.1 levels. There is significant evidence that the intervention had affect on increasing gain scores of trust in technology from pre-test to the *first post-test* among intervention participants.

Table 37 Small Firm Trust in Technology Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Trust in Technology					
Difference	1.47647	t Ratio	2.157164		
Std Err Dif	0.68445	DF	35		
Upper CL Dif	2.86598	Prob > |t|	0.0379		
Lower CL Dif	0.08696	Prob > t	0.019		
Confidence	0.95	Prob < t	0.981		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	-0.1765	0.50322	-1.198	0.8451
Intervention	20	1.3	0.46394	0.358	2.2419

Based on the results (Independent Sample t=2.0715, df=33, p=.0462) the null hypothesis is rejected at both the .05 and 0.1 levels. There is significant evidence that the intervention had an affect on increasing gain scores of trust in technology from the pre-test to the *second post-test* among intervention participants.

Table 38 Small Firm Trust in Technology Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Trust in Technology					
Difference	1.56536	t Ratio	2.071511		
Std Err Dif	0.75566	DF	33		
Upper CL Dif	3.10276	Prob > |t|	0.0462		
Lower CL Dif	0.02796	Prob > t	0.0231		
Confidence	0.95	Prob < t	0.9769		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	-0.1765	0.54191	-1.279	0.9261
Intervention	18	1.3889	0.52664	0.317	2.4604

4.2.4 Small Firm Perceived Usefulness

Based on the results (Independent Sample t= 1.74, df=35, p=.089) the null hypothesis is not rejected at the .05 and rejected at the 0.1 level. There is significant evidence at the 0.1 level that the intervention had an affect on increasing gain scores of perceived usefulness from pre-test to the *first post-test* among intervention participants.

Table 39 Small Firm Perceived Usefulness Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Perceived Usefulness					
Difference	3.1147	t Ratio	1.74421		
Std Err Dif	1.7857	DF	35		
Upper CL Dif	6.74	Prob > |t|	0.0899		
Lower CL Dif	-0.5105	Prob > t	0.045		
Confidence	0.95	Prob < t	0.955		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	1.23529	1.3129	-1.43	3.9006
Intervention	20	4.35	1.2104	1.893	6.8073

Based on the results (Independent Sample t=1.93, df=33, p=.0626) the null hypothesis is not rejected at the .05 and rejected at the 0.1 level. There is significant evidence at the 0.1 level that the intervention had an affect on increasing gain scores of perceived usefulness from pre-test to the *second post-test* among intervention participants.

Table 40 Small Firm Perceived Usefulness Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Perceived Usefulness					
Difference	1.9444	t Ratio	1.276427		
Std Err Dif	1.5233	DF	36		
Upper CL Dif	5.0339	Prob > |t|	0.21		
Lower CL Dif	-1.1451	Prob > t	0.105		
Confidence	0.95	Prob < t	0.895		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	18	0.55556	1.1052	-1.686	2.7969
Intervention	20	2.5	1.0484	0.374	4.6263

4.2.5 Small Firm Perceived Ease of Use

Based on the results (Independent Sample t= 1.96, df=35, p=.578) the null hypothesis is not rejected at the .05 and rejected at the 0.1 level. There is significant evidence at the 0.1 level that the intervention had an affect on increasing gain scores of perceived ease of use from pre-test to the *first post-test* among intervention participants.

Table 41 Small Firm Perceived Ease of Use Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Perceived Ease of Use					
Difference	3.8203	t Ratio	1.926946		
Std Err Dif	1.9825	DF	33		
Upper CL Dif	7.8538	Prob > |t|	0.0626		
Lower CL Dif	-0.2133	Prob > t	0.0313		
Confidence	0.95	Prob < t	0.9687		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	1.23529	1.4218	-1.657	4.1279
Intervention	18	5.05556	1.3817	2.244	7.8666

Based on the results (Independent Sample t=2.419, df=32, p=.0214) the null hypothesis is rejected at both the .05 and 0.1 levels. There is significant evidence that the intervention had an affect on increasing gain scores of perceived ease of use from the pre-test to the *second post-test* among intervention participants.

Table 42 Small Firm Perceived Ease of Use Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Perceived Ease of Use					
Difference	3.8088	t Ratio	1.9615		
Std Err Dif	1.9418	DF	35		
Upper CL Dif	7.7509	Prob > |t|	0.0578		
Lower CL Dif	-0.1332	Prob > t	0.0289		
Confidence	0.95	Prob < t	0.9711		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	-1.0588	1.4276	-3.957	1.8394
Intervention	20	2.75	1.3162	0.078	5.4221

4.2.6 Small Firm Adoption Readiness

Based on the results (Independent Sample t= 1.24, df=35, p=.223) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any affect on increasing gain scores of adoption readiness from pre-test to the *first post-test* among intervention participants.

Table 43 Small Firm Adoption Readiness Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct:Adoption Readiness					
Difference	5.41176	t Ratio	2.419482		
Std Err Dif	2.23674	DF	32		
Upper CL Dif	9.96786	Prob > |t|	0.0214		
Lower CL Dif	0.85566	Prob > t	0.0107		
Confidence	0.95	Prob < t	0.9893		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	-1.0588	1.5816	-4.28	2.1628
Intervention	17	4.3529	1.5816	1.131	7.5746

Based on the results (Independent Sample t=1.91, df=32, p=.0643) the null hypothesis is not rejected at the .05 and rejected at the 0.1 level. There is significant evidence at the .1 level that the intervention had an affect on increasing gain scores of adoption readiness from pre-test to the *second post-test* among intervention participants.

Table 44 Small Firm Adoption Readiness Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Adoption Readiness					
Difference	0.9235	t Ratio	1.240462		
Std Err Dif	0.7445	DF	35		
Upper CL Dif	2.435	Prob > |t|	0.2231		
Lower CL Dif	-0.5879	Prob > t	0.1115		
Confidence	0.95	Prob < t	0.8885		
Group	Number	Mean	Std Error	Lower 95%	Upper 95%
Control	17	0.17647	0.54737	-0.9348	1.2877
Intervention	20	1.1	0.50465	0.0755	2.1245

4.3 Large Firm Results

The following null hypotheses were examined to determine intervention effectiveness.

- Null Hypothesis 1= Post-test gain scores of **health knowledge** for large firm intervention participants will be no different than post-test scores in the large firm control group for post-test 1 and post-test 2.
- Null Hypothesis 2= Post-test gain scores of **perceived risk** for large firm intervention participants will be no different than post-test scores in the large firm control group for post-test 1 and post-test 2.
- Null Hypothesis 3= Post-test gain scores of **trust in technology** for large firm intervention participants will be no different than post-test scores in the large firm control group for post-test 1 and post-test 2.
- Null Hypothesis 4= Post-test gain scores of **perceived usefulness (PU)** for large firm intervention participants will be no different than post-test scores in the large firm control group for post-test 1 and post-test 2.
- Null Hypothesis 5= Post-test gain scores of **perceived ease of use (PEOU)** for large firm intervention participants will be no different than post-test scores in the large firm control group for post-test 1 and post-test 2.
- Null Hypothesis 6= Post-test gain scores of **adoption readiness** for large firm intervention participants will be no different than post-test scores in the large firm control group for post-test 1 and post-test 2.

A summary of the small firm intervention evaluation based on a gain score analysis measuring each construct is shown in Table 45. Individual construct statistical results are reported in more detail in the sections that follow.

Table 45 Large Firm Results Summary

Large Firm Intervention Results Summary

Construct Measured	Gain Score p value	Significant at .05	Significant at 0.1
Health Knowledge Post-Test 1	0.584	No	No
Health Knowledge Post-Test 2	0.171	No	No
Perceived Risk Post-Test 1	0.114	No	No
Perceived Risk Post-Test 2	0.06	No	Yes
Trust in Technology Post-Test 1	0.569	No	No
Trust in Technology Post-Test 2	0.209	No	No
Perceived Usefulness Post-Test 1	0.464	No	No
Perceived Usefulness Post-Test 2	0.057	No	Yes
Perceived Ease of Use Post-Test 1	0.03	Yes	Yes
Perceived Ease of Use Post-Test 2	0.059	No	Yes
Adoption Readiness Post-Test 1	0.864	No	No
Adoption Readiness Post-Test 2	0.568	No	No

4.3.1 Large Firm Health Knowledge

Based on the results (Independent Sample t= .550, df=45, p=.584) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any affect on increasing gain scores of health knowledge from pre-test to the *first post-test* among intervention participants.

Table 46 Large Firm Health Knowledge Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Health Knowledge					
Difference	0.2971	t Ratio	0.550495		
Std Err Dif	0.5397	DF	45		
Upper CL Dif	1.3841	Prob > |t|	0.5847		
Lower CL Dif	-0.7899	Prob > t	0.2924		
Confidence	0.95	Prob < t	0.7076		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	-0.13043	0.38566	-0.9072	0.64633
1	24	0.16667	0.37754	-0.5937	0.92708

Based on the results (Independent Sample t=1.394, df=39, p=.1710) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any affect on increasing gain scores of health knowledge from the pre-test to the *second post-test* among intervention participants.

Table 47 Large Firm Health Knowledge Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Health Knowledge					
Difference	1.0193	t Ratio	1.394581		
Std Err Dif	0.7309	DF	39		
Upper CL Dif	2.4977	Prob > |t|	0.171		
Lower CL Dif	-0.4591	Prob > t	0.0855		
Confidence	0.95	Prob < t	0.9145		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	-0.13043	0.4843	-1.11	0.8492
1	18	0.88889	0.54744	-0.218	1.9962

4.3.2 Large Firm Perceived Risk

Based on the results (Independent Sample t= 1.613, df=45, p= .1137) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any affect on increasing gain scores of perceived risk from pre-test to the *first post-test* among intervention participants.

Table 48 Large Firm Perceived Risk Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Perceived Risk					
Difference	1.2337	t Ratio	1.613181		
Std Err Dif	0.7648	DF	45		
Upper CL Dif	2.774	Prob > |t|	0.1137		
Lower CL Dif	-0.3066	Prob > t	0.0568		
Confidence	0.95	Prob < t	0.9432		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	-0.6087	0.54649	-1.709	0.492
1	24	0.625	0.53498	-0.453	1.7025

Based on the results (Independent Sample t=1.935, df=39, p= .0603) the null hypothesis is not rejected at the .05 and rejected at the 0.1 level. There is significant evidence at the 0.1 level that the intervention had an affect on increasing gain scores of perceived risk from pre-test to the *second post-test* among intervention participants.

Table 49 Large Firm Perceived Risk Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Perceived Risk					
Difference	1.8309	t Ratio	1.934973		
Std Err Dif	0.9462	DF	39		
Upper CL Dif	3.7448	Prob > |t|	0.0603		
Lower CL Dif	-0.083	Prob > t	0.0301		
Confidence	0.95	Prob < t	0.9699		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	-0.6087	0.62696	-1.877	0.6594
1	18	1.2222	0.70871	-0.211	2.6557

4.3.3 Large Firm Trust in Technology

Based on the results (Independent Sample t= .573, df=45, p= .569) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores of trust in technology from pre-test to the *first post-test* among intervention participants.

Table 50 Large Firm Trust in Technology Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Trust in Technology					
Difference	0.3315	t Ratio	0.573543		
Std Err Dif	0.578	DF	45		
Upper CL Dif	1.4957	Prob > |t|	0.5691		
Lower CL Dif	-0.8327	Prob > t	0.2846		
Confidence	0.95	Prob < t	0.7154		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	0.043478	0.41305	-0.7884	0.8754
1	24	0.375	0.40435	-0.4394	1.1894

Based on the results (Independent Sample t=1.28, df=39, p= .209) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores of trust in technology from the pre-test to the *second post-test* among intervention participants.

Table 51 Large Firm Trust in Technology Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Trust in Technology					
Difference	1.0121	t Ratio	1.275602		
Std Err Dif	0.7934	DF	39		
Upper CL Dif	2.6169	Prob > |t|	0.2096		
Lower CL Dif	-0.5927	Prob > t	0.1048		
Confidence	0.95	Prob < t	0.8952		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	0.04348	0.52571	-1.02	1.1068
1	18	1.05556	0.59425	-0.146	2.2575

4.3.4 Large Firm Perceived Usefulness

Based on the results (Independent Sample t= .738, df=45, p= .464) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores of perceived usefulness from pre-test to the *first post-test* among intervention participants.

Table 52 Large Firm Perceived Usefulness Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Perceived Usefulness					
Difference	1.3243	t Ratio	0.737975		
Std Err Dif	1.7945	DF	45		
Upper CL Dif	4.9385	Prob > |t|	0.4644		
Lower CL Dif	-2.29	Prob > t	0.2322		
Confidence	0.95	Prob < t	0.7678		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	2.21739	1.2823	-0.365	4.8001
1	24	3.54167	1.2553	1.013	6.07

Based on the results (Independent Sample t=1.964, df=39, p= .0567) the null hypothesis is not rejected at the .05 and rejected at the 0.1 level. There is significant evidence at the 0.1 level that the intervention had an effect on increasing gain scores of perceived usefulness from pre-test to the *second post-test* among intervention participants.

Table 53 Large Firm Perceived Usefulness Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Perceived Usefulness					
Difference	4.949	t Ratio	1.964157		
Std Err Dif	2.52	DF	39		
Upper CL Dif	10.046	Prob > |t|	0.0567		
Lower CL Dif	-0.147	Prob > t	0.0283		
Confidence	0.95	Prob < t	0.9717		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	2.21739	1.6696	-1.16	5.594
1	18	7.16667	1.8873	3.349	10.984

4.3.5 Large Firm Perceived Ease of Use

Based on the results (Independent Sample t= 2.238, df=45, p= .030) the null hypothesis is rejected at both the .05 and 0.1 levels. There is significant evidence that the intervention had an effect on increasing gain scores of PEOU from pre-test to the *first post-test* among intervention participants.

Table 54 Large Firm Perceived Ease of Use Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct: Perceived Ease of Use					
Difference	3.16848	t Ratio	2.237744		
Std Err Dif	1.41593	DF	45		
Upper CL Dif	6.0203	Prob > |t|	0.0302		
Lower CL Dif	0.31666	Prob > t	0.0151		
Confidence	0.95	Prob < t	0.9849		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	-0.0435	1.0118	-2.081	1.9944
1	24	3.125	0.9905	1.13	5.12

Based on the results (Independent Sample t=1.946, df=39, p= .0589) the null hypothesis is not rejected at the .05 and rejected at the 0.1 level. There is significant evidence at the 0.1 level that the intervention had an effect on increasing gain scores of PEOU from pre-test to the *second post-test* among intervention participants.

Table 55 Large Firm Perceived Ease of Use Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Perceived Ease of Use					
Difference	4.2657	t Ratio	1.946088		
Std Err Dif	2.1919	DF	39		
Upper CL Dif	8.6993	Prob > |t|	0.0589		
Lower CL Dif	-0.1679	Prob > t	0.0294		
Confidence	0.95	Prob < t	0.9706		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	-0.0435	1.4524	-2.981	2.8942
1	18	4.2222	1.6417	0.902	7.5429

4.3.6 Large Firm Adoption Readiness

Based on the results (Independent Sample t= -.171, df=45, p= .864) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores of adoption readiness from pre-test to the *first post-test* among intervention participants.

Table 56 Large Firm Adoption Readiness Post-Test 1 Results

Gain Score Anova Pre-Test to Post-Test 1 Construct:Adoption Readiness					
Difference	-0.0996	t Ratio	-0.17148		
Std Err Dif	0.5811	DF	45		
Upper CL Dif	1.0707	Prob > |t|	0.8646		
Lower CL Dif	-1.2699	Prob > t	0.5677		
Confidence	0.95	Prob < t	0.4323		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	0.391304	0.41521	-0.445	1.2276
1	24	0.291667	0.40647	-0.527	1.1103

Based on the results (Independent Sample t= -.575, df=39, p= .568) the null hypothesis is not rejected at both the .05 and 0.1 levels. There is no significant evidence that the intervention had any effect on increasing gain scores of adoption readiness from the pre-test to the *second post-test* among intervention participants.

Table 57 Large Firm Adoption Readiness Post-Test 2 Results

Gain Score Anova Pre-Test to Post-Test 2 Construct: Adoption Readiness					
Difference	-0.6135	t Ratio	-0.57484		
Std Err Dif	1.0673	DF	39		
Upper CL Dif	1.5453	Prob > |t|	0.5687		
Lower CL Dif	-2.7723	Prob > t	0.7157		
Confidence	0.95	Prob < t	0.2843		
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
0	23	0.3913	0.70718	-1.039	1.8217
1	18	-0.22222	0.79938	-1.839	1.3947

4.4 Open Ended Response Results

Content analysis procedures were used to analyze the open-ended survey response items included on the small and large firm instrument. The items for these instruments were the same for both groups and the researcher developed codes that were both exhaustive and mutually exclusive for each quest set of questions. These codes were then assigned to each unit of response by independent coders who had been trained by the researcher on the category code definitions and coding process. Inter-rater reliability was calculated for each set of codes, using Krippendorff's alpha with significance set at alpha = 0.8(Krippendorff 2004). Items that did not have adequate rater agreement were not included in frequency counts.

4.4.1 Problems Associated with Drywall Dust Analysis

Inter-Rater reliability for the survey item "What are some potential problems associated with drywall dust and how could they affect your business?" was calculated and yielded a Krippendorff's alpha value of .933.

Table 58 Potential Problems with Drywall Dust Inter-Rater Calculations

Percent Agreement	**Scott's Pi**	**Cohen's Kappa**	**Krippendorff's Alpha (nominal)**	N Agreements	N Disagreements	N Cases	N Decisions
95.20%	0.933	0.933	0.933	158	8	166	332

The analysis of responses to this item of the survey instrument is summarized in Table 59 and Figure 11. Emergent themes were that there is a high recognition by employers that drywall dust could cause health, clean up, customer satisfaction, employee lost time and insurance problems for businesses in the drywall industry. The emergent themes associated with drywall dust creating a health problem for businesses were that there is a risk to worker health and that working around drywall dust causes problems with health as well as possible lost time from employee days away from work related to inhalation of drywall dust. Clean up concerns in regards to productivity and also customer satisfaction were also commonly reported as a problem drywall dust creates for businesses.

Table 59 Potential Problems with Drywall Dust Response Summary

Response Code/Category	Frequency	Percent	Sub-categories
Health	74	45%	Dust could be harmful to employees not wearing protection Health risks Employee safety Breathing problems Can cause health problems Negative effects on my employees health
Clean Up	39	23%	Dirty, more cleanup Dust accumulating on finished surfaces and/or equipment in occupied buildings clean up on remodels is time consuming
Lost Time at Work	22	13%	Health problems for workers causing missed time and delays in finishing projects on time More employee sick days Could cause trouble breathing so people could miss days
Customer Satisfaction	16	10%	Clients complain, possibly lose customers When dust settles it poses a problem when we do renovations which the client is still open for business People don't want dust throughout the house
Insurance	6	4%	Employee work comp or health insurance claims Increase in workers comp premiums
Legal	3	2%	Clean up insurance claims for damaged equipment and OSHA fines for not using proper dust masks Air conditioned filters, claims against company for AC problems
Quality	2	1%	Too much sanding affects finish Lingering dust affects paint jobs
Productivity	2	1%	Affects productivity Lost time due to drywall dust related ailments; productivity; and equipment costs
Government Regulation	2	1%	Govt regulation on employee exposure increase costs and reporting" Government regulation and record keeping
Total responses	166	100%	

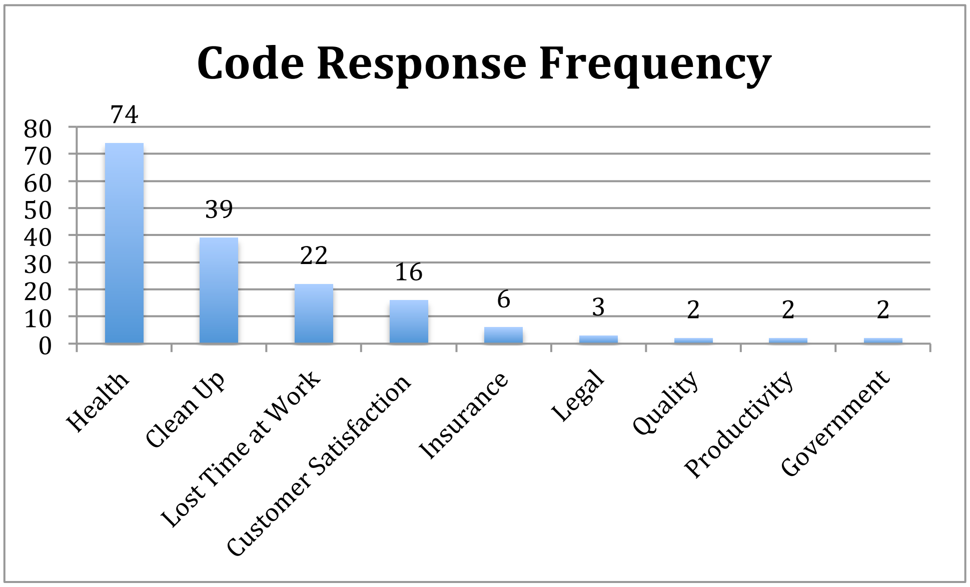


Figure 11 Problems with Drywall Dust Code Response Frequency

4.4.2 Opinions about Drywall Vacuum Sanders

Inter-Rater reliability for the survey item "What are your thoughts on using vacuum sanders as a dust control method in drywall sanding?" was calculated and yielded a Krippendorff's alpha value of .92 as shown in Table 60.

Table 60 Inter-Rater Results for Vacuum Sanders

Percent Agreement	**Scott's Pi**	**Cohen's Kappa**	**Krippendorff's Alpha (nominal)**	N Agreements	N Disagreements	N Cases	N Decisions
94%	0.922	0.922	0.922	173	11	184	368

The analysis of response units to this item of the survey instrument is summarized in Tables 61-63 and Figure 12. Units of response were coded first into type of reaction i.e. positive, negative, or neutral response and then coded by independent coders using determined categories set forth by the researcher. Emergent themes were that small and large firms view vacuum sanders as an effective method of controlling dust on a project although there are limitations to the tools' effectiveness for regular usage. Many of the comments stated that the idea of vacuum sanding to control dust is good but that the limitations prevent wider adoption. Limitations of vacuum sander dust-control technology that have been found to exist in previous studies (Young-Corbett, 2009) relating to unfamiliarity with the technology, cost, quality, ease of use and productivity were also reported in the open ended responses. Contractors reporting regular usage of sanders were classified as champions of the product who have adopted the technology and have seen the benefits of use. Other findings included respondents who only used the technology if specified on projects and those who prefer alternate methods of dust control.

Table 61 Vacuum Sander Response Analysis-Part 1

Response Code/Category	Unit Frequency	%	Sub-categories/Response Sample
Effectiveness	**69**	**38%**	**Effective tool, controls dust, good idea,**
Positive	60	87%	Work well, contains major portion of airborne dust Very good way to control dust Excellent way of controlling dust I like them because it keeps you healthy and saves time on clean up
Neutral	2	2.9%	Would seem to be effective and eliminate some of the additional clean up work I have no strong opinion regarding vacuum sanders
Negative	7	10.1%	They do not control all dust and take more time. I feel there are more effective ways. Vacuum sanders work well when working over finished floors, etc. but for everyday drywall I feel they would not work well. While I am familiar with vacuum sanders I don't know if they stop as much dust as they claim. Because of their size they cannot get into all areas of typical construction projects where detailed hand sanding is required.
Perceived Barriers/Limitations	**45**	**24%**	**Perceived barriers to adoption/limitations of vacuum sanders**
Positive	20	44.4%	Works fine if you change the filters as directed Sanders need to last longer Good method. Problem is they are so bulky and hard to break out for a little job I have used vacuum sanders in the past and still do and they work effectively when the machine is new. As the vacuums wear out they become less effective.
Neutral	7	15.6%	Sometimes it is not feasible to use in tight conditions. Could be useful once a finisher learned to use them proficiently Technology needs to improve on actual products
Negative	18	40%	I think they are somewhat hard to use and would take a learning curve and adjustment period to our production rates in taping. I have found them to be cumbersome and difficult to use Way to bulky, need to empty and/or clean the filter. They are a good idea but the application is not cost effective. Many commercial projects do not have power in the area that you are working. We cover large areas so moving a vacuum around cost time thus money. If the drywall mud is applied correctly there is not a lot of sanding that needs to take place between coats so moving a vacuum would be cumbersome. Final coat sanding would take longer using a vacuums just moving it around and dealing with the cord so most production employees will not even give it a try

Table 62 Vacuum Sander Response Analysis Part 2

Response Code/Category	Unit Frequency	%	Sub-categories/Response Sample
Productivity	**23**	**13%**	**Impact on Productivity or Time on the Project**
Positive	8	34.8%	Very helpful and time saving Yo pienso que es una herramienta muy indispensable en estos dias ya que aumenta la productividad y la limpieza en el trabajo (I think it is a tool very essential in these days because it increases the productivity and cleanliness at work) A faster & more efficient way to sand
Neutral	2	8.7%	Time factor Time and Money
Negative	13	56.5%	Cumbersome, cuts down productivity It slows productivity but may be necessary due to project type They do not control all dust and take more time.
Champion	**10**	**5%**	**Current User, Encourages Others to Use**
Positive	10	100%	Vacuum sanders are a must when sanding drywall One of the best products in 10 years If you don't use one, start We use them in our company especially when dust is an issue with in the work space. It's a nice option to have. Have used it since the first survey, loved it.
Neutral			
Negative			
Quality	**9**	**5%**	**Quality of Drywall Finish**
Positive	0		
Neutral	0		
Negative	9	100%	Poor finish cumbersome clog easily slows productivity Expensive initial costs, can cause problems with finish. Probably due to inexperience we have had quality issues due to roughed up paper and swirl marks. I have found that vacuum sanders do not leave a quality as good as block sanding, also vacuum sanders require much more training for proper use

Table 63 Vacuum Sander Response Analysis Part 3

Response Code/Category	Unit Frequency	%	Sub-categories/Response Sample
Cost	**9**	**5%**	**Cost**
Positive	0		
Neutral	1	11.1%	Time and money
Negative	8	88.9%	Expensive equipment and filter costs Extra costs, extra maintenance, But they are a good tool for controlling dust when needed. Expensive initial costs, can cause problems with finish.
Specified Use Only	**9**	**5%**	**Only if Project Specifies**
Positive	0		
Neutral	6	66.7%	We'd likely use them if required We do not use vacuum sanders unless they are required on the job
Negative	3	33.3%	Slower production. Used only as required due to jobsite conditions (occupied spaces or Owner requirements). Only use them when we have to
New	**8**	**4%**	**Unfamiliar with technology or would be open to try**
Positive	1	12.5%	I like the idea but have yet to try one
Neutral	7	87.5%	I have never used one. If it really lessens employee risk and makes a better finish. Then I would be open to using them. Have never used these types of sanders.
Negative	0		
Alternate Method	**2**	**1%**	**Alternate Method Preferred**
Positive	1	50%	I think it is a good solution. The best solution would be to stop using dry wall finish and just use plaster instead.
Neutral			
Negative	1	50%	I think wet sanding is much more productive

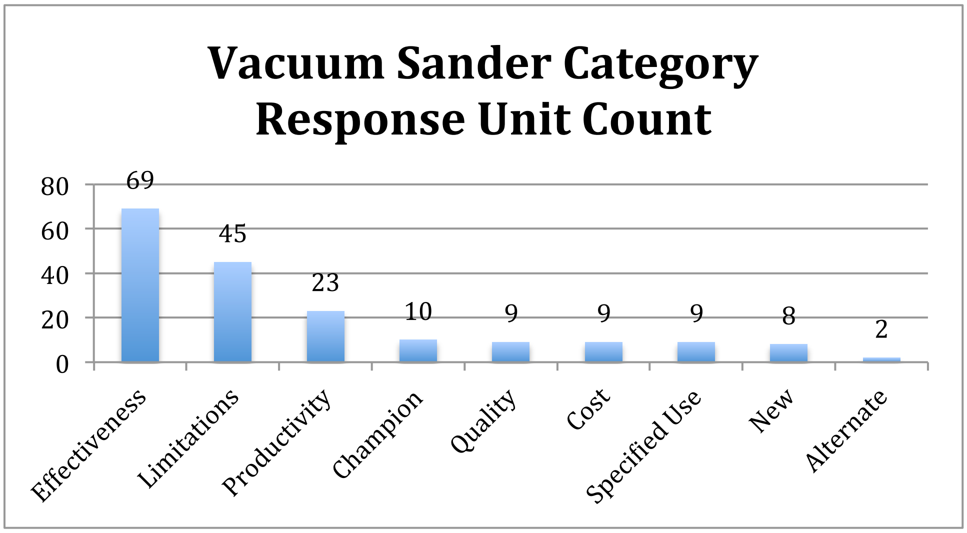


Figure 12 Vacuum Sander Unit Response Code Frequency

Of the 184 units of response to the survey item "What are your thoughts on using vacuum sanders as a dust control method in drywall sanding?", 100 response units were coded as being positive in reaction to vacuums as a method of dust control with 59 units as negative reactions and 25 Neutral reactions.

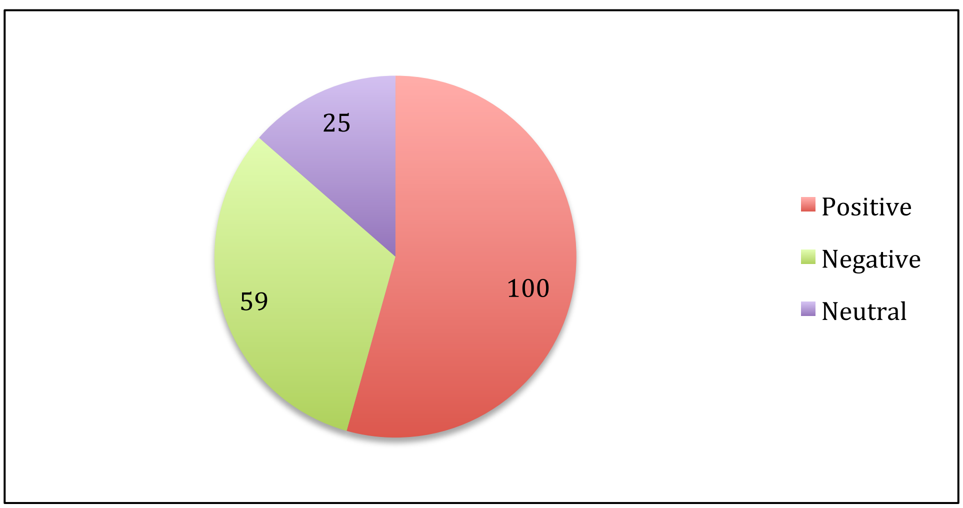


Figure 13 Frequency of Response Type,Vacuum Sanders as Dust-Control Method

4.4.3 Opinions about Low Dust Drywall Joint Compound

Inter-Rater reliability for the survey item "What are your thoughts on using low dust drywall joint compound as a dust control method in drywall sanding?" was calculated and yielded a Krippendorff's alpha value of .886 as shown in Table 64.

Table 64 Inter-Rater Results for Low Dust Joint Compound

Percent Agreement	Scott's Pi	Cohen's Kappa	Krippendorff's Alpha (nominal)	N Agreements	N Disagreements	N Cases	N Decisions
91.70%	0.886	0.886	0.886	143	13	156	312

Units of response were coded first into type of reaction i.e. positive, negative, or neutral response and then coded by independent coders using predetermined categories set forth by the researcher. The breakdown of positive, negative and neutral response units is shown in Figure 14.

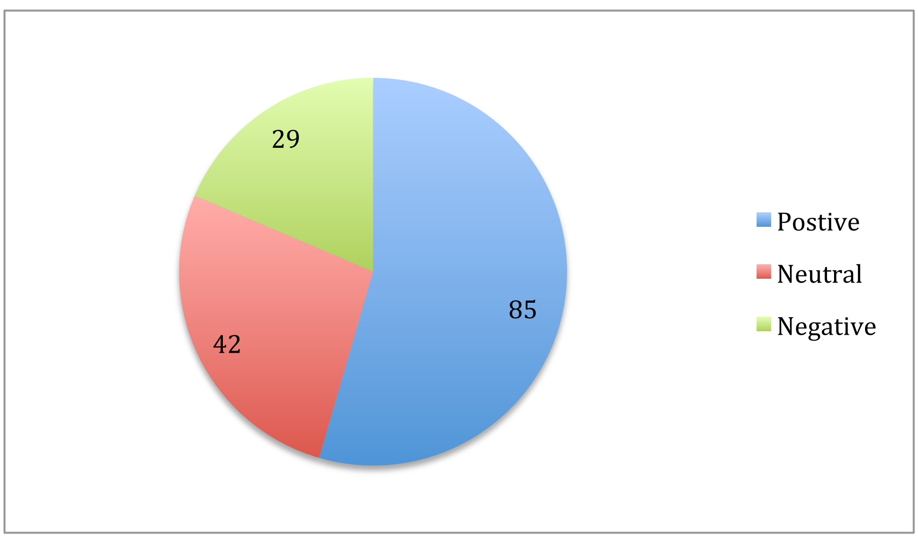


Figure 14 Frequency of Type of Response for Low Dust Joint Compound Used for Dust-Control

The analysis of response units to this item of the survey instrument is summarized in Tables 65-67 and Figure 15. Emergent themes were that small and large firms view low dust joint compound as a potential effective method of controlling dust on project although there are many who are unfamiliar with the product or have never tried it. Many of the comments stated that the idea of low dust joint compound to control dust is good but that the cost, limitations and unfamiliarity could be preventing wider adoption. Limitations of low dust joint compound technology that have been found to exist in previous studies (Young-Corbett, 2009) relating to unfamiliarity with the technology, cost, quality, ease of use and productivity were also reported in the open ended responses. Contractors reporting regular usage of low dust joint compound were classified as champions of the product who have adopted the technology and have seen the benefits of use. Other findings included respondents who only used the technology if specified on projects and those who prefer alternate methods of dust control.

Table 65 Low Dust Joint Compound Analysis Part 1

Response Code/Category	Unit Frequency	%	Sub-categories/Response Sample
Effectiveness	**56**	**36 %**	**Effective as a Dust-Control Method for Health and Cleanup**
Positive	40	71.4%	That would be helpful with dust control, cleanup and health problems Low dust joint compound is a much more effective and productive method. I have tried them. There seems to be less airborne dust. We have used it before, it is more expensive, but the job site clean up seems somewhat less
Neutral	6	10.7%	Needs to be a good product at equal priced It's often necessary Less dust to breath in
Negative	10	17.9%	It's a gimmick. If it's specified, we will buy it, otherwise no immediate interest in the product. Does not work well with my guys training wise/ not cost effective Doesn’t work, misleading I've used it. Didn't see significant difference.
New	**50**	**32%**	**Unfamiliar with the product or willing to try it**
Positive	26	52%	If technology can make cost and product feasible, then great. Haven't used it before but would be willing to try it Good idea but have not had much exposure to it. I will try it.
Neutral	24	48%	I have not tried yet I don't have enough information about it. That would be fine if the compound were as workable as standard compounds
Negative	0		

Table 66 Low Dust Joint Compound Analysis Part 2

Response Code/Category	Unit Frequency	%	Sub-categories/Response Sample
Quality	**23**	**15%**	**Quality of Finish**
Positive	7	30.4%	Has started using it and it does cut down on some dust. It finishes pretty similar Works better than conventional Works well, we should use this more often As long as finished results are the same
Neutral	5	21.7%	Low dust only means that becoming airborne, it falls straight down. Still the same amount of dust. We use this as well my only concern is with the quality of the product whether it will hold up over the years Needs to be a good product at equal priced
Negative	11	47.8%	Doesn't finish as well. Have not seen remarkable difference when used. Have also been told it is not as hard and scratches easier when dry. Usually these type of products do not produce the quality of wall finish that is required and harder to use. Does not work as well as conventional tape and mud.
Cost	**13**	**8%**	**Cost of Product/Productivity**
Positive	5	38.5%	If it works that would be a great alternative depending on cost We have used it before but it is more expensive but the jobsite cleanup seems somewhat less I think it would speed up production and cut labor cost
Neutral	2	15.4%	Needs to be a good product at equal priced Make it economically based on the industry tough economy.
Negative	6	46.2%	Does not work well with my guys training wise/ not cost effective Overall finish is more costly As I can tell it is not cost effective

Table 67 Low Dust Joint Compound Analysis Part 3

Response Code/Category	Unit Frequency	%	Sub-categories/Response Sample
Champion	**6**	**4%**	**Current User, Encourages Usage**
Positive	6	100%	We started using this product This is our preferred method Very fond of this method
Neutral	0		
Negative	0		
Alternate Product	**5**	**3%**	**Suggest Alternate Method**
Positive	1	20%	Helps but not the solution
Neutral	3	60%	I don't think there is a low dust dry wall compound. Oh wait, there is. It's called plaster. Our company does not use premixed mud
Negative	1	20%	Our tapers are very particular regarding the manufacturer of our joint compound. We have used one brand for years. Low dust compound affects our productions rates negatively.
Specified Use	**3**	**2%**	**Only Use When Specified**
Positive			
Neutral	2	66.7%	We only use when specified Price is a factor, started to see more jobs specify this for use
Negative	1	33.3%	It's a gimic. If it's specified, we will buy it, otherwise no immediate interest in the product.

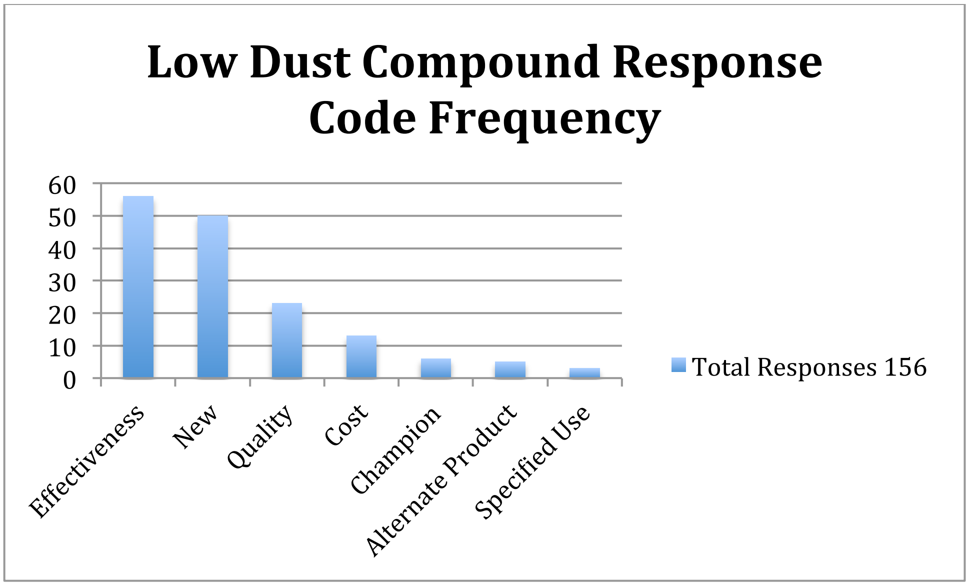


Figure 15 Low Dust Joint Compound Response Code Frequency Results

4.5 Chapter 4 Summary

Significant gains in construct scores were found at both the .05 and 0.1 significance levels in all three interventions. Significant gains in the employee intervention included self-efficacy, trust in technology and adoption readiness. Significant gains in the small firm intervention included perceived risk, trust in technology, perceived ease of use, and adoption readiness. Significant gains in the large firm intervention included perceived risk, perceived usefulness, and perceived ease of use.

Open-ended response items were analyzed using content analysis procedures utilizing inter-rater reliability procedures to determine and report findings. Emergent themes from the open-ended questions included a high reporting of health risk and clean up as a potential problems drywall dust could pose to businesses and both the effectiveness and limitations of vacuum sanders and low dust joint compound as dust-control methods. The findings of both the gain score analysis of the theoretical constructs and open-ended response analysis will serve as the basis for discussion of the effectiveness of the interventions in Chapter 5.

Chapter 5

5 Conclusion

The goal of the research study was to develop, implement and evaluate intervention strategies aimed at increasing adoption readiness dust-control technology among employees, small firms, and large firms in the drywall industry. The development of the interventions attempted to address barriers to adoption of dust-control technology found in previous studies (Young-Corbett et al. 2009). This research focused on using theoretical construct principles taken from the Health Belief Model (HBM), Diffusion of Innovation (DOI) Model and the Technology Acceptance Model (TAM) as guides in the design and implementation of the research. An integrated PtD adoption readiness model was created outlining the relationships between the constructs of the three theoretical models and was used to design the interventions. The primary hypothesis was that following the interventions, post-test construct scores would be significantly greater than pre-test scores in the intervention group when compared with the control group. The author was interested in determining if an intervention using theoretical constructs would show improvement in participant's intention to use dust-control technology. The results were analyzed using a gain score ANOVA analysis between pre and post-tests questionnaire scores for intervention and control group participants. Examination of the results and perspective on the implications of the results is presented in the discussion section of this chapter. In addition this chapter sheds light on how intervention strategies using theoretical models could be implemented in the future in other areas regarding health and safety in the workplace.

5.1 Discussion

The findings of this research showed that of the constructs measured in the dust-control usage interventions, multiple constructs showed significant gains among intervention group participants when compared with the control group. Workers, small firms and large firms all showed increases in at least one construct showing that some level of effectiveness was achieved in all three interventions. The individual constructs measured in each intervention will be discussed in relation to the significance of the results as compared to the methods used for design of the interventions based on previous interventions and how the constructs were implemented. Gain score results for all three of the intervention groups and open-ended response results from small firm and large firm participants will be discussed. Lacking similar studies of this population in the literature by which to determine the process of setting strict performance standards, our targets for expected improvement were based on significance in gain score change.

5.1.1 Worker Intervention

The worker intervention construct gain scores that were shown to increase among intervention group participants were self-efficacy, trust in technology and adoption readiness. Construct gain scores not found to be significant were health knowledge, perceived risk, and trust in organization.

5.1.1.1 Worker Self-Efficacy Discussion

Self-efficacy gain scores for the worker intervention group were found significant on the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. The first post-test for self-efficacy was not found to be significant. This could be explained since the workers were only shown how to use vacuum sanders during the intervention and had limited hands-on training to provide a lot of experience with the technology. The second post-test scores did show significant improvement that is in line with the HBM guidelines for using self-efficacy to enhance personal skills (Rosenstock 1988). The intervention targeted self-efficacy because skill training may be required to help people enhance self-efficacy before adopting a certain behavior. Performance accomplishments where the person has the ability to successfully try the skill or behavior and master the skill has been found to be the most effective method of obtaining self-efficacy (Rosenstock 1988). This finding is similar to those of an intervention to improve lead safety practices among painting contractors and their employees who were trained on-site and given the skills to improve their self-efficacy in implementing safe practices on the jobsite (Materna 2002). Workers in this lead safety study received educational training including technical assistance, focusing on hands-on demonstrations, participatory exercises and hands-on demonstrations of vacuum power tools. It was found that the workers in the lead safety study improved their skill and usage of ventilated tools and became more accurate in selecting appropriate respiratory protection methods. This study is similar to the DUSTI intervention in that workers gained self-efficacy with the vacuum sanders after the training and increased in their intent to adopt the new technology that can lead to implementation.

5.1.1.2 Worker Trust in Technology Discussion

Trust in technology gain scores for the worker intervention group were found to be significant on the first post-test which immediately followed the intervention. The gain scores on the second post-test for trust in technology were not found to be significant. The gain in trust in technology scores on the first post-test were expected since efforts were made to enhance the individual's expectation that the technology will exhibit the elements of predictability, reliability and utility (Lippert 2005). The intervention showed the effectiveness of the technology and allowed the users to interact with the technology and see potential benefits of using the tool as found in previous studies where trust in technology was built in physicians accepting new technology when the perceived benefits could be seen and the tangible results of the technology are apparent to users (Yi et al. 2006).

The lack of significance in gain score differences for trust in technology on the second post-test for workers was unexpected. Possible explanations for this lack of gain could be related to the findings in the open ended responses from employers stating that while the vacuum sanding technology is a good idea and reduces dust, the quality of finishes could be diminished. A previous intervention dealing with implementing new working methods to reduce the knee strain in floor layers found that workers can be reluctant to accept changes in working methods because they will at least for a period decrease their work intensity and output. This study found that workers who did not implement the new practices immediately after the interventions did not tend to use them later and have not increased their trust in the new system (Jensen and Kofoed 2002). If the workers in the intervention were not able to use the sanders immediately after the intervention in their work, it could explain the lack of increased gain scores for trust in technology.

5.1.1.3 Worker Adoption Readiness Discussion

Adoption readiness gain scores for the worker intervention group were found significant on the first post-test that immediately followed the intervention. The gain scores on the second post-test for adoption readiness were not found to be significant. The gain in trust in technology scores on the first post-test were expected because as in other interventions that have been successful at increasing adoption readiness, the elements of relative advantage, compatibility, complexity, triability, and observability of the DOI model were all incorporated into the design of the intervention (Rogers 2003). Other interventions successfully using these elements of the

DOI to increase adoption readiness include using hydraulic ladder racks for mechanical contractors (Kramer 2009) and the intention of utility companies to adopt energy conservation interventions (Vollink 2002).

The lack of significance in gain score differences for adoption readiness on the second post-test for workers was unexpected. Possible explanations for this lack of gain could be related to the findings relating to the concern over the quality of finish the vacuum sanders produce. An innovation must allow the adopter to execute actions that increase the organization's performance (Toole 1998). If workers did not perceive the technology to increase their performance upon gaining experience with the technology, their adoption readiness level could potentially affected.

5.1.1.4 Worker Health Knowledge Discussion

Health Knowledge gain scores for the worker intervention group were not found to be significant on the first post-test which immediately followed the intervention or on the second post-test three months following the intervention. This lack of gain score increase was unexpected at the onset of the research. However, upon review of the data, it was noted that pre-test scores of health knowledge were already high, leaving little room for gain-score increase upon post-testing. Initial mean scores for health knowledge were (5.51) based on a 7-point scale. Post-test mean scores for the immediate post-test (6.24) and for the three month follow up post-test (6.3) were higher than the initial pre-test scores but overall gain scores were not found to be significant. The mean scores for health knowledge items shows there was some increase in health knowledge among some employees but with the mean scores being scoring high on a scale of 1-7, there was already a high level of health knowledge among workers in the drywall industry about the possible health effects drywall dust can pose. Results from other worksite health promotion activities have yielded promising yet modest health behavioral changes while evidence suggests that employees who participate in workplace health promotion interventions achieve positive health outcomes (Linnan 2001). Helping workers to become aware of the risks they are exposed to by increasing health knowledge, perceived susceptibility, perceived severity and helping them to break down any perceived barriers by teaching self-efficacy and allowing them to realize the benefits of healthy behaviors can easily be adapted to work site situations and hazards (Conrad et al. 1996).

5.1.1.5 Worker Perceived Risks Discussion

Perceived risk to health gain scores for the worker intervention group were not found to be significant on the first post-test which immediately followed the intervention or on the second post-test three months following the intervention. This lack of gain score increase was unexpected at the onset of the research. However, upon review of the data, it was noted that pre test scores showed evidence of perceived risk from working around drywall dust was found to exist but not at a high level. The mean score for perceived risk on the initial pre-test was (5.23) based on a 7-point scale. Post-test mean scores for the immediate post-test (5.99) and for the three month follow up post-test (6.05) were higher than the initial pre-test scores but overall gain scores were not found to be significant. These scores reveal that there is some level of perceived risk but that the intervention failed to increase the health threat workers view working around drywall to be. The main elements that make up the perceived risk construct are: perceived susceptibility and perceived severity (Rosenstock 1960; Rosenstock 1988; Elder 1999). These elements are the major determining factors that cause people to adopt or continue practices that are meant to protect a person's safety and health. The first is the degree to which a person feels he or she is susceptible to a certain health problem or disease. The second is the severity the person believes that contracting the disease or health problem would have serious consequences to them (Rosenstock 1960).

Explanations for the lack of gain score increase could be that the intervention did not adequately communicate the severity of drywall dust risk. Also, the intervention might not have adequately addressed the worker susceptibility to disease from this dust. Another possible explanation is the delay between adoption and health benefits. This time lag may make perception of risk difficult in the immediate term. The consequence of not adopting the innovation on their health may never occur. Preventative innovations such as the one conducted in this research have been perceived as having low relative advantage as compared to other innovations that show immediate impact on health benefits or that are designed to create a profit (Rogers 2002).

5.1.1.6 Worker Trust in Organization Discussion

Trust in organization gain scores for the worker intervention group were not found to be significant on the first post-test which immediately followed the intervention or on the second post-test three months following the intervention. This lack of gain score increase was unexpected at the onset of the research. However, upon review of the data, it was noted that pre-test scores of trust in organization among participants, a level of trust in organization was found to exist. The mean score for organizational trust on the initial pre-test was (5.73) based on a 7-point scale. Post-test mean scores for the immediate post-test (5.92) and for the three month follow up post-test (5.76) were slightly higher than the initial pre-test scores but overall gain scores were not found to be significant. These scores reveal that there was some level of trust in organization already present and that the intervention failed to significantly increase the trust in organization of workers. The intervention focused on improving worker skills and ability to use dust-control methods that has been found to increase trust in organizations. Employees who view themselves as having a high degree of ability and experience are more likely to place a higher degree of trust in the organization than those who do not view themselves as having the ability and experience in the company (Podsakoff et al. 1996). By working with employers and workers, the intervention tried to foster better communication, sharing in decision making and sharing of information with employees helps to build organizational trust (Gilbert and Tang 1998). The lack of gain score increase in the organizational trust construct indicated that the health and safety intervention had little if any impact on organizational trust or that there were deficiencies in the instrument measuring this construct. This finding is doesn't support the use of trust in organization as an integral component of increasing worker intent to adopt new technology.

5.1.2 Small-Firm Intervention

The small firm intervention construct gain scores that were shown to increase among intervention group participants were perceived risk, trust in technology, perceived usefulness, perceived ease of use, trust in technology and adoption readiness. The construct gain scores not found to be significant in the small firm intervention were health knowledge.

5.1.2.1 Small Firm Perceived Risk Discussion

Perceived Risk gain scores for the small firm intervention group were found significant on both the immediate post-test following the intervention as well as on the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. This outcome was expected at the outset of this research and is consistent with past interventions using this construct of the HBM for increasing the perceived risk to health of participants. As small firms learned about the severity and susceptibility of their employees to health related problems associated with drywall dust exposure, their level of perceive risk increased similar to that of participants in other HBM interventions outlined in section 2.6 of this dissertation. Intervention examples discovered through the literature review which also used the HBM to increase participant's perceived risk include interventions to reduce smoking, interventions to increase breast cancer screening, increased nutrition at worksites, increase in colorectal cancer screenings, increased diabetes awareness and prevention, increased vaccination participation and various other health related concerns (Bastani 1995; Conrad et al. 1996; Vernon 1997; Aoun et al. 2002; Abood 2003; Dempsey 2006). This model focuses on perceptions, beliefs and other personal characteristics that influence whether a person feels at risk for a certain health problem and whether they position themselves to change certain health behaviors, health practices and/or to utilize health care services (Lux 1994). The DUSTI interventions presented health information to participants aimed at increasing their awareness of potential health issues. Attention was given to how accepting the PtD solutions could reduce their health risks and that they were in postion to change their behavior with their choice of tools. Open-ended responses of contractors noted that health related days away from work, potential health problems, and insurance premium increases due to worker's compensation claims were a risk for their company and that there was a need to control employee exposure.

5.1.2.2 Small Firm Trust in Technology Discussion

Trust in technology gain scores for the small firm intervention group were found significant on both the immediate post-test following the intervention as well as on the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. This outcome was expected at the outset of this research and is consistent with past interventions using this construct of trust in technology to increase intent to use new technology. In order for changes in work procedures and practices in relation to technology acceptance to take place, trust must be a fundamental part of the organizational culture if the change is to be sustainable and adopted effectively (Podsakoff et al. 1996). Trust in technology research has been conducted in various fields including ecommerce, online marketplaces, information systems, medical technology and food science (Eiser 2002; Misiolek 2002; Yee 2005; Li et al. 2008; Montague et al. 2009). By increasing the small firm owner's knowledge of dust-control technology, their trust in the technology improved. This strategy was consistent with the intent of using the trust in technology construct to show that the more someone understands how something works, the more likely they are to put their trust in it (Dzindolet et al. 2003). Better operator knowledge of how a technology works will result in more appropriate use of technology (Parasuraman and Riley 1997).

5.1.2.3 Small Firm Perceived Usefulness Discussion

Perceived usefulness (PU) gain scores for the small firm intervention group were found significant on both the immediate post-test following the intervention as well as on the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. This outcome was expected at the outset of this research and is consistent with past interventions using the construct of PU combined with the PEOU construct of the TAM to increase PU. By showing the small firm owners how the tool worked and the advantages that using the tool provided to their firm, it can be assumed that the intervention demonstrated perceived usefulness to the firm owners and, thus, gain scores increased. This is consistent with interventions using this construct of the TAM including introducing new computer management systems in manufacturing firms (cite), increasing physician's decisions to adopt telemedicine and introducing a new interactive online help desk system (Hu 1999; Venkatesh 2000b, 2000c).

5.1.2.4 Small Firm Perceived Ease of Use Discussion

Perceived ease of use (PEOU) gain scores for the small firm intervention group were found significant on the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. The first post-test gain scores for PEOU was not found to be significant. This could be expected since the small firms were shown how to use the vacuum sanders during the intervention and had limited hands-on training to provide a lot of experience with the technology. The second post-test scores did show significant improvement that is in line with the TAM guidelines for using PEOU to enhance personal skills. This is consistent with interventions combining this construct of the TAM with the construct of PU. Interventions including introducing new computer management systems in manufacturing firms, increasing physician's decisions to adopt telemedicine and introducing a new interactive online help desk system have successfully used these constructs to also improve PEOU (Hu 1999; Venkatesh 2000b, 2000c). As companies were given the tool for use, they were able to become familiar with the technology and as experience is gained, PEOU is increased. The construct of self-efficacy has also been compared to PEOU in that a persons' perception of efficacy with a technology can influence their view on the ease of use the technology offers (Venkatesh 2000c; Yi et al. 2006).

5.2.1.5 Small Firm Adoption Readiness Discussion

Adoption readiness gain scores for the small firm intervention group were found significant on the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. The first post-test gain scores for adoption readiness were not found to be significant. This result was unexpected because as in other interventions that have been successful at increasing adoption readiness, the elements of relative advantage, compatibility, complexity, triability, and observability of the DOI model were all incorporated into the design of the intervention (Rogers 2003). The adoption readiness of firm owners might have not shown immediate impact due to the technology being new to them and they had yet to implement the tool to determine if the technology did follow the elements of the DOI model.

The significance of the second post-test gain scores was expected since small firms had time to implement the technology and use it on a trial basis to see if it provided relative advantage, was compatible with their work practices, wasn't too complex, had the opportunity to try the technology and were able to observe the tool in use. The increase in adoption readiness is consistent with other interventions successfully using these elements of the DOI to increase adoption readiness include using hydraulic ladder racks for mechanical contractors (Kramer 2009) and the intention of utility companies to adopt energy conservation interventions (Vollink 2002). The study using hydraulic racks was similar to the DUSTI study since it provided mechanical contractors the ladder racks to use free of charge which enhanced the element of triability and also provided training on the relative advantages, compatibility, and complexity of the ladder racks. The intentions of utility companies study focused on the DOI elements relative advantage and compatibility with the existing work practices to increase adoption readiness.

5.1.2.6 Small Firm Health Knowledge Discussion

Health knowledge gain scores for the small firm intervention group were not found to be significant on the first post-test which immediately followed the intervention or on the second post-test three months following the intervention. While the lack of gain score increase was unexpected at the onset of the research, upon review of the initial mean scores of health knowledge among participants, the level of health knowledge about working around drywall dust and the effects it can have on health was evident among small firms. Another factor that could be present is that firm owners could be hesitant in reporting health knowledge that could expose them to liability. Initial mean scores for health knowledge were (5.26) based on a 7-point scale. Post-test mean scores for the immediate post-test (5.69) and for the three month follow up post-test (6.06) were higher than the initial pre-test scores but overall gain scores were not found to be significant. The mean scores for health knowledge items shows there was some increase in health knowledge among some small firms, but with the mean scores being scored on a scale of 1-7, there was already a level of health knowledge among small firms in the drywall industry about the possible health effects drywall dust can pose. This was also evident in the open-ended responses from many of the contractors stating that health risks or health problems are a potential problem when working around drywall dust. Helping small firms to become aware of the risks they are exposed to by increasing health knowledge, perceived susceptibility, perceived severity and helping them to break down any perceived barriers by teaching self-efficacy and allowing them to realize the benefits of healthy behaviors can easily be adapted to work site situations and hazards (Conrad et al. 1996).

5.1.3 Large Firm Intervention

The large firm intervention construct gain scores that were shown to have a significant increase among intervention group participants were perceived risk, perceived usefulness, and perceived ease of use. The construct gain scores that were not found to be significant in the large firm intervention were health knowledge, trust in technology, and adoption readiness.

5.1.3.1 Large Firm Perceived Risk Discussion

Perceived risk to health gain scores for the large firm intervention group were found significant on the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. The first post-test gain scores for perceived risk were not found to be significant. This result of the first post-test not showing a significant increase in gain scores was unexpected based on previous interventions using the perceived risk construct of the HBM. The significance in gain scores increase for the second post-test supports previous intervention examples discovered through the literature review which also used the HBM to increase participant's perceived risk include interventions to reduce smoking, interventions to increase breast cancer screening, increased nutrition at worksites, increase in colorectal cancer screenings, increased diabetes awareness and prevention, increased vaccination participation and various other health related concerns (Bastani 1995; Conrad et al. 1996; Vernon 1997; Aoun et al. 2002; Abood 2003; Dempsey 2006). The online training session outlined potential risks to health from overexposure to drywall dust. The mean scores of participants, initial (4.52) and the first post-test (4.58) reveal that there is a lower level of perceived risk and that the intervention failed to immediately increase the perceived risk to health threat large firm owners view working around drywall to be. Over time based on the significant increase in gain scores, perceived risk to health increased among large firm owners that supported the use of the perceived risk construct. The main elements that make up the perceived risk construct are: perceived susceptibility and perceived severity (Rosenstock 1960; Rosenstock 1988; Elder 1999). These elements are the major determining factors that cause people to adopt or continue practices that are meant to protect a person's safety and health. The first is the degree to which a person feels he or she is susceptible to a certain health problem or disease. The second is the severity the person believes that contracting the disease or health problem would have serious consequences to them (Rosenstock 1960).

Explanations for the lack of gain score increase in the initial post-test could be that the online intervention did not adequately communicate the severity of working around drywall dust or that employers do not feel that their workers are susceptible problems relating to dust inhalation. Considering that the health rewards that adopting individuals will gain may be delayed in time and are not immediately visible and may not be viewed as being severe enough to take immediate action, large firms may not view have viewed exposure as an immediate risk. The consequence of not adopting the innovation on their employee's health may never occur. Preventative innovations such as the one conducted in this research have been perceived as having low relative advantage as compared to other innovations that are designed to create a profit (Rogers 2002).This model focuses on perceptions, beliefs and other personal characteristics that influence whether a person feels at risk for a certain health problem and whether they position themselves to change certain health behaviors, health practices and/or to utilize health care services (Lux 1994). Open-ended responses of contractors showed that while there was not a high level of perceived risk, health related days away from work, potential health problems, and insurance premium increases due to worker's compensation claims were a risk for their companies and that there was a need to control employee exposure.

5.1.3.2 Large Firm Perceived Usefulness Discussion

Perceived usefulness (PU) gain scores for the large firm intervention group were not found significant on the immediate post-test following the intervention but were found to be significant on the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. The outcome of increased PU of large firms over time was expected at the outset of this research and is consistent with past interventions using the construct of PU combined with the PEOU construct of the TAM to increase PU. The initial failure to increase PU scores was not expected based on previous interventions using the TAM. By showing the large firm owners how the tool worked and the advantages that using the tool provided to their firm through online video, the intervention demonstrated perceived usefulness to the firm owners. This is consistent with interventions using this construct of the TAM including introducing new computer management systems in manufacturing firms, increasing physician's decisions to adopt telemedicine and introducing a new interactive online help desk system (Hu 1999; Venkatesh 2000b, 2000c). Due to the lack of hands-on demonstrations of the tool online and not in person along with hand-on training, and giving the technology and not giving the tool to the large firms to use, the initial PU of large contractors could have been affected when compared with the in-person intervention small firm recipients received.

5.1.3.3 Large Firm Perceived Ease of Use Discussion

Perceived ease of use (PEOU) gain scores for the large firm intervention group were found significant on both the initial post-test and the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. The post-test gain scores did show significant improvement that supports the TAM methods for using PEOU to enhance personal acceptance of technology. This is consistent with interventions combining this construct of the TAM with the construct of PU. Interventions including introducing new computer management systems in manufacturing firms, increasing physician's decisions to adopt telemedicine and introducing a new interactive online help desk system have successfully used these constructs to also improve PEOU (Hu 1999; Venkatesh 2000b, 2000c). As companies were shown video of the tool in use, they were able to become familiar with the technology and as experience is gained, PEOU is increased. The influence of PEOU is greater in organizational settings where adoption is mandatory while in voluntary settings PU is the stronger determinant of behavior intention to use technology (Brown 2002). In drywall companies where the use of vacuum sanders will be mandated, the PEOU of the technology is important to increase adoption readiness among employees. In companies where the use of vacuum sanders is not mandated, then PU will most likely be the stronger determinant on behavioral intentions to use the sanders.

5.1.3.4 Large Firm Health Knowledge Discussion

Health knowledge gain scores for the large firm intervention group were not found to be significant on the first post-test which immediately followed the intervention or on the second post-test three months following the intervention. While the lack of gain score increase was unexpected at the onset of the research upon review of the initial mean scores of health knowledge among participants, the level of health knowledge about working around drywall dust and the effects it can have on health was evident among large firms. Another factor that could be present is that firm owners could be hesitant in reporting health knowledge that could expose them to liability. Many responses both on the pretest and post-tests of large firm participants were scored as “neither disagree or agree” which could provide contractors an option for not answering truthfully their level of health knowledge to remove any liability they perceived to have. Initial mean scores for health knowledge were (5.00) based on a 7-point scale. Post-test mean scores for the immediate post-test (5.05) and for the three month follow up post-test (5.61) were slightly higher than the initial pre-test scores but overall gain scores were not found to be significant. The mean scores for health knowledge items shows there was some increase in health knowledge among some large firms, but with the mean scores being scored on a scale of 1-7, there was already a level of health knowledge among small firms in the drywall industry about the possible health effects drywall dust can pose. This was also evident in the open-ended responses from many of the contractors stating that health risks or health problems are a potential problem when working around drywall dust. Results from other worksite health promotion activities have yielded promising yet modest health behavioral changes while evidence suggests that those who participate in workplace health promotion interventions achieve positive health outcomes (Linnan 2001). Helping large firms to become aware of the risks they are exposed to by increasing health knowledge, perceived susceptibility, perceived severity and helping them to break down any perceived barriers by teaching health knowledge and allowing them to realize the benefits of healthy behaviors can easily be adapted to work site situations and hazards (Conrad et al. 1996).

5.1.3.5 Large Firm Trust in Technology Discussion

Trust in technology gain scores for the large firm intervention group were not found to be significant on the first post-test which immediately followed the intervention or on the second post-test three months following the intervention. The lack of significance in gain score differences for trust in technology on the large firm intervention was unexpected. Possible explanations for this lack of gain could be related to the findings in the open ended responses from employers stating that while the vacuum sanding technology is a good idea and reduces dust, the quality of finishes could be diminished. Unlike the worker and small firm intervention, the large firm owners did not receive hands-on demonstrations of the vacuum sanders and that might explain the lack of gain score increase. A previous intervention dealing with implementing new working methods to reduce the knee strain in floor layers found that workers can be reluctant to accept changes in working methods because they will at least for a period decrease their work intensity and output found that workers who did not implement the new practices immediately after the interventions did not tend to use them later and have not increased their trust in the new system (Jensen and Kofoed 2002). If the large firm participants in the intervention were not able to use the sanders immediately after the intervention in their work or did not have access to the technology, it could explain the lack of increased gain scores for trust in technology.

The online intervention failed to enhance trust in technology by the strengthening the individual's expectation that the technology exhibits the elements of predictability, reliability and utility (Lippert 2005). The intervention showed the effectiveness of the technology and allowed the users to interact with the technology and see potential benefits of using the tool similar to previous studies where trust in technology was built in physicians accepting new technology when the perceived benefits could be seen and the tangible results of the technology are made apparent to users (Yi et al. 2006). The benefits shown through an online intervention may not have provided enough support to the participants to promote trust in the technology.

5.1.3.6 Large Firm Adoption Readiness Discussion

Adoption readiness gain scores for the large firm intervention group were not found to be significant on the initial post-test or on the second post-test which occurred three months after the initial pre-test, intervention, and initial post-test. These results were unexpected because as in other interventions that have been successful at increasing adoption readiness, the elements of relative advantage, compatibility, complexity, and observability of the DOI model were incorporated into the design of the intervention (Rogers 2003). The lack of the DOI element of triability included in the large firm intervention could explain the lack of adoption readiness gains that were found in the small firm interventions, which did allow for trialability. Large firms might not have shown impact due to the technology being new to them and they did not have the same opportunity to use tool to determine if the technology did meet all the elements of the DOI model.

The lack of increase in adoption readiness does not support other interventions successfully using these elements of the DOI to increase adoption readiness such as an intervention to increase the intention of utility companies to adopt energy conservation (Vollink 2002). Other possible explanations for this lack of gain could be related to the open-ended findings relating to the concern over the quality of finish the vacuum sanders produce. An innovation must allow the adopter to execute actions that increase the organization's performance (Toole 1998). If large firms did not perceive the technology to increase their performance, their adoption readiness level could potentially be affected. Open-end responses from large firms also noted that barriers found previously in studies (Young-Corbett 2009) are still prevalent in large firms. Quality of finish and production times as well as difficulty in moving vacuums around on jobsites while on scaffolding were listed by large firms as barriers to further adoption of vacuum sanders as viable dust control technology for large firms.

5.2 Open Ended Response Discussion

The open-ended responses obtained from the small and large firm intervention participants provided insight into the thoughts of contractors regarding the problems drywall dust poses to aspects of their business, how they view vacuum sanders as an option to control dust and how they view using low-dust joint compound as a dust-control method. Responses were analyzed using content analysis procedures. The majority of contractors surveyed reported that drywall dust is a concern for their businesses. Problems that were reported related to matters of health risks, clean up, customer satisfaction or lost time at work or legal issues. Some comments related that employee lost time due to inhalation of dust or dust related illness has had an impact on their business. Several contractors responded that they were aware of the potential problems dust poses but felt increased dust regulations were unnecessary and that as long as masks are used properly the workers were not susceptible to dust related health problems.

Contractors viewed vacuum sanders as a good option for dust-control however many also listed limitations regarding the use of vacuum sanders in regards to the quality, cost of equipment and maintenance, ease of use, and production time it took to use the tools. This was consistent with the findings of previous studies (Young-Corbett and Nussbaum 2009a) conducted regarding the implementation of dust-control technology. Large firms also listed logistical reasons that the use of vacuum sanders could be difficult to implement on larger projects. Some of these reasons included a lack of power to vacuums, and larger areas having to be sanded using scaffolding would prevent the effective use of vacuum sanders. Firms are seeing more projects specifying the use of vacuum sanders on projects particularly in hospital and information technology equipment work areas. One company noted that since the initial intervention they had used the tool and loved it. The introduction of vacuum sanders to companies who had not used the technology was also an aim of the interventions.

Contractors views of low-dust joint compound showed that many are still unaware of the product or do not have much experience with the product and some mentioned they would be willing to try it. The emergent theme from the content analysis was that the participants thought the idea of low-dust compound was good and the control option they would choose if the cost and quality of traditional joint compound could be achieved. Several contractors reported that they have seen more projects specifying low-dust compound and that the quality of the product is improving. Some users of low-dust compound listed cost and quality limitations with the product noting that the finished product is softer, and does not accept paint the same as traditional joint compound. Other participants felt that the product was a gimmick and did not reduce the amount of dust.

5.3 Recommendations for Practice

Recommendations for the further development of construction safety and health research have been formulated based on the results of this research. This research has yielded significant findings in the use of theory-based interventions to increase the intent to use dust-control technology among workers, small firms and large firms in the drywall industry. The problem of health and safety intervention research to increase intention to use control methods in construction is broad and complex. Addressing health and safety in the construction industry is more difficult than in a fixed industrial setting. The workplace and workforce are always changing so it makes any health or safety intervention difficult to implement or evaluate (Kramer et al. 2009). The regular change in workforce demographics is a critical factor in the allocation of safety educational and training resources. Better educated /trained workers are more aware of the hazards in the work environment and are more likely to take action to protect themselves (Brunette 2005).

The information obtained in this research has provided insights into the implementation of successful theoretical based drywall dust-control usage intervention practices using the HBM, TAM and DOI models. Measurement of the impacts of safety and health training poses a difficult challenge for the training community to quantify. Intervention evaluations should provide a theoretical basis for the intervention, create an intervention powerful enough to be measured, implement valid measurement instruments, and use appropriate statistical analysis (Becker 04). As Lipsey notes (1993) theory based research has the potential to support inferences about new and successful interventions. Theory based research can provide conceptual frameworks for improving hazard control methods as well as helping researchers design studies that provide more interpretable and generalizable results (Goldenhar 1996).

It is recommended that the construction industry needs to continue to develop effective intervention strategies using the methods used in this research and improving on theoretical based methods to increase the safety of those in the industry. The success of interventions relies heavily on the relative advantage the innovation provides to the users. Successful interventions to increase innovation usage requires that rewards be shared between the players involved in the construction process including clients (Manseau and Shields 2005). The PtD adoption readiness model integrating the HBM, TAM and DOI models has produced some significant results for increasing the intent to use control methods and should continue to be used and refined to design, implement and evaluate future safety and health interventions.

5.3.1 Worker Intervention Recommendations

Worker intervention training should be worker centered, include hands on training, and seek to motivate employees to remain active in improving their working conditions. The significant gain score increases that were found for the constructs of self-efficacy, trust in technology, and adoption readiness support the continued use of these theoretical constructs in future interventions. While significant gains were not found in the constructs of health knowledge, or perceived risk, it is recommended that these elements continue to be implemented into future health and safety intervention research due to workers needing to be informed of hazards they are exposed to. Greater focus should be placed on the severity and susceptibility of exposed hazards and attention given to the ability of the individual to control the hazard. The construct of organizational trust was also not found to yield significant increase in gain scores among workers. Worker hesitation to report distrust in organization could be reflected in these results. The use of this construct is still recommended based on a study aimed at influencing the attitudes and behaviors in safety in the UK construction industry, (Langford 2000) where it was determined that when employees believe that the company and management care about their personal safety, they are more willing to co-operate to improve safety performance in the organization.

An important limitation was the reliance on health and safety professionals as the primary means of presenting information in the intervention. Future studies should focus on ways to utilize peers or suppliers in delivering health and safety messages and encouraging owners to make changes. While the use of certified trained instructors is recommended for use in training sessions to support credibility, it is recommended that the use of peer training be used in future worker interventions for occupational safety and health training which has been reported to be more successful for increasing self-efficacy among trained workers than the use of professional trainers in a study (Becker 2004) comparing worker activities before and after safety trainings. While worker training is an important element of improved safety on jobsites, it can be severely enhanced or hindered by the organization to which it is applied (Becker 2004).

5.3.2 Small Firm Intervention Recommendations

The small firm intervention was found to be the most effective of the three interventions based on the theoretical construct gain score results. The significant gain score increases that were found for the constructs of perceived risk, trust in technology, perceived usefulness, perceived ease of use and adoption readiness support the continued use of these theoretical constructs in future interventions. While significant gains were not found in the construct of health knowledge, it is recommended that these elements continue to be implemented into future health and safety intervention research due to employers needing to be informed of hazards their employees are exposed to. Greater focus should be placed on the severity and susceptibility of exposed hazards and attention given to the ability of the individual to control the hazard.

Introducing innovations in construction interventions should not only focus on how the technology can be of benefit in daily work, but also should emphasize the delivery of long-term benefits of use (Chau 1996). Future interventions dealing with small firms should focus on presenting the proposed change in work practice as reasonable to those who are asked to utilize it and that it is consistent with current methods. This is also supported in an intervention study (Hess et al. 2004) to reduce risk factors for lower-back disorders in concrete laborers where the the first step was to get support from the company to invest financially and philosophically in trying a new intervention.

5.3.3 Large Firm Intervention Recommendations

The large firm intervention was found to be the least effective of the three interventions based on the theoretical construct gain score results. The significant gain score increases that were found for the constructs of perceived risk, perceived usefulness, perceived ease of use support the continued use of these theoretical constructs in future interventions. While significant gains were not found in the construct of health knowledge, it is recommended that these elements continue to be implemented into future health and safety intervention research due to employers needing to be informed of hazards their employees are exposed to. Greater focus should be placed on the severity and susceptibility of exposed hazards and attention given to the ability of the individual to control the hazard. The lack of gain score increases for the constructs of trust in technology and adoption readiness could be explained by the intervention being delivered as a web-based intervention instead of in person. Other factors that could have impacted gain scores could have been the lack of the DOI elements of triability and in person observability that were lacking in the online large firm intervention. Triability is an important element of intervention effectiveness that is recommended to be implemented in future interventions.

It is recommended that the use of online interventions to increase usage of innovations in the construction industry should be accompanied with some form of triability which is important to increase the trust in technology and adoption readiness of participants. Purchasing departments play a large role in the adoption of new products and methods in large companies and are responsible for the decisions made and innovative risks taken (Koebel 2008). Purchasing agents must be convinced of a product's benefits and that manufacturers will support their products. Understanding products and processes and the potential benefits that could be realized through the use of new innovations could help purchasing agents make informed decisions about adopting safety and health innovations. As experience is gained in using the innovation and reliability and accurate results are proven then trust will increase which will in turn increase adoption readiness (Parasuraman and Riley 1997).

5.4 Recommendations for Future Research

The intent of this research was to use theoretical based constructs to design, implement and evaluate interventions for workers, small firms and large firms in the drywall industry aimed at increasing intention to use engineered dust-control methods. Additional research evaluating the effectiveness of the PtD Adoption Readiness Model (PtD ARM), which integrated the HBM, TAM and DOI models, for enhancing intent to use new technologies and actual usage of new technologies in the construction industry should be explored. The PtD Adoption Readiness Model should be expanded beyond the drywall finishing trade and should be implemented into other sectors of the construction industry. Using the lessons learned from the implementation of dust-control usage among drywall workers, small firms and large firms, other health and safety interventions could build upon the findings and develop similar interventions to increase intentions to use health and safety controls for other areas of construction. Laws and regulations will be important as part of the infrastructure of safety management, but beliefs, and actions will have a stronger influence upon the safety climate of construction sites (Langford 2000). By using a more interdisciplinary approach, a stronger foundation will be developed for conducting intervention research in occupational health and safety.

Measurement of impacts of safety and health training remains the most difficult outcome for the training community to measure. Intervention research is the study of planned and applied activities designed to produce designated outcomes by applying scientific methods to measure the impact of health interventions. Such evaluation should carefully incorporate a theoretical basis for the intervention, an intervention powerful enough to be measured, a rigorous study design, valid measurement instruments, and appropriate use of statistical analysis (Becker 2004).

Drywall sanding innovations are modular in that they change the way the work is performed but leave the other components of the systems in place. Additional research is recommended to improve wall finish systems that would provide the function and look of drywall but where sanding is eliminated to where worker exposure to airborne dust is a not a problem. If changes to wall systems are not feasible continued research emphasis should be placed on the product development of low-dust joint compound in terms of quality and cost to promote the wide spread development of its use through the drywall industry. Building the control method into the product itself takes away the decision factor of employees on whether to use dust-control tools and will reduce equipment costs for employers.

Based on the lack of significance of gain scores on the large firm intervention, it is recommended that additional research be conducted on the effectiveness of online training interventions in the construction industry. Web-based interventions have potential advantages for reaching large numbers of candidates, can provide individually tailored messages based on participant knowledge, and can appeal to large numbers of users without the cost of traditional on-site interventions. Internet interventions don't always transfer directly what has worked in face-to-face interventions and considerations for the development and testing of interventions online should be carefully considered. Successful interventions using the HBM elements and the Internet to promote healthy behaviors including an intervention demonstrating the effectiveness of tailored diabetes health information on participant's health practices (Gottlieb, 2000) and behavioral interventions related to chronic back pain (Lorig et al ., 2002) show the promise of using web-based interventions to increase healthy behaviors (Salyers Bull 2004). Despite the growing number of Web-based health improvement programs in the workplace, in comparison to traditional in person interventions, there has been relatively little evaluation of Web-based workplace interventions, particularly preventive interventions targeting multiple health behaviors (Cook 2007).

Additional research should be conducted with large firm drywall contractors to determine efficient and cost effective ways of implementing the vacuum sanders as dust-control technologies into their operations. Increased efficiency and productivity in using this control method could increase the perceived relative advantage of using the technology that in turn could increase intent to use vacuum sanders in large firms.

5.5 Limitations

This research only addresses drywall dust control and not other types of occupational dust control. As with most survey research, the data collected was self-reported. This research was conducted in the United States during an economic down turn for the construction industry.

Interventions might be less effective when an industry is faced with a declining market because support for occupational health and safety activities decrease (Goldenhar 2001). This research addresses only the adoption readiness of workers and small firms in Virginia and North Carolina. The geographic limitation of the convenience sample for the employee and small firm interventions might have also impacted the findings.

5.6 Chapter Summary

The overall goal of this study has been to change the behavior of drywall dust finishers by implementing dust control technologies. The findings of the strategic dust-control usage interventions for workers, small firms and large firms in the drywall industry have been discussed in this chapter. Evaluation of theoretical construct measurement performance was discussed for each of the three interventions as well as a discussion on the open-ended response evaluations. Recommendations for construction industry health and safety intervention research practice were outlined along with recommendations for future research and implications of the research. All three interventions showed elements of effectiveness in increasing various constructs of the theoretical models used and future interventions can use this work to help build a body of knowledge to strengthen intervention research in the construction industry

Appendix A: Preliminary Survey Instruments

Employer Questionnaire

Drywall Finishing Survey

The items listed below refer to people's beliefs about the drywall finishing industry. We are interested in your feelings about your work with drywall. There are no right or wrong answers; we are looking only for your individual opinion. All answers will remain confidential. To indicate your reaction to these questions, please mark your response by checking the box that best describes your response.

Drywall finishing dust reducing technologies currently in use are vacuum sanders, wet sanding methods, pole sanding and low dust joint compounds.

Vacuum sanders are power-sanding tools that are connected to a vacuum system used to sand drywall joint compound.

1. How familiar are you with vacuum sanders used for drywall sanding?

☐ Not at all familiar ☐ Slightly familiar ☐ Somewhat familiar ☐ Very Familiar

2. How often do your employees use vacuum sanders when sanding drywall?

☐ Never☐ Rarely ☐ Sometimes ☐ Often ☐ Always

3. How often do your employees use a dust mask when sanding drywall?

☐ Never☐ Rarely ☐ Sometimes ☐ Often ☐ Always

<u>Please indicate you level of agreement with the following statements</u>

4. Exposure to drywall dust poses potential health risk to workers.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

5. Working around drywall dust is a risk factor for certain illnesses.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

6. When conventional block sanding is used, my employees are exposed to high dust concentration levels.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

7. When using vacuum sanders, workers are exposed to lower dust levels in comparison to conventional block sanding.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

8. My employees are susceptible to health problems from exposure to drywall dust.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

9. Components of drywall dust can cause health problems.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

10. My employees should wear a dust mask when using a vacuum sander.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

11. I feel confident in my employees' ability to correctly use a dust mask when sanding drywall.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

12. I feel confident in my employees' ability to correctly use a vacuum sander when sanding drywall.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

13. My company considers safety to be equally as important as production.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

14. Vacuum Sanders are easy to use.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

15. Using vacuum sanders decreases the cost of finishing drywall.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

16. Using vacuum sanders improves the quality of drywall finishes.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

17. Using vacuum sanders increases productivity.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

18. My company is proactive in removing workplace hazards.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

19. My company feels safety innovation leads to increased profits.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

20. My company feels it is risky to be among the first to try new safety technologies.

☐ Don't Know ☐ Strongly Disagree ☐ Somewhat Disagree ☐ Somewhat Agree ☐ Strongly Agree

21. My company is eager to adopt new technologies relating to dust control on our projects.

 Don’t Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

22. Vacuum sanders are a worthwhile investment to reduce worker exposure to drywall dust.

 Don’t Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

Open Response questions.

What business factors would affect the way you address dust exposure to employees?

 Insurance Premiums

 Government Regulations

 Dust exposure related employee days away from work

 Environmental

 Productivity

 Worker Safety

 Other (Please Specify) ____________________________________

What are some potential problems associated with drywall dust and how could these problems affect your business?

What are your thoughts on using vacuum sanders as a dust control method in drywall sanding?

What are your thoughts on using low dust drywall joint compound as a dust control method in drywall sanding?

Drywall Finishing Survey

The items listed below refer to people's beliefs about the drywall finishing industry. We are interested in your feelings about your work with drywall. There are no right or wrong answers; we are looking only for your individual opinion. All answers will remain confidential. To indicate your reaction to these questions, please mark your response by checking the box that best describes your response.

Vacuum sanders are power-sanding tools that are connected to a vacuum system used to sand drywall joint compound.

1. How familiar are you with vacuum sanders used for drywall sanding?

☐ Not at all familiar ☐ Slightly familiar ☐ Somewhat familiar ☐ Very Familiar

2. How often do you use vacuum sanders when sanding drywall?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

3. How often do other workers in your company use vacuum sanders when sanding?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

4. I *would like/like* to use a vacuum sander to sand drywall.

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

5. How often do you use a dust mask when sanding drywall?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

6. How often do other workers in your company use dust masks when sanding drywall?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

7. I would like/like to use a dust mask to sand drywall.

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

<u>Please indicate your level of agreement with the following statements</u>

8. The decision to use or not use a vacuum sander is up to me (as opposed to required by my supervisors or job description).

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

9. The decision to use or not use a dust mask is up to me (as opposed to required by my supervisors or job description).

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

10. I feel good about my employer's decision to *use/not use* vacuum sanders.

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

11. My employer has me sand drywall in a safe way.

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

12. My employer protects me from health risks.

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

13. I trust my employer.

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

14. Vacuum sanders are a good tool to use when sanding drywall.

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

15. Vacuum Sanders are a safe way to sand drywall.

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

16. I feel confident in my ability to use a vacuum sander to sand drywall.

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

17. **I feel confident that vacuum sanders lower the amount of dust I am exposed to.**

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

18. Using a vacuum sander is frustrating.

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

19. It's easy to get a vacuum sander to do what I want it to do.

 Don't Know Strongly Disagree Somewhat Disagree Somewhat Agree Strongly Agree

20. I am worried about being exposed to drywall dust.

□ Don’t Know □ Strongly Disagree □ Somewhat Disagree □ Somewhat Agree □ Strongly Agree

21. I am healthy so working around drywall dust doesn’t affect me.

□ Don’t Know □ Strongly Disagree □ Somewhat Disagree □ Somewhat Agree □ Strongly Agree

22. Working around drywall dust puts me at risk for health problems.

□ Don’t Know □ Strongly Disagree □ Somewhat Disagree □ Somewhat Agree □ Strongly Agree

23. I feel confident in my ability to properly protect myself from exposure to dust.

□ Don’t Know □ Strongly Disagree □ Somewhat Disagree □ Somewhat Agree □ Strongly Agree

24. I feel confident in my ability to correctly use a mask when sanding drywall.

□ Don’t Know □ Strongly Disagree □ Somewhat Disagree □ Somewhat Agree □ Strongly Agree

25. A mask should be worn even when using a vacuum sander to sand drywall.

□ Don’t Know □ Strongly Disagree □ Somewhat Disagree □ Somewhat Agree □ Strongly Agree

26. My company is proactive in removing workplace hazards.

□ Don’t Know □ Strongly Disagree □ Somewhat Disagree □ Somewhat Agree □ Strongly Agree

Appendix B: Intervention Health Information Handout Materials

Dust Control Usage Strategic Technology Intervention

Health Hazard:

Construction workers involved in the sanding of drywall joint compound are often exposed to high concentrations of dust that can contain respirable silica. The components of drywall joint compound includes: talc, calcite, mica, gypsum and silica. Some of these components have been associated with varying degrees of eye, nose, throat and respiratory tract irritation. Over time, breathing the dust from drywall joint compounds may cause persistent throat and airway irritation, coughing, phlegm production and breathing difficulties similar to asthma. Smokers and workers with sinus or respiratory conditions may risk even worse health problems. When silica is present, workers may also face an increased risk of silicosis and lung cancer. Studies have shown that drywall workers are at an increased risk of developing chronic respiratory disease.

Recent studies conducted by the National Institute for Occupational Safety and Health (NIOSH) have found that drywall sanders were exposed to as much as 10 times to permissible exposure limit (PEL) of $15mg/m^3$ for total dust set by the Occupational Safety and Health Administration (OSHA). The OSHA PEL for respirable dust ($5mg/m^3$), the very small particles that can go deep into the lungs, was also exceeded.

Controls:

Manufacturers Recommendations- Drywall joint compound manufacturers recognize that workers might be exposed to too much dust during drywall sanding. NIOSH studied five manufacturer's material safety data sheets (MSDS's) that warned workers to avoid generating dust and to use respiratory protection when dry sanding. Four of the MSDSs told construction workers to use wet sanding whenever possible, and the fifth said to cut dust exposures "by ventilation". However, these guidelines are seldom followed in actual work practice. Wet sanding is generally avoided because of concerns of drying time and finish texture. When respiratory protection is used, it is often used incorrectly with little thought to training, proper selection, or fit. Respiratory protection for drywall dust needs to meet or exceed the NIOSH approved type N95 respirator.

Vacuum Sanders- Several light-weight vacuum sanding systems are now sold to control employee dust exposures when sanding joint compound. These systems use portable vacuums to capture and remove the dust before the employee is exposed to it. NIOSH conducted a study and found that the 5 commercially available vacuum sanders they tested successfully reduced dust exposures by 80-97%. Four of the five tested cut exposures by nearly 95%. If these engineered controls had reduced total dust exposures by just 90%, the dust exposures in the NIOSH study described earlier would have remained below the OSHA PEL.

In addition to lower exposures, vacuum systems can help the sander, subcontractor, general contractor, and building owner in other ways. The dramatic reduction in airborne dust exposures results in a much cleaner work area during and after sanding. For workers, the clean working environment is more comfortable; less irritating to eyes, nose, and throat; and less likely to require respiratory protection. For subcontractors, a comfortable worker is likely to be more productive, be absent less often, and require fewer breaks for "fresh air". Other cost savings will result from a cleaner environment that reduces dirt, and cleanup time.

Low-Dust Joint Compound- Unlike traditional joint compounds, the fine dust particles in low-dust compounds bind together to form large particles when sanded. These larger particles quickly fall to the floor, reducing the potential exposure to airborne dust and silica. If sanding is brief and intermittent, this may reduce exposures enough that a respiratory protection program isn't required. However, continuous use may exceed the OSHA permissible PEL, even with the use of low-dust joint compounds. Manufacturers state that airborne dust is reduced by 70% when compared to sanding standard compounds.

Respiratory Protection- OSHA requires that employees exposed to dust concentrations higher than the Permissible Exposure Limit to wear Filtering Facepiece Respirators (Dust masks). Dust masks prevent the inhalation of airborne dust. Dust mask training is required for anyone who wears a dust mask. Dust masks will leak if they are not worn properly. Dust masks do not filter out chemical vapors and are not adequate for high concentrations of dust. NIOSH Type 95 or higher Dust Masks are required for exposure to concentrations above the PEL. Type 95 masks filter out 95% of dust particles. N99 or N100 masks are recommended for dangerous dusts such as asbestos or silica.

- Dust Masks must fit properly to prevent leaks around the edges. Fit testing must be done before first wearing a dust mask. Beards do not allow a good fit when wearing a dust mask.
- Dust masks cannot be cleaned or repaired if soiled or damaged.
- Replace dust mask if breathing becomes difficult or if the mask is torn.
- Dispose of dust masks at the end of the day or shift.
- If you notice an odor, find dust inside the mask, or think your mask leaks, notify your supervisor.
- Store masks when not being used in a sealed container that will prevent dust from getting on inside of the mask.

SUMMARY:

Sanding drywall joint compound generates high dust concentration levels that often exceed the permissible exposure limit set by OSHA. This dust could contain contaminants that have been found to increase the risk of certain respiratory diseases over time. NIOSH recommends that dust-control methods be implemented to protect workers from dust exposure. Engineered control methods such as vacuum sanders and low-dust drywall compounds are effective at reducing the amount of dust employees are exposed to. Personal Protective Equipment (PPE) such as dust masks should be a last line of protection. Protecting yourself and other workers from dust exposure could prevent work related illness and injuries now and in the future.

References:
NIOSH Report HETA 94-0078-2660
Center for Construction Research and Training- Construction Solutions Database

Appendix C: Website Screen Shots

Project DUSTI

A Dust-Control Usage Strategic Technology Intervention

Begin

A project by the Virginia Tech Occupational & Construction Hazard Reduction Engineering Lab

This project is sponsored by The National Institute for Occupational Safety And Health (NIOSH).

Project DUSTI

A Dust-Control Usage Strategic Technology Intervention

Review of Procedures

- Take online Survey # 1.
- Review website contents.
- Take online follow-up survey.
- $25.00 Home Depot gift card will be emailed to you upon completion of the follow-up survey.
- In 3 months time you will be asked to take the survey again and will receive another $25.00 Home Depot gift card email upon completion of the survey.

Next >

Health Hazard - Drywall Dust

- Construction workers involved in the sanding of drywall joint compound are often exposed to high concentrations of dust that can contain respirable silica.
- The components of drywall joint compound includes: talc, calcite, mica, gypsum and silica. Some of these components have been associated with varying degrees of eye, nose, throat and respiratory tract irritation.
- Over time, breathing the dust from drywall joint compounds may cause persistent throat and airway irritation, coughing, phlegm production and breathing difficulties similar to asthma.
- Smokers and workers with sinus or respiratory conditions may risk even worse health problems. When silica is present, workers may also face an increased risk of silicosis and lung cancer.
- Studies have shown that drywall workers are at an increased risk of developing chronic respiratory disease.
- Recent studies conducted by the National Institute for Occupational Safety and Health (NIOSH) have found that drywall sanders were exposed to as much as 10 times to permissible exposure limit (PEL) of 15mg/m3 for total dust set by the Occupational Safety and Health Administration (OSHA). The OSHA PEL for respirable dust (5mg/m3), the very small particles that can go deep into the lungs, was also exceeded.

NEXT >

Dust-Control Methods

Methods of finishing drywall have been developed that control dust exposures of workers and have been found to be effective at reducing the concentrations of dust to levels below the permissible limits as prescribed by OSHA. These methods and materials that have been found to reduce the dust levels during sanding operations when properly used are not widely used in the drywall industry for various reasons. Using dust-control methods can reduce the risk of illness and disease caused by exposure to drywall joint compound dust exposure. The following dust-control methods have been recommended by NIOSH to reduce worker exposure to dust:

- Wet Sanding
- Vacuum Sanding
- Low Dust Joint Compound
- PPE

NEXT >

Dust-Control Methods

Manufacturer's Recommendations: Wet Sanding

Drywall joint compound manufacturers recognize that workers might be exposed to too much dust during drywall sanding. NIOSH studied five manufacturer's material safety data sheets (MSDS's) that warned workers to avoid generating dust and to use respiratory protection when dry sanding. Four of the MSDSs told construction workers to use wet sanding whenever possible, and the fifth said to cut dust exposures "by ventilation." However, these guidelines are seldom followed in actual work practice. Wet sanding is generally avoided because of concerns of drying time and finish texture. When respiratory protection is used, it is often used incorrectly with little thought to training, proper selection, or fit. Respiratory protection for drywall dust needs to meet or exceed the NIOSH approved type N95 respirator.

NEXT >

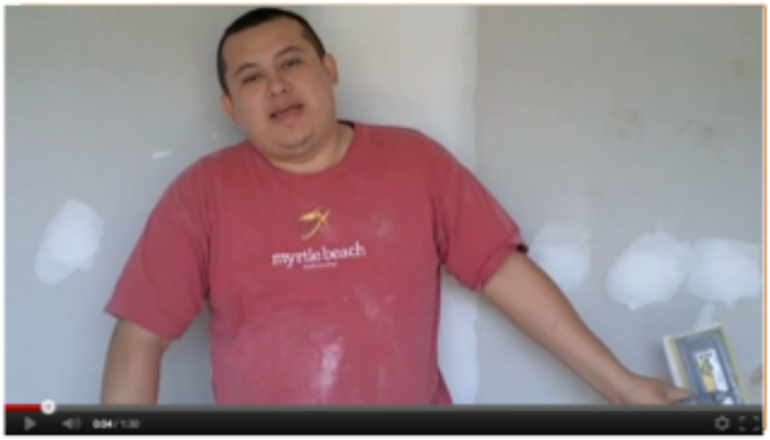
Vacuum Sanders

- Several light-weight vacuum sanding systems are now sold to control employee dust exposures when sanding joint compound. These systems use portable vacuums to capture and remove the dust before the employee is exposed to it. NIOSH conducted a study and found that the 5 commercially available vacuum sanders they tested successfully reduced dust exposures by 80- 97%. Four of the five tested cut exposures by nearly 95%. If these engineered controls had reduced total dust exposures by just 90%, the dust exposures in the NIOSH study described earlier would have remained below the OSHA PEL.
- In addition to lower exposures, vacuum systems can help the sander, subcontractor, general contractor, and building owner in other ways. The dramatic reduction in airborne dust exposures results in a much cleaner work area during and after sanding.
- For workers, the clean working environment is more comfortable; less irritating to eyes, nose, and throat; and less likely to require respiratory protection.
- For subcontractors, a comfortable worker is likely to be more productive, be absent less often, and require fewer breaks for "fresh air." Other cost savings will result from a cleaner environment that reduces dirt, and cleanup time.

NEXT >

Benefits of Vacuum Sanders

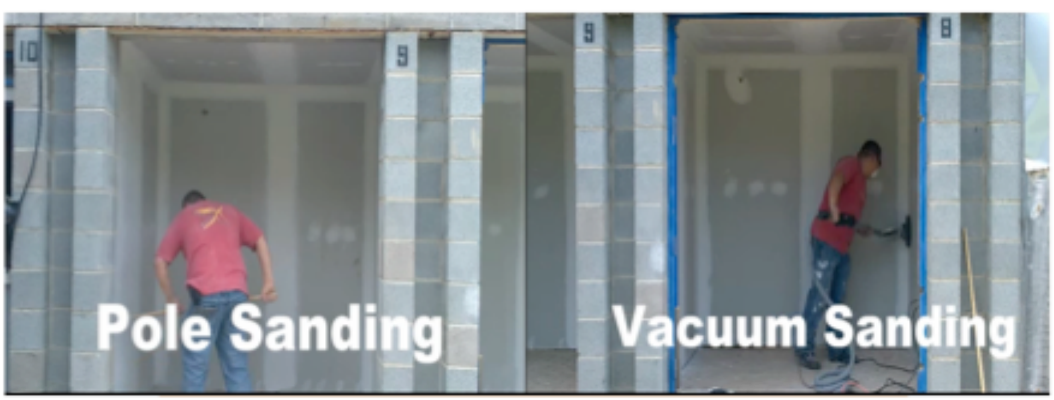
Edwin Gomez a drywall contractor in Virginia discusses the benefits of using vacuum sanders.



NEXT >

Benefits of Vacuum Sanders - Productivity

Vacuum sanders save your company time. A group of student researchers at Virginia Tech University conducted a Time and Motion Study Analysis comparing vacuum sanding and pole sanding and found that along with significant reductions in dust exposure, the powered vacuum sander increase productivity by 27%. The physical effort required by workers was reduced when measuring fatigue factors and and finish quality was comparable to hand or pole sanding when reviewed by an experienced drywall finisher.



NEXT >

Misuse of Powered Vacuum Sanders

Researchers have found that drywall finishers sometimes use creative disablement when using vacuum sanders and disable the safety features that are designed to control dust. Workers who use the vacuum sanders improperly and without the vacuum can cause greater health hazard exposures. The vacuum should always be connected when using power drywall sanders.

NEXT >

A Dust-Control Usage Strategic Technology Intervention

Low-Dust Drywall Compounds

Unlike traditional joint compounds, the fine dust particles in low-dust compounds bind together to form large particles when sanded. These larger particles quickly fall to the floor, reducing the potential exposure to airborne dust and silica. If sanding is brief and intermittent, this may reduce exposures enough that a respiratory protection program isn't required. However, continuous use may exceed the OSHA permissible PEL, even with the use of low-dust joint compounds. Manufacturers state that airborne dust is reduced by 70% when compared to sanding standard compounds.

- http://www.downwithdust.com/faqs.php
- http://www.nationalgypsum.com/

NEXT >

Personal Protective Equipment (PPE)

Respiratory Protection - OSHA requires that employees exposed to dust concentrations higher than the Permissible Exposure Limit to wear Filtering Facepiece Respirators (Dust masks). Dust masks prevent the inhalation of airborne dust. Dust mask training is required for anyone who wears a dust mask. Dust masks will leak if they are not worn properly. Dust masks do not filter out chemical vapors and are not adequate for high concentrations of dust. NIOSH Type 95 or higher Dust Masks are required for exposure to concentrations above the PEL. Type 95 masks filter out 95% of dust particles. N99 or N100 masks are recommended for dangerous dusts such as asbestos or silica. PPE is a last line of defense and OSHA would prefer that prevention of hazards through the design of tools and materials be used in lieu of PPE. Designing preventative measures into tools and materials takes away the decision employees make in when and how to use PPE. If PPE is required:

- Employers must train employees on proper usage of masks and provide fit testing and provide the masks for their employees.
- Dust Masks must fit properly to prevent leaks around the edges. Fit testing must be done before first wearing a dust mask. Beards do not allow a good fit when wearing a dust mask.
- Dust masks cannot be cleaned or repaired if soiled or damaged.
- Replace dust mask if breathing becomes difficult or if the mask is torn.
- Dispose of dust masks at the end of the day or shift.
- If you notice an odor, find dust inside the mask, or think your mask leaks, notify your supervisor.
- Store masks when not being used in a sealed container that will prevent dust from getting on inside of the mask.

NEXT >

A Dust-Control Usage Strategic Technology Intervention

Begin Survey

Having completed the Dust-Control Usage Strategic Technology Intervention, you will now be asked to complete the survey again.

NEXT >

Intervention Completed

- References
  - NIOSH Drywall Dust Control Hazard Video with dust concentration

  - http://www.cdc.gov/niosh/docs/99-113/
- Other Team OCHRE Projects
  - Project BREATHE: Building Related Environmental Assessment & Technology in Housing, Existing
  - Sustainable Healthy Schools
  - Construction Organization Nationwide Trends in Reducing Occupational Levels

Appendix D: Final Survey Instruments

Drywall Finishing Survey

The items listed below refer to people's beliefs about the drywall finishing industry. We are interested in your feelings about your work with drywall. There are no right or wrong answers; we are looking only for your individual opinion. All answers will remain anonymous. To indicate your reaction to these questions, please mark your response by checking the box that best describes your response.

Vacuum sanders are power-sanding tools that are connected to a vacuum system used to sand drywall joint compound.

1 **How familiar are you with vacuum sanders used for drywall sanding?**
☐ Not at all familiar ☐ Slightly familiar ☐ Somewhat familiar ☐ Very Familiar

2 **How often do you use vacuum sanders when sanding drywall?**
☐ Never ☐ Rarely ☐ Sometimes ☐ Regularly ☐ Always

3 **How often do other workers in your company use vacuum sanders when sanding drywall?**
☐ Never ☐ Rarely ☐ Sometimes ☐ Regularly ☐ Always

<u>**On the following Questions, mark your level of agreement with each statement. If you don't know or the question is not applicable, mark N/A.**</u>

4 **The use of vacuum sanders is voluntary.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

5 **Assuming I have access to a vacuum sander, I intend to use it.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

6 **Serious health problems can result from working around drywall dust.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

7 **Vacuum sanders are good tools to use when sanding drywall.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

8 **I trust my employer to protect me from hazards.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

9 **I feel confident in my ability to use a vacuum sander.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

10 **I am the one who gets to choose whether to use a vacuum sander.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

11 **I am worried about being exposed to drywall dust.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

12 **Working around drywall dust puts me at risk for health problems.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

13 **I trust vacuum sanders.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

14 **Components of drywall dust can cause health problems.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

15 **I believe my employer is open and up-front with me.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

16 **Using a vacuum sander improves performance in my job.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

17 **I fully trust my employer.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

18 **I have control over the decision to use a vacuum sander.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

19 **It is easy for me to become skillful at using a vacuum sander**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

20 **If I have access to a vacuum sander, I want to use it as much as possible.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

21 **I believe my employer's motive's and intentions are good.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

22 **I feel that vacuum sanders can lower the amount of dust I am exposed to.**
☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

Drywall Employer Questionnaire

The items listed below refer to people's beliefs about the drywall finishing industry. We are interested in your feelings about your work with drywall. There are no right or wrong answers; we are looking only for your individual opinion. All answers will remain anonymous. To indicate your reaction to these questions, please mark your response by checking the box that best describes your response.

Drywall finishing dust reducing technologies currently in use are vacuum sanders, wet sanding methods, pole sanding and low dust joint compounds.

Vacuum sanders are power-sanding tools that are connected to a vacuum system used to sand drywall joint compound.

1 How familiar are you with vacuum sanders used for drywall sanding?

☐ Not at all familiar ☐ Slightly familiar ☐ Somewhat familiar ☐ Very Familiar

2 How often do your employees use vacuum sanders when sanding drywall?

☐ Never ☐ Rarely ☐ Sometimes ☐ Regularly ☐ Always

Please indicate you level of agreement with the following statements. If you don't know or the statement is not applicable to you mark N/A.

3 My employees could effectively use vacuum sanders.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

4 Components of drywall dust can cause health problems.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

5 Vacuum sanders are too complex.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

6 Using vacuum sanders increases productivity.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

7 Using a vacuum sander improves the quality of drywall finishes.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

8 Vacuum sanders are good tools to use for sanding drywall.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

9 I anticipate my company will use (or continue to use) drywall sanders in our work.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

10 Exposure to drywall dust poses a potential health risk to workers.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

11 It will take a long time for my employees to learn to use vacuum sanders.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

12 Vacuum sanders save my company time.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

13 I trust vacuum sanders.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

14 Vacuum sanders are difficult to use.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

15 Serious health problems can result from working around drywall dust.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

16 When using vacuum sanders, workers are exposed to lower dust levels in comparison to conventional block sanding

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

17 My employees are susceptible to major health problems from exposure to drywall dust.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

18 Vacuum sanders produce quality drywall finishes.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

19 It is convenient to use a vacuum sander.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

20 Working in the drywall industry is a risk factor for certain illnesses.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

21 Vacuum sanders are easy to use.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

22 My company always tries to use vacuum sanders in as many cases/occasions as possible.

☐ Strongly Disagree ☐ Disagree ☐ Somewhat Disagree ☐ Neither Disagree or Agree ☐ Somewhat Agree ☐ Agree ☐ Strongly Agree ☐ N/A

What business factors would affect the way you address dust-control on your projects?

- [ ] **Insurance Premiums**
- [ ] **Government Regulations**
- [ ] **Dust exposure related employee days away from work**
- [ ] **Environmental**
- [ ] **Productivity**
- [ ] **Worker Safety**
- [ ] **Other (Please Specify) ___________________________________**

What are some potential problems associated with drywall dust and how could they affect your business?

What are your thoughts on using vacuum sanders as a dust control method in drywall sanding?

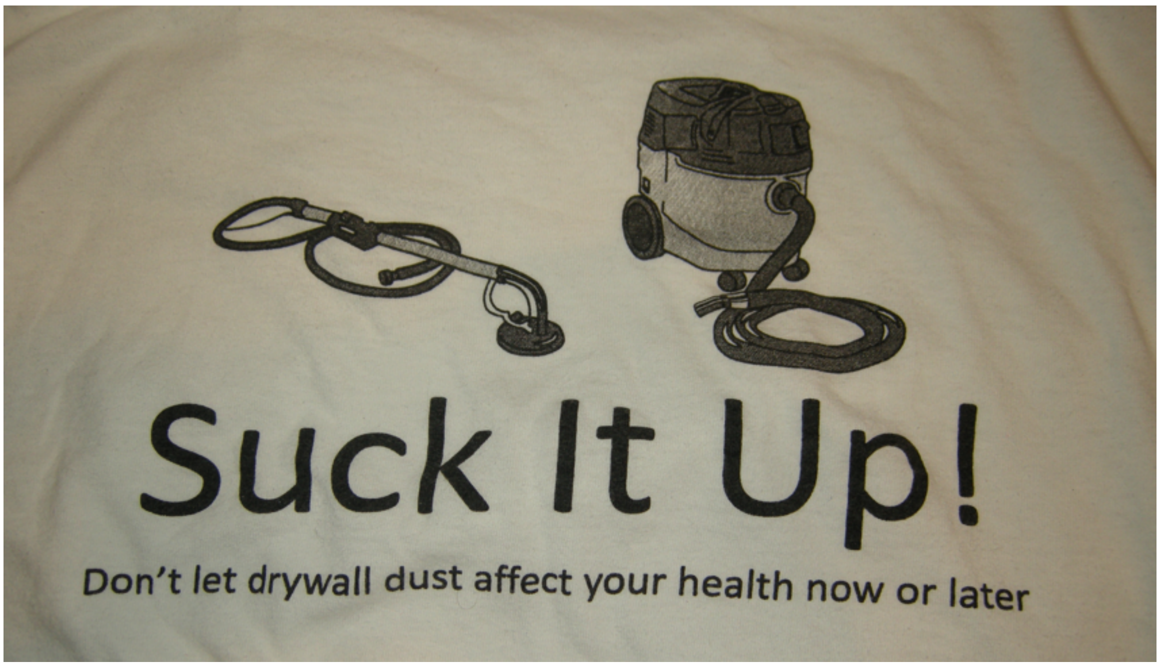
What are you thoughts on using low dust drywall joint compound as a dust control method in drywall sanding?

Have you seen an increase in projects specifying dust-control methods?

What percent of your work specifies using dust-control methods?

Appendix E: Employee Cues to Action

T-Shirt Design



Hard Hat Sticker Design

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